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Barnsley Hospital - CAU & ED

Flood Risk Assessment

13th July 2018

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Contents

Executive summary

Mott MacDonald (MM) was commissioned to carry out a Flood Risk and Runoff Assessment for Barnsley Hospital's co-located children's ED and CA unit.

This report is to support a preliminary Outline Planning Application for this site and to incorporate a SuDS based storm water management scheme.

The site is to be assessed with regard to the requirements of the Planning Practice Guidance (PPG) and the associated Technical Guidance to determine the suitability of the proposed development on the site.

As well as fluvial flood risk the report will also assess the risk posed locally by the development itself and the runoff it may generate.

This element will include a general overview of the suitability of Sustainable Drainage Systems (SuDS) type systems.

If required, mitigation measures and recommendations will be made that will enable the site to be suitably developed while actively seeking to reduce flood risk locally.

The following guidelines and references have been used in the preparation of this report:

- Planning Practice Guidance – Technical Guidance (PPG-TG)[1]
- Environment Agency Flood Risk Standing Advice for England[2]
- Mott MacDonald archives

The report is also based on additional information received from the Environment Agency (EA), Yorkshire Water (YW), Barnsley Borough Metropolitan Council (BBMC) and NHS.

The report concludes that the development is suitable for this location and can be safely developed to manage and control all identified long term residual flood risks in this area. The provision of a positive, attenuated drainage system on the site may also contribute to a reduction in flood risk locally.

Notwithstanding this, it is demonstrated that the layout may be developed to incorporate a SuDS based system that will provide adequate runoff protection.

[1] http://planningguidance.planningportal.gov.uk/blog/guidance/flood-risk-and-coastal-change/

[2] https://www.gov.uk/flood-risk-assessment-local-planning-authorities

1 Introduction

Barnsley Hospital NHS Trust are proposing the development of a new co-located children's ED and CA unit as an extension to the existing site. The proposed development is located to the north of the existing building and will extend the existing Emergency Department towards Gawber Road.

The Government has placed increasing priority on the need to take full account of the risks associated with flooding at all stages of the planning and development process, to reduce future damage to property and loss of life. The PPG- Technical Guidance (PPG-TG) identifies how the issue of flooding is dealt with in the drafting of planning policy and the consideration of planning applications.

The purpose of this report is to assist our client and the Local Planning Authority to make an informed decision on the flood risks associated with the site development.

Local Planning Authorities have the powers to control development in accordance with the guidelines contained in PPG-TG, and are expected to apply a risk-based approach to development with the Sequential Test in Table 1. This sets out a sequential; characterisation of flood risk in terms of annual probability of river, tidal and coastal flooding.

In accordance with the sequential test in the technical guidance, sites are to be classed as follows:[3]

Table 1: Flood Zones – PPG-TG Table 3

Flood Zone	Appropriate Users
Flood Zone 1 - Low Probability This zone comprises land having less than 1 in 1000 annual probability of river or sea flooding (<0.1%)	All uses of land are appropriate in this zone
Flood Zone 2 - Medium Probability This zone comprises land assessed as having between 1 in 100 and 1 in 1000 annual probability of river flooding (1%-0.1%) or between 1 in 200 and 1 in 1000 annual probability of sea flooding (0.5%- 0.1%) in any year	The water-compatible, less vulnerable and more vulnerable uses of land and essential infrastructure in Table D.2 are appropriate in this Zone Subject to the Sequential Test being applied, the highly vulnerable uses in Table D.2 are only appropriate in this zone if the Exception Test is passed
Flood Zone 3a - High Probability This zone comprises land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%) or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year	The water-compatible and less vulnerable uses of land in Table D.2 area appropriate in this zone. The highly vulnerable uses in Table D.2 should not be permitted in this zone. The more vulnerable and essential infrastructure uses in Table D.2 should only be permitted in this zone if the Exception Test is passed. Essential infrastructure permitted in this should be designed and constructed to remain operational and safe for users in time of flood.
Flood Zone 3b - Functional Floodplain This zone comprises land where water has to flow or be stored in times of flood. SFRAs should identify this Flood Zone (land which would flood with an annual probability of 1 in 20 (5%) or greater in any year or is designed to flood in an extreme (0.1%) flood, or at another probability to be agreed between the LPA and the Environment Agency, including water conveyance routes)	Only the water-compatible uses and the essential infrastructure listed in Table D.2 that has to be there should be permitted in this zone. It should be designed and constructed to: Remain operational and safe for users in times of flood; Result in no net loss of floodplain storage; Not impede water flows; and Not increase flood risk elsewhere. Essential infrastructure in this zone should pass the Exception Test.

[3] http://planningguidance.planningportal.gov.uk/blog/guidance/flood-risk-and-coastal-change/

Source: http://planningguidance.planningportal.gov.uk/blog/guidance/flood-risk-and-coastal-change/flood-zone-andflood-risktables/table-3-flood-risk-vulnerability-and-flood-zone-compatibility/

Mott MacDonald has followed accepted procedure in providing the services but given the residual risk associated with any prediction and the variability which can be experienced in flood conditions, we take no liability for and give no warranty against actual flooding of any property (client's or third party) or the consequences of flooding in relation to the performance of the service. This report has been prepared for the purposes of planning approval only and is to assist our client and the local Planning Authority to make an informed decision on the flood risks associated with the site redevelopment.

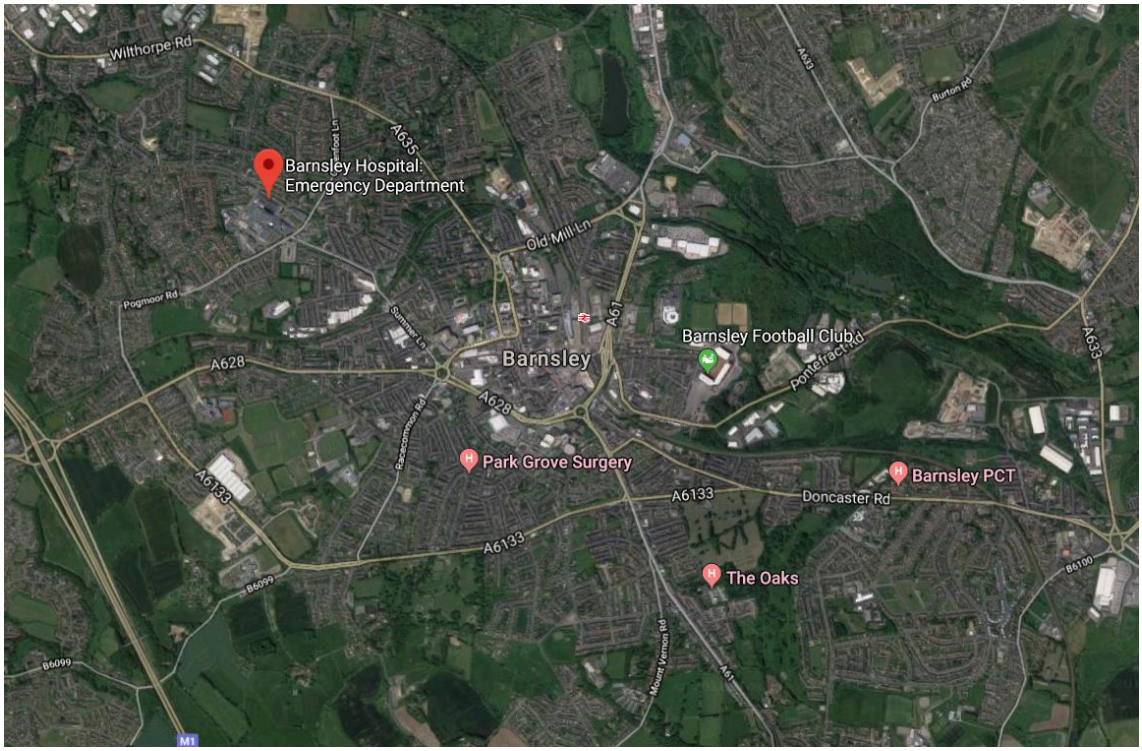
Allowance for the effects of climate change will be made in accordance with government recommendations in place and statistical data available at the time of writing this report. These recommendations may become more onerous and the statistical data may be revised in the future; we will not make any estimate of what changes may result from this. Please be aware that this, and other issues over which the Mott MacDonald has no control, may affect future flood risk at the development and require further work to be undertaken for which we accept no liability.

2 Existing Site

2.1 Site Location

Barnsley Hospital is located in the north east of Barnsley, approximately 1.5km from the town centre. The OS grid reference of the site is SE332070 and has postcode S75 2PX.

Figure 1: Barnsley ED Location Plan



Source: Google Maps 2018

2.2 Site Description

The site is currently part of the Barnsley Hospital NHS site and is used as disabled parking and drop-off for the existing Emergency Department. The proposed site will have an area of approximately 0.5ha. The proposed development area is accessed via two entrances off Gawber Road that serve the ED drop off and the ambulance arrival area.

Historic topographical information has been made available by Barnsley Hospital NHS Trust. This information was produced as part of an existing drainage survey in 1970 and has been included in Appendix C.

The topographical information shows the site falls from north-west to south -east and south-west to north-east. The lowest point on the proposed site is closest to Gawber Road, by the existing entrance, the level is 136.4mAOD. The access road then rises up to the existing car park level of 137.5mAOD. The car park has an elevation of between 137.5mAOD, in the north-east corner and 139.9mAOD in the north-west corner. We recommend that an updated, detailed

topographical survey is completed at the next project stage to confirm and provide more detailed information regarding existing levels and site falls.

2.3 Existing Site Drainage

Barnsley Hospital is located in the area covered by Yorkshire Water. Sewer records obtained from YW show a surface water sewer (225Ø) and a combined sewer (225Ø) beneath Gawber Road to the north of the site. The records indicate these are at a depth of approximately 0.91m and 1.52m for the surface water and combined water respectively.

Historic information provided by Barnsley Hospital NHS Trust also shows a private surface water and foul water sewer running parallel to Gawber Road, beneath the existing car parking and verge area. The quality of the historic documents limit the information able to be extracted, however, it is indicated that the pipe diameters for the foul and surface water pipes are 18" (c.450mm) and 12" (c.300mm) respectively. The depth of the surface water at the exit onto Gawber Road is estimated to be 1.1m and the foul 1.7m.

2.4 Existing Land Drainage

As the site is developed and positively drained it is assumed there is no land drainage. There is no evidence to suggest any existing.

2.5 Existing Watercourses

There are two watercourses within a 1km radius of the proposed development. The first is an unnamed watercourse to the north of the site. OS open source maps indicates it starts 300m from the site, beneath Samuel Road. It flows north and outfalls into the River Dearne. The second watercourse is 650m south of the proposed development and is known as Sough Dyke. The watercourse is indicated to start at May Terrace, before flowing east. The watercourse is culverted at Perseverance Street, where it travels through Barnsley town centre.

3 Sources and Extents of Flooding

3.1 Summary

Table 2: Summary of sources and extent of flooding

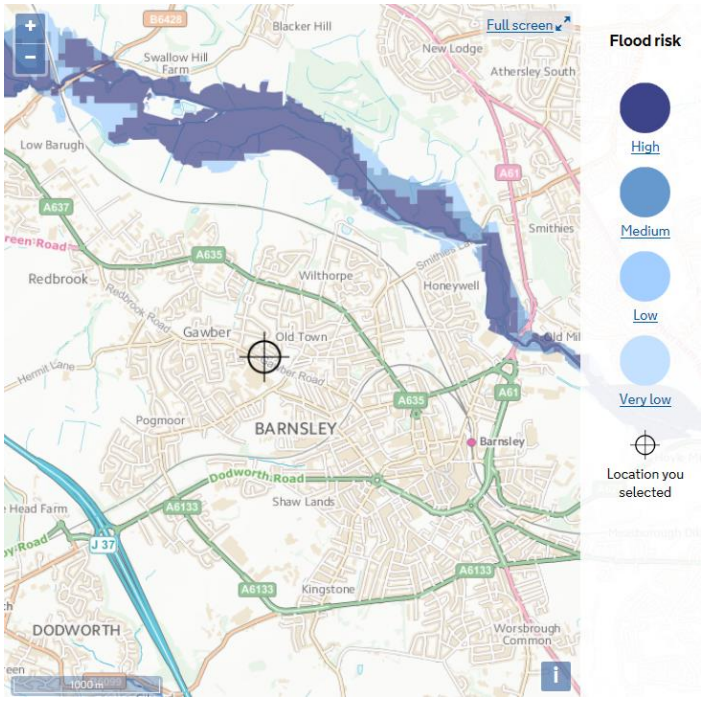
Potential Source of Flooding	Is there a flood risk to the development?	Does the development increase the flood risk upstream?	Does the development increase the flood risk downstream?
Fluvial Flooding	No	No	No
Pluvial Flooding and Overland Flow	No	No	No
Ground Water Flooding	No	No	No
Adopted Drainage	No	No	No
Private Drainage	No	No	No
Highway Drainage	No	No	No
Reservoir Flooding	No	No	No
Development Drainage	No	No	No

3.2 Natural Drainage

3.2.1 Fluvial Flooding

With reference to the EA's indicative flood maps, it can be seen that the site lies in Flood Zone 1 and therefore is shown to have less than 0.1% chance of flooding in any year.

Figure 2: Fluvial Flood Map

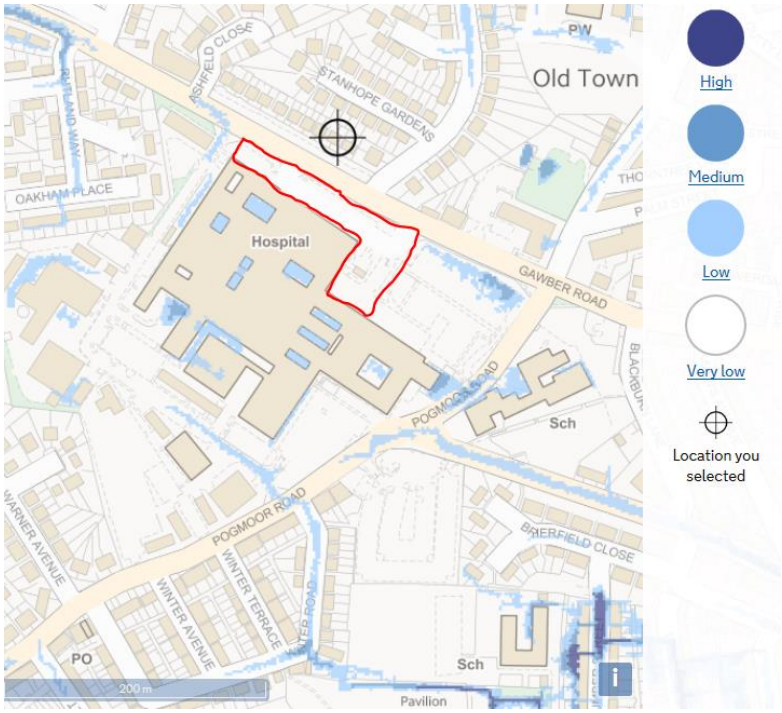


Source: https://flood-warning-information.service.gov.uk/long-term-flood-risk

3.2.2 Pluvial Flooding and Overland Flow

With reference to the EA's online mapping, data related to the risk of potential surface water inundation or flooding is also provided. This shows that the risk of pluvial flooding is low.

Figure 3: Pluvial Flood Risk Map



Source: https://flood-warning-information.service.gov.uk/long-term-flood-risk

3.2.3 Ground Water Flooding

A Strategic Flood Risk Assessment produced for BBMC in 2010 does not present a risk of groundwater flooding for the area of the hospital. The closest area deemed a likely candidate for groundwater flooding by the report is the Kingstone area of Barnsley, located in the south west of the town.

Notwithstanding this, there are no features on the site that may indicate elevated ground water.

3.2.4 Climate Change

The Environment Agency requires, in accordance with the Government's PPG-TG document, that there should be no increase in the rate of surface water emanating from a newly developed site above that of any previous development. Furthermore, it is the joint aim of the Environment Agency and Local Planning Authorities, to actively encourage a reduction in the discharge of storm water as a condition of approval for new developments. In addition, all drainage systems should be sized to accommodate the runoff arising from a 1 in 100-year rainfall event, and should include a further allowance to account for the further effects of climate change. Table 3 below, shows the anticipated increases in rainfall intensities and river flows with time, and has been reproduced in part from Table 4 of PPG-TG.

Table 3: Climate Change Allowance

Type	Applies across all of England	2015 to 2039	2040 to 2069	2070 to 2115
Rainfall	Upper End	10%	20%	40%
	Central	5%	10%	20%

Source: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#table-2

The development has a proposed design life of 60 years, which if constructed in 2018 will be until 2078. Therefore, a climate change value for rainfall of 20% climate change will be used for design, and 40% for checking.

3.3 Artificial Drainage

3.3.1 Adopted Drainage

Sewer records obtained from Yorkshire Water are included in Appendix A for reference.

These records show that there is a surface water sewer (225Ø) and a combined sewer (225Ø) beneath Gawber Road to the north of the site. The records indicate these are at a depth of 0.91m and 1.52m for the surface water and combined water respectively. Assuming a gradient of 1:100, the full bore capacity for the foul and surface water is 46l/s and 52l/s respectively.

3.3.2 Private Drainage System

Historic information provided by Barnsley Hospital NHS Trust shows a private surface water and foul water sewer running parallel to Gawber Road, beneath the existing car park and verge area. The proposed building will clash with this and a diversion may be required. The quality of the historical documents limits the information able to be extracted, however it is indicated that the pipe diameters for the foul and surface water pipes are 18” (450mm) and 12” (300mm) respectively. The depth of the surface water at the exit onto Gawber Road is estimated to be 1.1m and the foul 1.7m. Assuming a gradient of 1:100, the full bore capacity for the foul and surface water is 287l/s and 111l/s respectively.

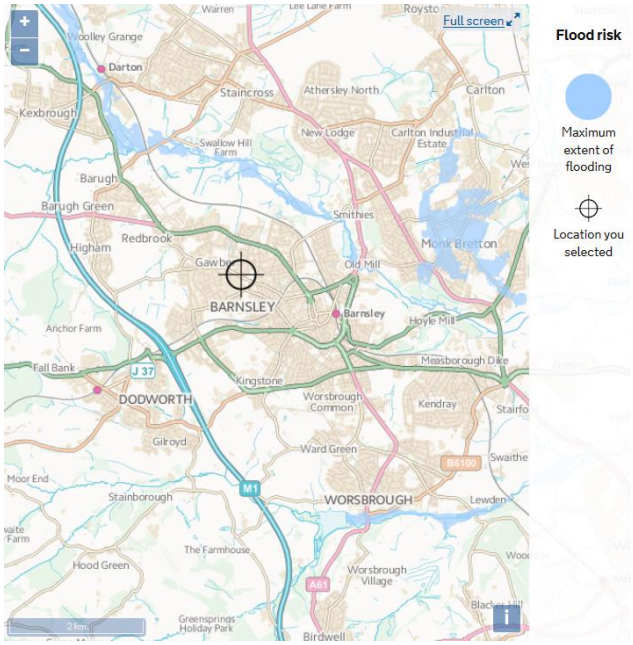
3.3.3 Highway Drainage

Highway drainage beneath Gawber Street is assumed to feed in the adopted surface water sewer displayed on the Yorkshire Water sewer records.

3.3.4 Reservoir Flooding

With reference to the EA's online mapping, data related to the risk of potential reservoir flooding is also provided.

Figure 4: Reservoir Flooding Extents



Source: https://flood-warning-information.service.gov.uk/long-term-flood-risk

3.3.5 Development Drainage

The current proposed layout for the site is shown in Appendix B

The total site is approximately 0.33ha in area and includes the following impermeable areas:

- New CAU/ED
- Hardstanding

For the purpose of this study 0.07ha will be classed as permeable and is predominantly landscaping.

As the site is previously been used as a car park and is shown to be positively drained, the run-off has been estimated using the Lloyd-Davis Method for a 50mm/hr event;

$$Q = 2.78AIC$$

Where:
A = Area (ha), I = Rainfall Intensity (mm/hr), C = Constant

$$Q = 2.78 \times 0.26 \times 50 \times 1$$

$$Q = 36.14l/s$$

4 Flood Risk Assessment

4.1 Natural Drainage

4.1.1 Fluvial Flooding

With reference to the EA's published flood maps (see Figure 2 in 3.2.1) the site can be shown to be outside the influence of the flood envelope of any rivers.

The site can therefore be classified as within the Flood Zone 1.

4.1.2 Pluvial Flooding and Overland Flow

The EA maps show that the site is at low risk of pluvial flooding. There are minor areas of low and medium risk around the site, but none within the proposed site boundary. The main areas of pluvial flooding in the area coincide with the unnamed river to the north and Summer Lane to the south-east.

4.1.3 Groundwater Flooding

The Barnsley Strategic Flood Risk Assessment does not indicate that the area is at significant risk of groundwater flooding.

It is recommended that groundwater is measured and monitored as part of any future intrusive ground investigation.

4.1.4 Climate Change

As discussed in Section 3.2.4, all designs will be based on an allowance of 40% increase in rainfall intensity for future climate change. This will be reduced if the external levels strategy offers the opportunity for surface storage during high rainfall events.

4.2 Artificial Systems

4.2.1 Adopted Drainage

As there is no increase in impermeable area from the proposed development and a proposed betterment of 30% reduction in surface water run-off, the risk of flooding from adopted drainage assets is seen to be reduced. However, it is know that existing drainage assets in the basement currently flood and therefore a blockage in the system downstream could worsen this. A drainage survey Is required to assess the impact of this. As the adopted assets beneath Gawber Street have a lower cover level than the sites low spot, there is no risk of flooding from a potential failure either. As a detailed topographical survey is not available at this stage it is difficult to assess the flood path for failed adopted assets, however an initial assessment would suggest flood waters would flow towards the junction of Gawber Road and Pogmoor Road.

4.2.2 Private Drainage

Historical sewer records do not provide the level of required information for proper assessment of private drainage. As there is no increase in impermeable area, the capacity of this network is seen to be sufficient. There are no known reports of flooding from private drainage systems by the hospital for the new development. However, the existing basement area is subject to regular flooding from the internal drainage network and is mitigated by the use of pumps. As the

proposed development does not include a basement, this is not seen to pose a risk. If there is a failure of the site drainage it would flow north-east onto Gawber Road.

4.2.3 Highway Drainage

As the highway is approximately 1-2m lower than the proposed building. The existing highway drainage is not thought to pose a significant risk of flooding.

4.2.4 Development Drainage

It will be necessary to provide a suitably designed storm water drainage system to collect, convey and attenuate the additional runoff generated by the development of this site. The net result should be that there is no increase in flood risk to either downstream properties or assets as a result of the development. Yorkshire Water are likely to require a reduction in the peak discharge rate, for this reason a 30% reduction in surface water discharge is proposed from the new development.

This will be demonstrated by the developing drainage strategy of the site. This strategy should also include measures to improve run-off quality whilst maximising bio-diversity and amenity to provide a sustainable drainage system as noted in PPG.

Foul flows from the development should be drained through an entirely separate system designed to adoptable standards to minimise the risk of foul flooding occurring as a result of the development.

5 Sequential Test

As the development site is shown to be wholly within Flood Zone 1 and outside the influence of any other local flood risk elements, in accordance with table 3 of the PPG it is concluded that the development is suitable for this location and the Sequential Test is deemed to have been passed.

6 Storm Water Management

6.1 Control of Surface Water Run-off

It should be acknowledged that the satisfactory collection, control and discharge of storm water is now a principal planning and design consideration. This is reflected in recently implemented guidance and the National SuDS Standards.

Part H of the Building Regulations 2015 recommends that surface water run-off shall discharge to one of the following, listed in order of priority:

- An adequate soakaway or some other infiltration system, or where that is not reasonably practicable;
- A watercourse, or, where that is not reasonably practicable;
- A surface water sewer.

It is necessary to identify the most appropriate method of controlling and discharging surface water. The design should seek to improve the local run-off profile by using systems that can either attenuate run-off and reduce peak flow rates or positively impact on the existing flood profile.

6.1.1 Infiltration Based Systems

Historical borehole logs available through the British Geological Survey maps (http://mapapps.bgs.ac.uk/geologyofbritain/home.html) indicate the presence of made ground to approximately 2.20m depth, clay to approximately 3.95m depth then a sandstone bedrock at 4.17m depth.

Given these observations of the known geology, the use of an infiltration based system does not appear viable due to the likely depth of made ground, however, in-situ, site specific testing would need to be undertaken. Therefore, in-lieu of this data, for the purpose of this study alternative methods of surface water discharge shall be considered as the primary means of disposal of storm water.

6.1.2 Watercourses

As discussed in Section 2.5, the closest watercourse is located 300m to the south. A connection to this watercourse would be impractical due to the presence of existing infrastructure along the route. For this reason, discharge to a watercourse has been discounted.

6.1.3 Adopted Sewers

As the existing site is drained to a private drainage network that discharges to the adopted sewer beneath Gawber Road, it is proposed to re-use this existing system and connection where possible.

6.2 Allowable Site Discharge

As the site is classified as a brownfield site, it is proposed to offer a 30% reduction on the existing M30-30 storm event (50mm/hr). As shown in Section 3.3.5, the existing site run-off is estimated to be 36.14l/s.

Based on the site area (0.33ha) and using the Lloyd-Davis Method for the undeveloped site, the proposed run-off will be 25.3l/s

6.3 Site Attenuation

The provision of suitable attenuation on-site to mitigate flood risk resulting from the proposed development will be a key factor in the evolution of the site development layout.

The provision of attenuation, as is likely in this case, can be achieved by a number of methods; however, not all systems can be assessed in direct comparison.

One of the aims of PPG is to provide not only flood risk mitigation but also maximise additional gains such as improvements in runoff quality and provision of amenity and bio-diversity. Systems incorporating these features are often termed Sustainable Drainage Systems (SuDS) and it is a requirement of PPG that these are considered as the primary means of collection, control and disposal for storm water as close to source as possible.

The volume of attenuation required for the development may be estimated using design software. The proposed impermeable areas taken from the current layout may be used to evaluate the runoff response of the site during varying rainfall events.

For the purposed of this assessment a geo-cellular storage tank with flow control device has been used. The software uses the FSR characteristics of M5- 60= 19.000 mm and ratio R=0.360. A climate change percentage of 40% has been used as at this point surface storage does not appear to be possible. Following external levels design, this may change and the volume of attenuation can be reduced.

Table 4: Summary of Anticipated Attenuation Volume

	Impermeable Area	Anticipated Unrestricted Run-off	Flow Restriction	Approximate Attenuation Volume (1 in 100 +40%)
	ha	ls^{-1}	ls^{-1}	m^3
Whole Site	0.26	36	25.3	135

Source: Microdrainage Calculation

This assessment is for the whole impermeable area discharging to a single system such as a geo-cellular storage system. Undeveloped areas within the site boundary have not been considered as it is assumed that drainage of these areas will be as existing.

If infiltration does prove to be viable for the site, then it should be possible to reduce the overall size of the attenuation required.

6.4 Sustainable Drainage Systems (SuDS) and Water Quality

The most appropriate attenuation system should satisfy three main characteristics:

- Provide the required volume of storage;
- Minimise the loss of developable land and;
- Where possible provide local amenity.

A summary of the various types of attenuation is included overleaf.

The application of the ‘SuDS Manual’ CIRIA report C753 for new developments requires that the runoff from sites is not only restricted to meet the pre-development runoff characteristics but

also that SuDS systems are utilised to improve the quality of the runoff prior to outfall to watercourses.

The manual and EA guidance applies a sustainability hierarchy to the various types of SuDS systems, this is summarised in Table 5: SuDS .

Table 5: SuDS Hierarchy

	SuDS Technique	Flood Reductions	Pollution Reductions	Landscape & Wildlife Benefit
Most Sustainable	Living Roofs	√	√	√
	Basins and Ponds • Constructed Wetlands • Balancing Ponds • Detention Basins • Retention Ponds	√	√	√
	Filter strips and swales • Infiltration devices • Soakaways • Infiltration trenches and basins	√	√	√
	Permeable surfaces and filter drains • Gravelled areas • Solid paving blocks • Porous paviours	√	√	
Least Sustainable	Tanked Systems • Oversized pipes/ tanks • Cellular Storage	√		

Source: CIRIA SuDS Manual C753

Systems at the top of the hierarchy provide a combination of attenuation, treatment and ecology and are deemed the most sustainable options. There are always specific scenarios where some systems are more suitable than others and at this stage it is not possible to guide the development towards a particular strategy. However, included below are summaries of some of the main types of SuDS systems that may be applied to the development outlining the main benefits and constraints to their application.

In addition to the above hierarchy, the CIRIA SuDS Manual C753 identifies a number of treatment trains or SuDS devices through which flow should pass from various point sources of runoff. This is designed to ensure that the receiving watercourses are not put at risk of pollution by new development.

Table 6 taken from the SuDS Manual identifies the number of treatment trains as a function of runoff source and receiving water sensitivity. This site lies within a low sensitive catchment and thus the required number of treatment trains is determined below as 1;

Table 6: Watercourse Sensitivity and Treatment Trains

	Receiving Watercourse Sensitivity		
Runoff Catchment Characteristics	Low	Medium	High
Roof Only	1	1	1
Residential roads Parking Areas	2	2	3

	Receiving Watercourse Sensitivity		
Commercial Zones			
Refuse collection Industrial areas Loading bays Lorry parks Highways	3	3	4

Source: CIRIA SuDS Manual C753

6.4.1 Living or Green Roofs

Larger areas of roof may be designated as living or green roofs to provide both point water treatment and significant enhancement of local bio-diversity. The assessed gains are such that these systems are the preferred EA option for the provision of SuDS.

If considered at the outset of the design of a unit, a green roof can be integrated within the provision of a roof terrace area to multiply the benefits, alternatively, a maintained roof can be installed that may require specialised access.

There are numerous propriety systems available on the market to suit various specific applications and it is recommended that if these systems are being considered discussion with several suppliers is instigated as soon as possible.

At this stage a green roof is not being considered. This is due to the roof area been designated for the use of plant and other building services equipment.

6.4.2 Ponds and Basins

The nature of these systems is such that the run-off from the development can be treated by biological action and stilling to significantly improve the quality of water discharged from the system.

Basins also provide large areas of open space that can be developed for recreational uses or as new habitat for wildlife.

Both systems do, however, take up developable land and have residual maintenance and liability issues attached to their implementation.

Due to the constrained nature of the site, there is not the available external area to accommodate a pond or basin structure. For this reason, it is not being considered.

6.4.3 Filter Strips and Swales

Often used adjacent to roads and footpaths, swales and filter strips can be used to collect water directly from linear features, percolate some of the flow, attenuate and then discharge the flow to either a traditional system or a secondary SuDS device.

The use of these systems is more suited to linear applications such as roads as the typical cross section is relatively small and longer runs are required to provide attenuation volume.

Filter strips will be smaller in plan area than a swale although the swale can be landscaped to be incorporated in to the verge of the carriageway, combining two functions.

Land take can be relatively small in comparison to other systems and both types perform well in improving water quality. They are also ideally suited for disposal of water via a secondary infiltration.

As there is not sufficient space on the proposed site to accommodate a swale for storage or for treatment, this is not to be considered further.

6.4.4 Rain Gardens

Rain gardens are designed to mimic the natural water retention of undeveloped land and reduce the volume of rainwater running off into drains from impervious areas. They also have the added benefit that they are able to treat low levels of pollution. In construction, they are shallow depressions with absorbent, yet, free draining soil which are populated with plants that are able to withstand temporary flooding conditions.

This type of system not only has the advantage of meeting the requirements of SuDS but could also provide additional educational benefits for certain sites.

Similar to swales, the site does not have adequate external space to provide a raingarden. It is therefore not to be considered further.

6.4.5 Permeable Paving

Larger areas of block paved hardstanding can easily be converted to provide significant volumes of storage. These systems also encourage biological treatment of flow and extraction of oils and heavy metals from the run-off.

Land take is reduced as storage is located under car parks and access roads. However, maintenance is potentially a long-term issue and the possibility of the paving being damaged, dug up and not properly reinstated or not regularly swept could lead to compromising the future capacity of the system.

This system will negate the need for a separate collection system such as kerbs and gullies. It will also assist in reducing the flood profile of the site by significantly attenuating the run-off from the development within the sub-base material.

There is no specific amenity provided by the system other than enabling other areas to be utilised for development rather than potentially sterilizing area with an easement for a sewer or stand-off for a basin.

These systems may be incorporated into normal car-parking areas and driveways but may not be suitable for areas accessed by larger vehicles. These systems can also be used in conjunction with geo-cellular attenuation where attenuation volumes are large.

As the required storage volume is 135m³, a 500mm deep permeable paving system would have a required area of 900m². This area of paving cannot be accommodated on the site, this option is therefore discontinued. Permeable paving will however be considered for the external areas as a mean of collection.

6.4.6 Cellular Storage

Large volumes of storage can be provided under grassed and lightly trafficked areas by using proprietary geo-cellular systems. This will maximise the developable area of the site.

There are no specific mechanisms within the system designed to treat flow but extended detention times will allow sedimentation reducing the suspended solids within the discharge.

There is no creation of amenity by the installation of these types of systems, indeed by maintaining access to the system small areas may need to be reserved.

If the developable footprint is constrained then these systems may be advantageous, however, to ensure suitability it is recommended that the use of these systems is discussed with the maintaining body as they are not always preferred.

The installation of cellular storage requires significant excavation and therefore where space is not a critical issue other forms of attenuation should be considered. These systems will also require occasional maintenance to remove sediments which can be difficult depending on the design and access arrangements.

As this site is constrained, a viable option for surface water storage is a geo-cellular storage system. The benefits are that a system can be installed at a relatively shallow depth to allow connection to the existing drainage system, which depth is currently unknown. It also allows for the required storage volume to be attenuated in the smallest total volume.

6.4.7 Tank or Culvert Storage

Hard engineered tank storage systems have traditionally been used for attenuation structures for the past decade and are often specified where large volumes of storage are required (>200m^3) and available space is an issue.

These systems have no inherent water treatment properties except potential sedimentation of the attenuated flow and offer no additional amenity benefits. In some cases, the easement to the tank or culvert is such that a significant portion of land area is sterilized from development as are certain types of landscape planting.

There are also significant costs associated with these systems in production, transportation, and installation. However, once installed the long-term maintenance requirement of the system is relatively low.

With a proven record of successful installation, tanks and culverts are regularly adopted by water authorities across the country, albeit with a large associated easement that will sterilise that portion of the site. It should be noted however, that these systems will require occasional maintenance to remove sediments which can be difficult depending on the design and access arrangements.

As any storage structure is not planned to be adopted, a tank has been discounted in favour of a geo-cellular storage system.

6.4.8 Surface Storage

The use of roads, public areas and even landscaped areas as additional storage for an extreme rainfall event is becoming a widely accepted form of attenuation.

Water spilling from the drainage systems can be collected via roads and kerbs and channelled to lower lying areas where it would be stored until the capacity in the existing system returns.

These systems have the advantage of requiring little additional infrastructure merely detailing of the proposed roads and grassed areas.

As these systems will only by used in extreme events when the adopted drainage system is exceeded (>1 in 30 years), they provide a very efficient way of catering for these events rather than providing permanent capacity.

There is no inherent water treatment capability in this system nor any particular increase in amenity, however, the costs associated with this provision are relatively small.

As previously mentioned, at this point in time, as there is no detailed external level strategy the effectiveness of surface storage cannot be assessed. As the external strategy is developed this ca be revisited.

6.4.9 Oversized Pipework

It is often possible to provide the required volume of storage within the existing collection pipework of the proposed system. This may be incorporated by using oversized pipework designed to act as inline storage.

As the diameter of larger pipes readily available is limited the applicability of these types of systems is more suited to <200m^3 of attenuation. Above this volume, the length of pipe required is excessive and difficult to suitably fit into a normal site layout.

There is no intrinsic amenity provided by the use of this system neither is there any specific level of run-off treatment over and above that of a standard pipe and gully system.

However, due to their traditional nature, the adoption of these types of systems by water companies is straightforward and does not require any specialist input. The pipes are generally available direct from suppliers with little or no lead time and the satisfactory long-term performance of these systems is well documented.

To provide the required 135m^3 of storage, with a assumed viable maximum pipe length of 100m, the required pipe diameter would be 1.35m. As this would require an extensive excavation along the length of the site, the option does not appear viable.

6.5 Summary

The application of a SuDS based system needs to be considered as the primary measures for dealing with surface water for any proposals, these systems are the only ones that provide the required level of treatment.

The natural topography and nature of the site is such that available space for surface water management is limited. This means that many options including swale, ponds, permeable paving and surface storage are not viable for the site in its current form. A geo-cellular storage system has a reduced size when compared to permeable paving and its benefit of a potential shallow installation, for this reason it appears the most suited to this site.

6.6 Design Example

In order to give some idea of the size of attenuation features that may be required and thus begin the process of integration, it is possible to provisionally size a typical feature at this stage based upon the assumptions discussed previously. Assuming a required volume of 135m^3 for 40% climate change, Source Control has been used to assess the required volume, the results are included in Appendix D.

6.7 Flood Routing

The performance of the system during extreme events (>1 in 100 years) should also be considered at this stage.

The routing of potential storm water run-off, should the capacity of the proposed site drainage system be exceeded, needs to be built into the layout of the site such that the residual risk of flooding from this element can be easily mitigated.

In the event of the surface water system being inundated, flood waters would flow off site in the western corner onto Gawber Road. Gawber Road is lower than the existing lowest point on the site. Flood waters would either be managed by the highway drainage or continue to flow down Gawber Street.

6.8 Foul Drainage

6.8.1 Foul Water Flow Rates

Based on an early assessment of the proposed layout at this preliminary stage and with the assumption of 200 users per day an approximate dry weather flow of 1l/s has been estimated using Flows and Loads. This equates to an approximate peak flow of 2-4l/s.

6.8.2 Proposed Outfall

It is proposed to re-use the existing foul connection to the adopted sewer beneath Gawber Road. Site investigations are required to assess the diameter and depth of the existing private sewer network on site and a capacity assessment is also required to confirm its potential use.

6.8.3 Strategy

Foul flows would be collected using an internal pipe network, leaving the proposed building to the north. The flows would then connect to the existing private sewer network that runs parallel to Gawber Road, before discharging to the existing combined sewer beneath Gawber Road, indicated on the Yorkshire Water sewer records in Appendix A.

7 Conclusions and Recommendations

There is a low chance of flooding across the site from the following sources, fluvial, pluvial, reservoir or groundwater. The site is located in a flood zone 1 and EA maps show no surface water flooding on the site. Failure of highway or adopted drainage assets pose little risk to the site as the ground level is elevated above the existing carriageway. The greatest flood risk to the site is failure of the private drainage network. As discussed, Barnsley Hospital has stated that failure of the existing above ground drainage causes regular flooding of the basement which is handled with a pumping system. There is no basement proposed for the new development.

Infiltration is not expected to be an option. This is due to the depth of made ground and presence of clay and sandstone layer. Further GI assessments will be carried out to confirm this on site.

preferred viable method of attenuation on site is a geo-cellular storage system and initial assessment suggests that 135m³ of storage will be required. This is due to the constrained nature of the site and the potential need for any storage system to be relatively shallow. Surface storage is not seen to be an option at this point in time due to any over ground flood waters flowing off site. Following completion of the external levels strategy, this will be reviewed. A proposed betterment of 30% for an M30-30 storm is proposed, this limits site surface water discharge to 25.1l/s.

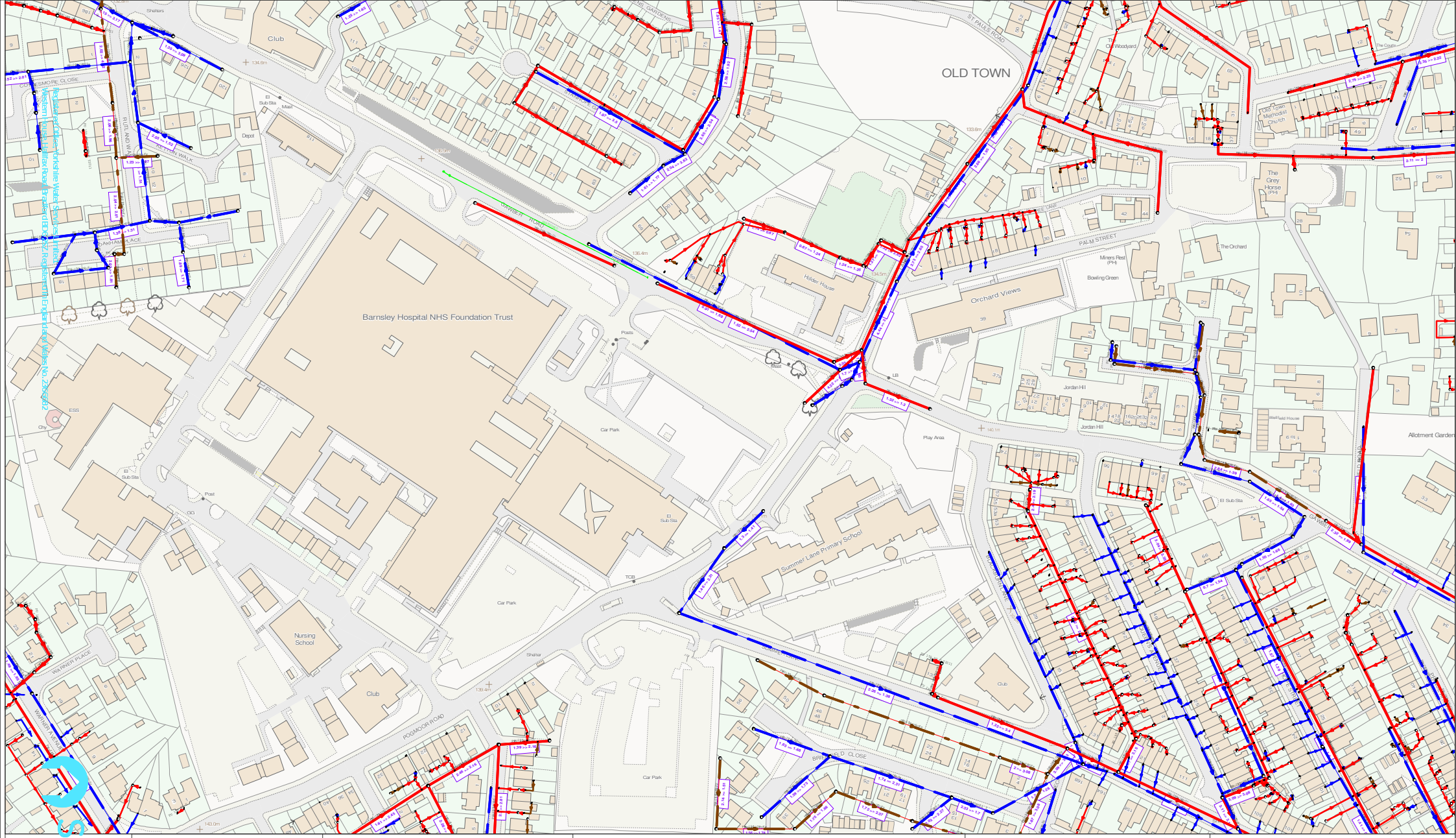
The proposed foul system is to re-use the existing connection to the adopted drainage assets below Gawber Road. The assumed peak flow rate is to be between 2-4l/s. Site investigations are required to assess the level of this connection.

A detailed topographical survey, including below ground drainage survey and condition assessment should be completed prior to development of a detailed drainage strategy. The design of the drainage systems will be based on the principals described within this report.

Appendices

A. Yorkshire Water Sewer Records

A.1 Yorkshire Water Sewer Records



SafeMove
A part of YorkshireWater

432956 : 406747	Map Name : SE3306NW	Title
YorkshireWater Yorkshire Water, PO Box 500, Halifax Road, Bradford BD6 2LZ Contact Name : Search Advisor L MULLOCK Contact Tel : 75 4506	Notes	

Partial Key

Foul Sewer = F
Combined Sewer = C
Surface Water Sewer = SW
Trade Sewer = TD
Partially Separate = PS

This plan is furnished as a general guide only and no warranty as to its correctness is given or implied. This plan must not be relied upon in the event of excavations or other works made in the vicinity of public sewers. No house or property connections are shown.

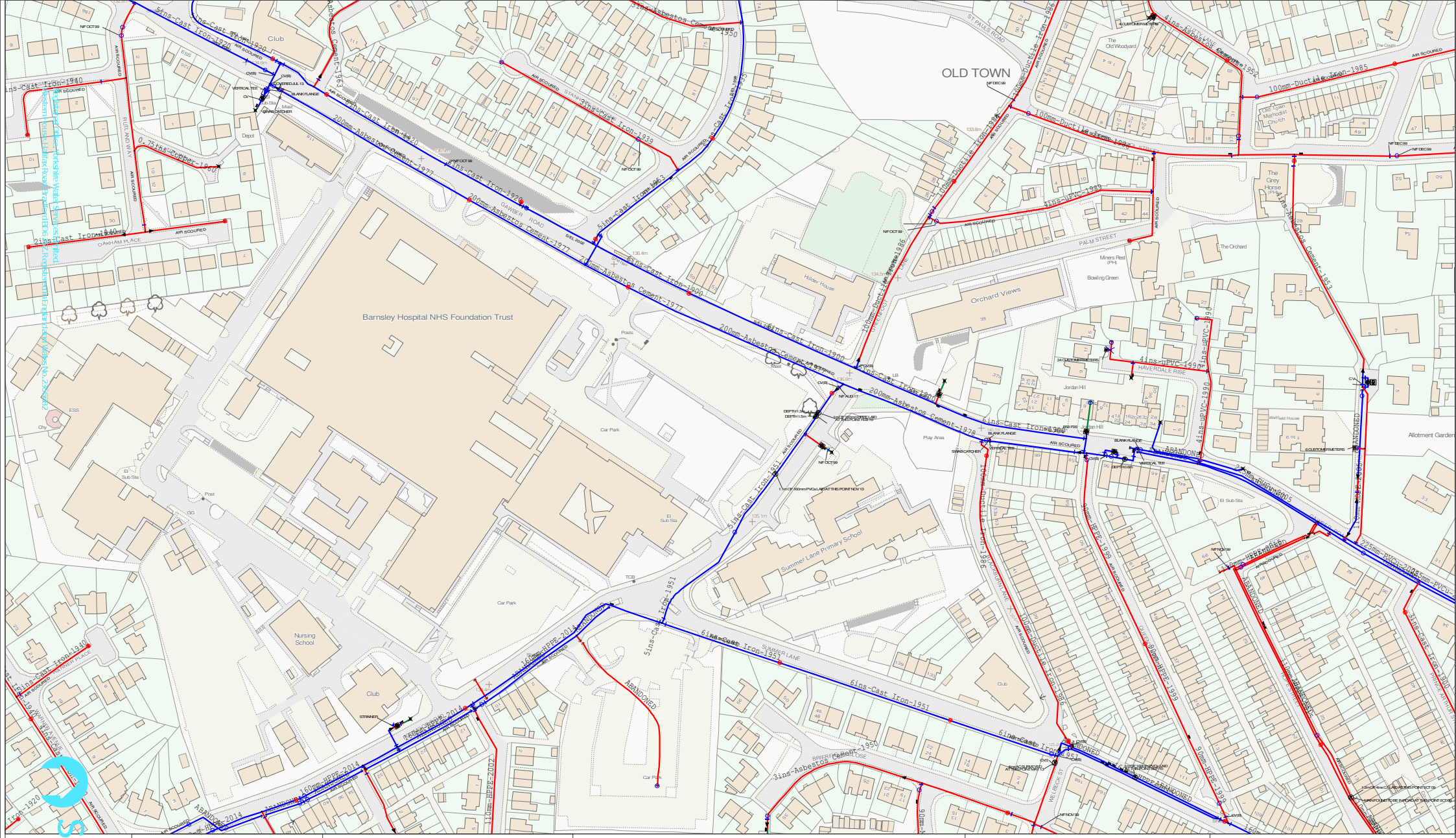
Date Req : 08/06/2018, 13:42:55

Date Gen : 08/06/2018, 13:42:59

Source : Sewer Network Enquiry

UPN: Undefined

Originator: L MULLOCK, Safe-Move, 75 4506



SafeMove
A part of YorkshireWater

432956 : 406747	Map Name : SE3306NW	Title	Partial Key Water mains up to 4" in diameter Water mains over 4" in diameter Raw water mains Private water mains
YorkshireWater Yorkshire Water, PO Box 500, Halifax Road, Bradford BD6 2LZ Contact Name : Search Advisor L MULLOCK Contact Tel : 75 4506		Notes	The position and depths of apparatus shown on this plan are approximate only. The exact positions and depths should be obtained by excavation trial holes.
		(Ody) COPYRIGHT STATEMENTS: Reproduced by permission of Ordnance Survey on behalf of HMSO © Crown copyright and database 2014. All rights reserved Ordnance Survey Licence number 100022432	Scale : 1:2500
			Drg No : / Maris No :
			Date Req : 08/06/2018, 13:43:21 / Date Gen : 08/06/2018, 13:43:24
			Source : Water Network Enquiry

UPN: Undefined Originator: L MULLOCK, Safe-Move, 75 4506

B. Initial Drainage Strategy

B.1 Initial Site Drainage General Arrangement: BPU-MMD-00-XX-DR-D-0001

Geo-Cellular Storage Tank
Required Volume = 135m³
Working Depth = 1m
Minimum Cover = 1.2m

Existing manholes beneath proposed hospital to be abandoned. Structure to be broken down to 1m below groud level, holes to be drilled through base and backfilled with selected fill

Abandoned pipework to be grouted and capped at either end

Vortex Flow Control Chamber
Discharge limited to 25.3l/s

Shallow foul pipe to be constructed above existing diverted pipe

Shallow foul pipe to be constructed above existing diverted pipe

LIGHTCOURT

GAWBER ROAD

Notes

1. Do not scale from this drawing. If in doubt, please ask.
2. All details are preliminary and subject to review.
3. All levels are in metres above ordnance datum
4. All dimensions are in mm unless otherwise noted
5. Existing surface water and foul sewers taken from historical drainage drawings (C B Pearson Son & Partners drawing 90/04). Drainage survey required to establish precise position
6. Depth of drainage assets taken from C B Pearson Son & Partners drawing 894/102. Drainage survey required to assess condition and invert levels of existing assets.
7. SVP and RWP locations shown as indicative only.

Key to symbols

- Proposed Surface Water Sewer
- Proposed Foul Water Sewer
- Existing Surface Water Sewer (Assumed Route)
- Existing Foul Water Sewer (Assumed Route)
- Proposed Foul Sewer Diversion
- Proposed Surface Sewer Diversion
- Abandoned Sewer
- Flow Control Manhole
- Geo-Cellular Storage Tank

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P01	06/07/18	MCS	Preliminary Issue	AJP	IH

MOTT MACDONALD

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150 Arundel Gate
Sheffield
United Kingdom
T +44 (0)191 261 0866
W www.mottmac.com

Client
Race Cottam Associates
3 Vincent House
Solly Street
Sheffield
S1 4BB

Title
Barnsley Hospital CAU/ED
Drainage
Outline General Arrangement

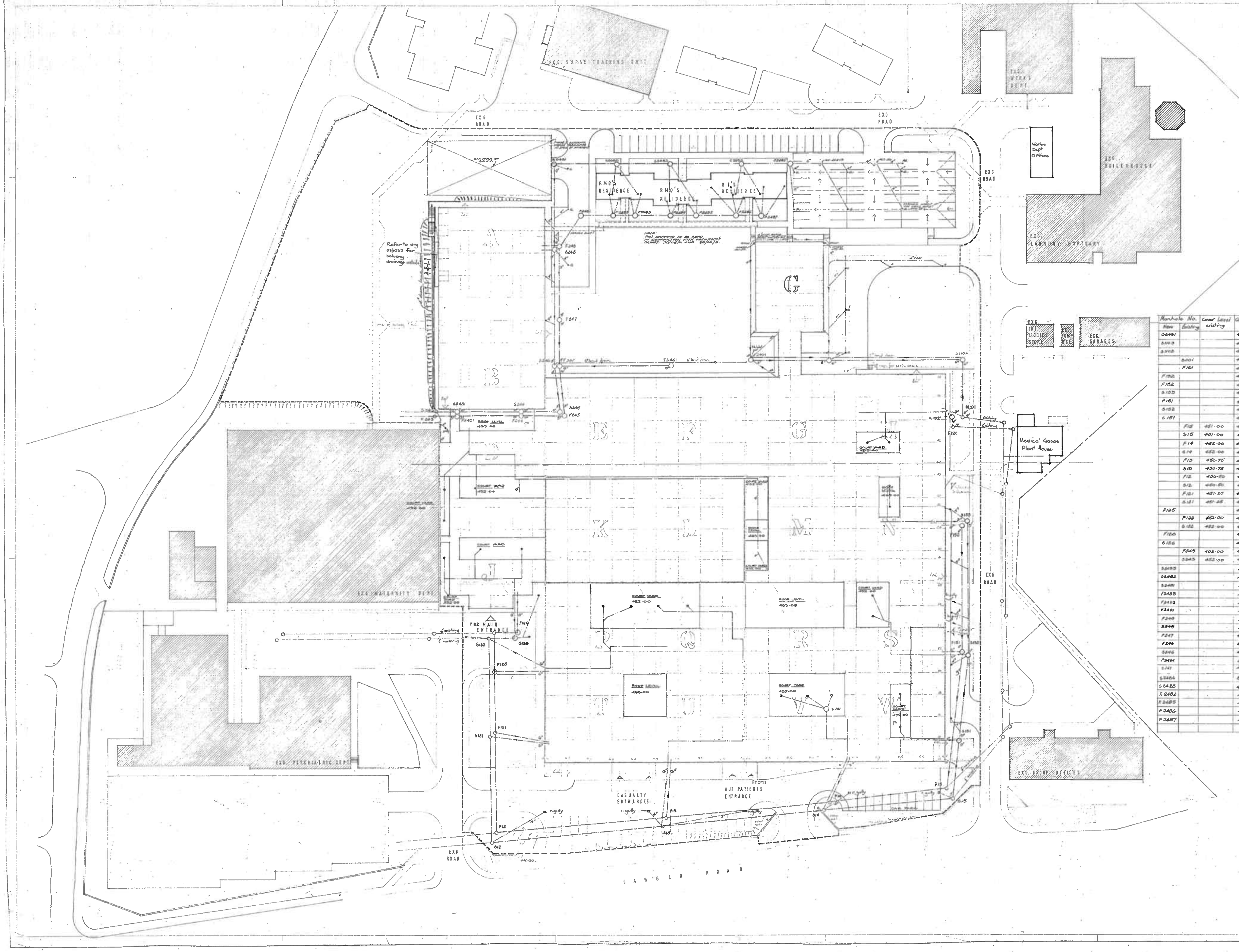
Designed	M Smith	MCS	Eng check	A Precious	AJP
Drawn	M Smith	MCS	Coordination	J Svikis	JS
Dwg check	A Precious	AJP	Approved	I Hurst	IH

Scale at A1	Suitability	Rev
1:200	S2	P01

Drawing Number
BPU-MMD-00-XX-DR-D-0001

C. Historic Site Drainage Survey

C.1 Historic Site Drainage Survey



NOTES

NO DIMENSIONS TO BE SCALED FROM THIS DRAWING.

ALL DIMENSIONS TO BE CHECKED BY THE CONTRACTOR ON THE SITE, AND ANY ERRORS OR DISCREPANCIES TO BE REPORTED TO THE ARCHITECTS.

G. Revision to S.W drainage for ... access road to external bulk stores ... WKB

F. ... Future car park at S.W end of ... block ... footpaths & curb radii adj. to drive. 50/06/D. S.W drainage to car park at S.W end of MO's block amended. Land drains added at S.W end of ... bulk stores. ... 77

E. Drainage revised to RMO's + M.O.'s Blocks. Invert Levels to M.H.'s S2483 + S2482 revised. New M.H.'s S2484 + 5 added. Cover Levels revised in accordance with 50/06/C. Additional S.W. drainage indicated in front of Block J + in adjacent courtyards. 3.1.75. JB

D. ... 3. 02. 73 K.G

C. Surface water drainage from internal courtyards added. Court yard and roof levels added. M/hole ... added to schedule. 4·07·72 K.G.

B. External drainage to Block A amended plus 4" diam land drain. 30.07.71 CAT

A. Repositioning of M.H F124 + S124 23·4·71 JB

Manhole No. New	Manhole No. Existing	Cover Level existing	Cover Level new	Invert Level	
S2461			464·88	460·00	
S1103			462·36	458·00	
S1102			465·81	456·00	Drop connection to MH S101
	S1101		464·83	449·78	
	F101		464·88	446·51	
F192			464·80	453·00	Drop connection to MH F181
F152			451·70	447·00	
S153			451·92	448·66	
F161			451·70	445·50	
S152			451·92	447·66	
S151			451·58	446·96	
	F15	451·00	451·18	443·36	
	S15	451·00	451·58	446·58	
	F14	452·00	451·57	442·20	
	S14	452·00	451·50	444·14	
	F13	450·75	450·80	440·40	
	S13	450·75	450·90	441·77	
	F12	450·60	449·83	438·57	
	S12	450·60	449·33	439·77	
	F121	451·25	451·49	443·00	
	S121	451·25	451·57	445·00	
F125			452·04	445·75	
	F122	452·00	451·57	444·24	
	S122	452·00	451·50	445·89	
F126			451·57	444·60	
S126			451·50	446·25	
	F243	452·00	452·00	438·07	
	S243	452·00	452·00	438·35	
S2483			465·30	461·36	A. Rev.
S2482			464·34	460·42	A. Rev.
S2481			463·50	459·50	A. Rev. (C.L. over)
F2483			465·01	460·43	A. Rev.
F2482			464·88	459·97	A. Rev.
F2481			464·26	459·37	A. Rev.
F248			464·26	458·50	A. Rev. (C.L. over)
S248			464·34	458·50	Drop connection to MH S246
F247			464·83	457·85	Drop connection to MH F246
F246			460·45	454·00	
S246			464·83	454·00	
F2461			464·88	456·50	
S141			451·67	449·70	
S2484			466·91	462·46	A. Rev.
S2485			467·39	463·36	A. Rev.
F2484			465·60	460·98	A. Rev.
F2485			466·04	461·45	A. Rev.
F2486			466·63	462·35	A. Rev.
F2487			467·50	462·95	A. Rev.

ISS	REVISION	DATE	IN

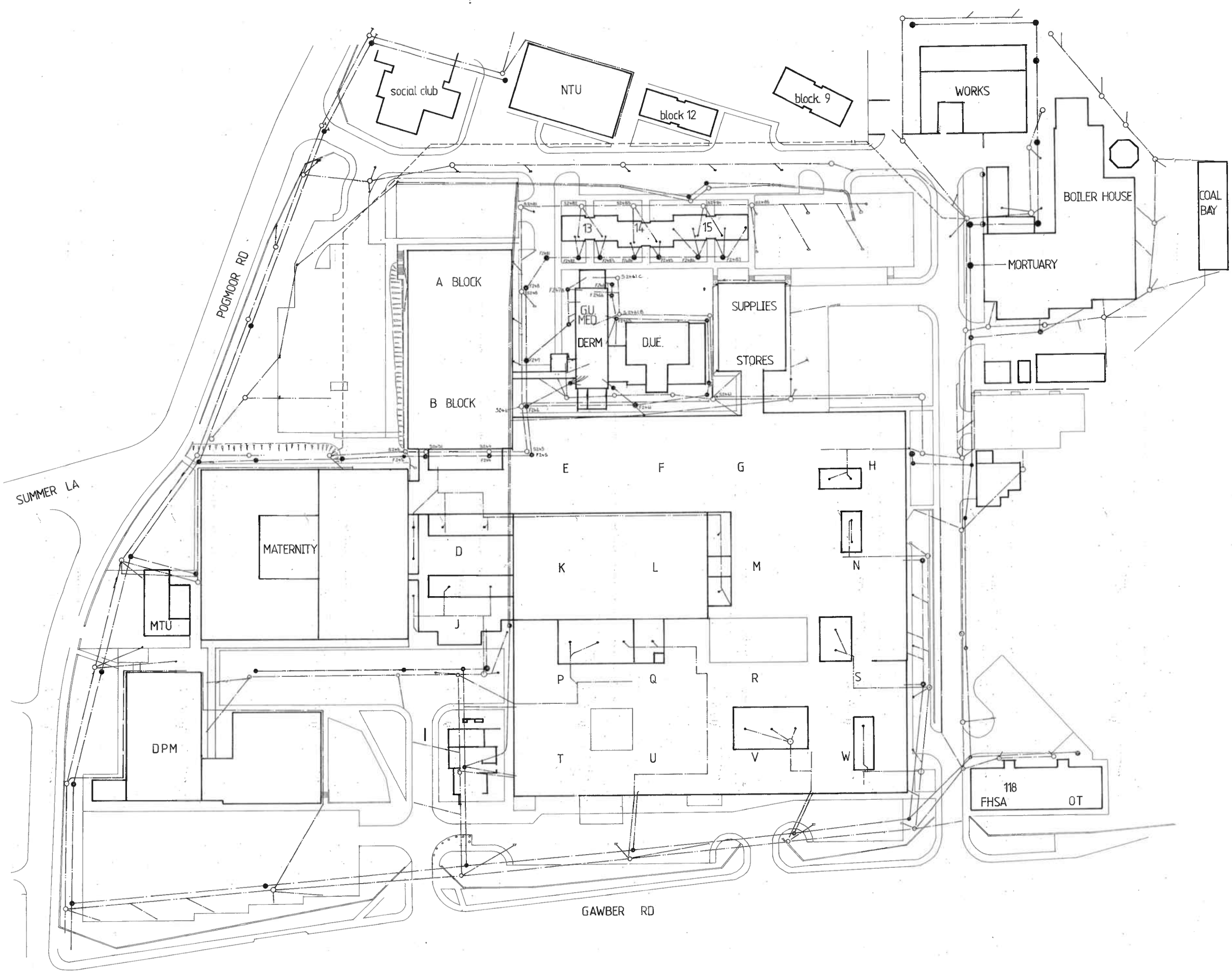
C B PEARSON SON & PARTNERS

SITE PLAN PH. TWO
DRAINAGE LAYOUT

date: December 1970

ALL	50	06	G.

50/06
DRAINAGE LAYOUT.



○ surface water

● foul water

BARNSLEY AREA HEALTH AUTHORITY

Job
DRAINAGE RUNS

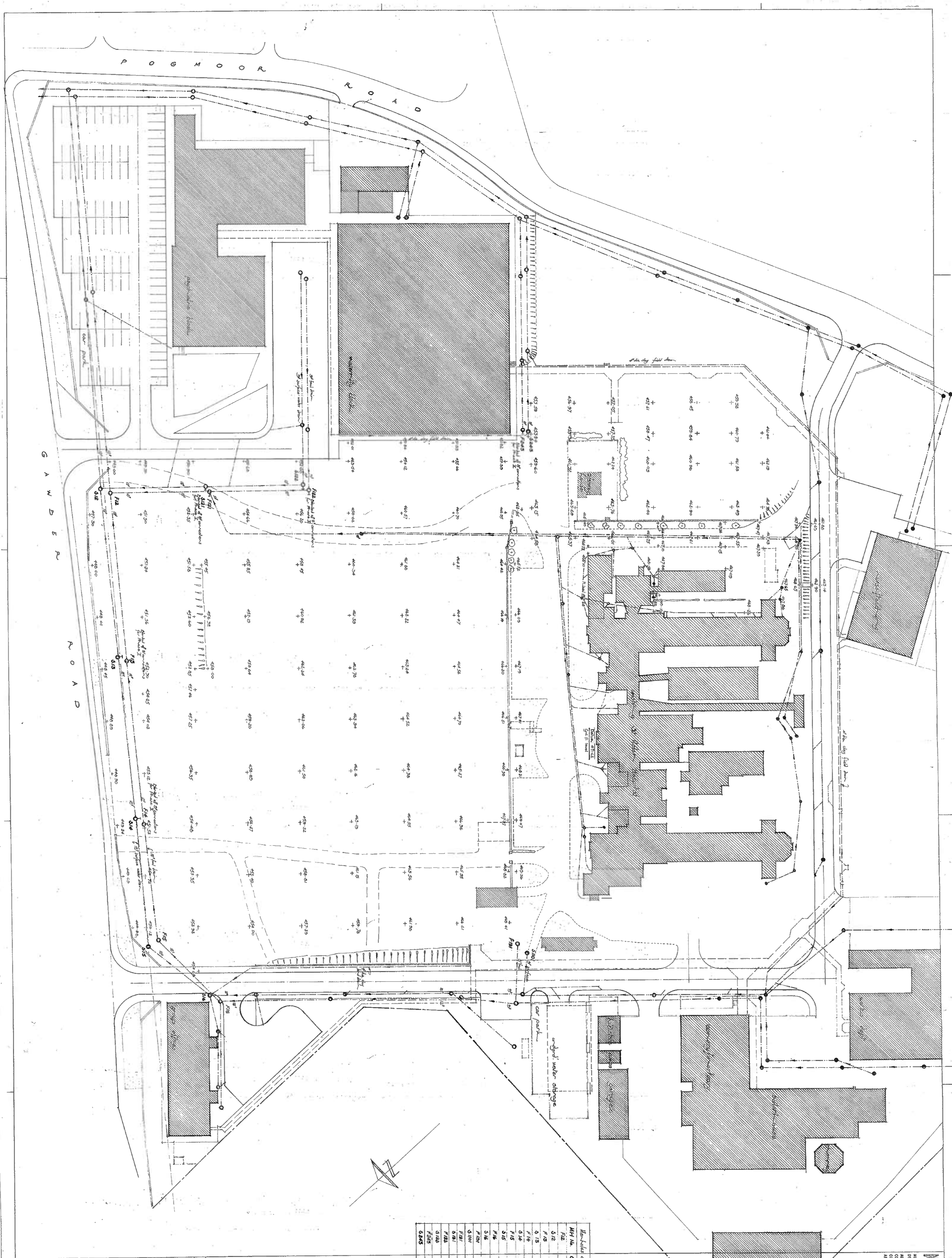
This drawing is to form part of the specification

Location
SITE PLAN
BDGH

Scale	Drawing No
Date	All measurements to be checked on site
Drawn by	

W.Y.D.O.S. Ltd.

R1222



Manholes constructed under Ph. I Contract

MH No.	Cover level	Invert level
F12	450.80	448.57
S12	450.80	449.77
F13	450.76	440.40
S13	450.75	441.77
F14	452.00	443.20
S14	452.00	444.14
F15	451.00	445.56
S15	451.00	446.66
F16	450.80	445.50
S16	450.80	447.00
F191		446.61
S1101		449.78
F181	451.26	448.00
S181	451.25	446.00
F182	452.00	444.24
S182	452.00	446.99
F245	452.00	438.07
S245	452.00	480.35

NOTES

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ISS	REVISION	DATE	IN

C B PEARSON SON & PARTNERS
LANCASTER

job

drawing: SURVEY OF EXISTING DRAINAGE

scale: 1/32" = 1'-0"
drawn: [illegible]
date: Nov. 1970
check:

block	storey	element	serial no	rev
ALL		90	04	

EXISTING DRAINAGE
90/04

M.H. Nº F.	COVER LEVEL	INVERT LEVEL	Approx. depth	REMARKS.	M.H. Type	Cover Type
F.0.	444.50.	435.00.	10½'	Connect to L.A. M.H.	Z	B
F.11	447.25	436.00	11½'		Z	A
F.12	450.50	438.60	12'	Branch drops from [illegible]	Z.	B
F.121	451.25	445.00	6½'		Z	A
F.122	452.00	446.00.	6'		X.	B.
F.123	461.75	446.50	5¼'	Branch from internal	X.	A
F.124	461.75	448.00	3¾'	Branch from internal	X.	A
F.13	452.75	440.40	12¼'		Z.	A
F.14	452.00	442.20	10'		Z	B
F.15	449.50	444.00	5½'		X	B.
F.16	451.16	444.50	6½'		Z	B.
F.161	451.50	449.00	2½'		X	B.
F.17	456.00	445.25	10¾'		Z.	B
F.18	460.00	446.25	13¾'	Main run drops from [illegible] / Branch drops from 453.00	Z	B
F.181	462.00	452.25	10¾		Z	C.
F.182	466.00	455.00	11'		Z	C
F.183	466.50	456.10	10½'		Z	A
F.1831	467.00	462.50	4½'		X.	A.
F.184	466.38	456.50	10'		Z	A
F.185	466.75	458.10	8½'		Z	A
F.186	467.00	459.30	7¾'		Z	A
F.19	465.76.	453.00	12¾		Z	B.
F.191	464.00	453.65	10½'		Z	B
F.192	461.25	454.50	6¾'		Z	A
F.193	464.00	455.70	8½'		Z.	B.
F.194	464.00	456.65	7½'		Z	B
F.195	464.00	457.15	7'		Z	B
F.196	464.00	457.65	6½'		Z	B.
F.197	464.00	458.14	6'		X.	B.
F.198.	469.00	462.75	6¼'	Diversion of existing	Z.	B
F.199	469.00	463.00	6'	Diversion of existing	X.	A.
F.110	470.00	466.13	15'	Main run drops from [illegible]	Z.	B.
F.111	468.35	465.00	3½'		X.	A
F.112	469.00.	466.00	3'		X.	A.
F.113	470.00	467.00	3'		X.	A
F.114	471.00	467.15	4¼'		X	A.
F.115	472.00	469.00	3'		X.	C.
F.21	445.00.	433.75	11¼'		Z.	B
F.22	452.00	434.50	17½'		Z	B.
F.23.	449.00	435.25	13¾'		Z	B.
F.231	448.80	436.00	12'		Z	B.
F.24	448.00	436.25	11¾'	Main run drops from 446.00	Z.	B
F.241	448.00	436.75	11¼'		Z.	B
F.242	448.00	437.75	10¼'		Z	B.
F.2421	455.00	438.50	16½'		Z	B.
F.243	448.00	438.00	10'		Z	B
F.25	455.00	447.50	7½'		Z	B.
F.26	460.00	451.00	9'		Z	B.
F.27	462.30	453.80	8½'		Z	A
F.28.	463.69	454.60	9'		Z	A.

MANHOLES.

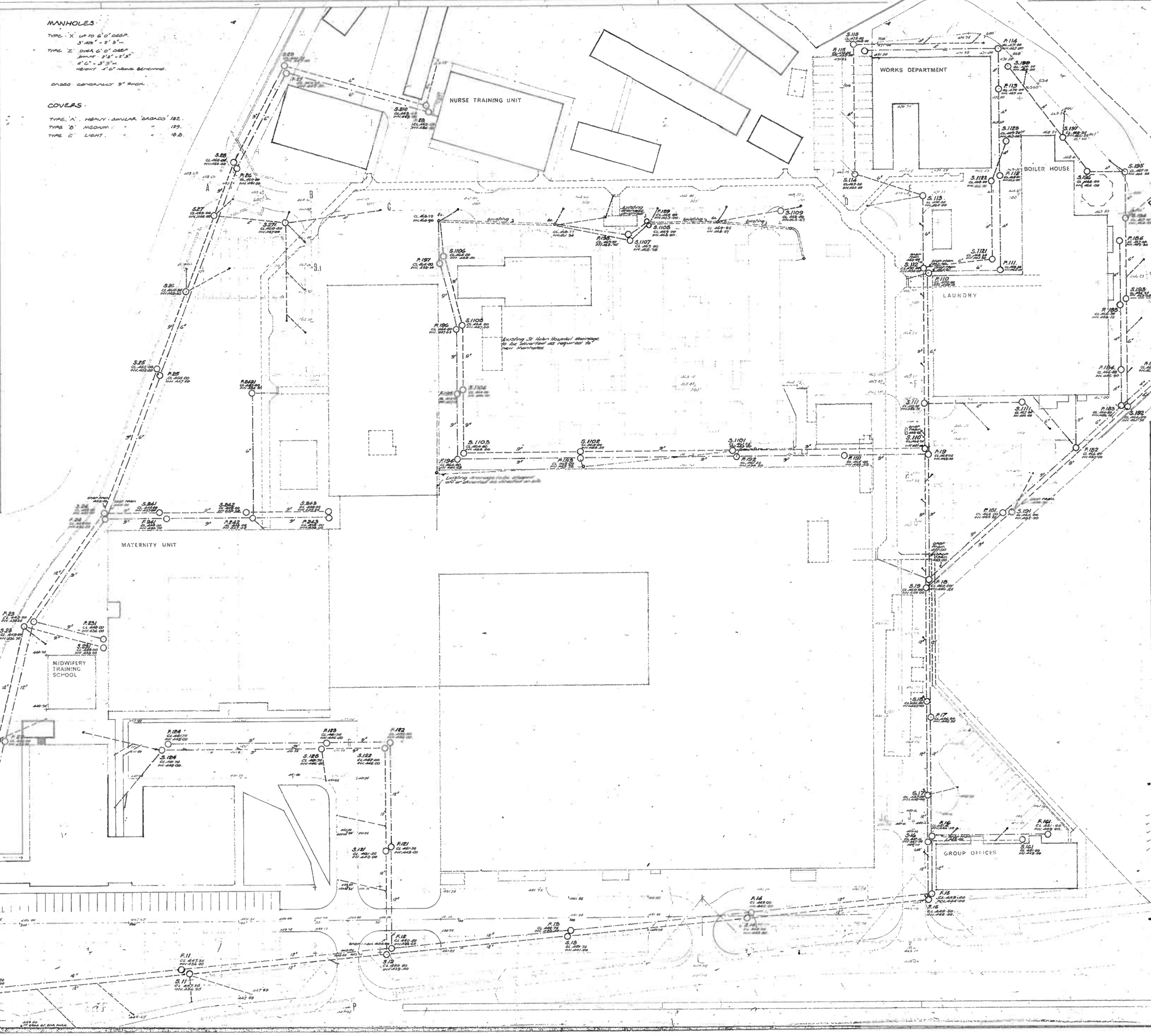
TYPE 'X' UP TO 6'0" DEEP.
3'4½" × 2'3" W.

TYPE 'Z' OVER 6'0" DEEP.
SHAFT - 2'3" × 2'3".
4'6" × 3'9" W.
HEIGHT 4'6" ABOVE BENCHING.

BASES GENERALLY 9" THICK.

COVERS.

TYPE 'A'. HEAVY. SIMILAR 'BROADS' 182.
TYPE 'B' MEDIUM. " " 129.
TYPE 'C' LIGHT. " " 10.B.



NOTES

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M.H. Nº S.	COVER LEVEL	INVERT LEVEL	Approx. depth	REMARKS	M.H. Type	Cover Type
S.0.	444.50	434.60.	10'	Connect to L.A. M.H.	Z	B.
S.11	447.25	436.50	11¼'		Z.	A
S.12	450.60	439.40	11'	Branch drops from 444.60	Z.	B.
S.121	451.25	445.60	5¾'		Z	B
S.122	452.00	446.00	6'		X.	B.
S.123	461.75	446.60	5¼'	Branch from internal	X.	A.
S.124	461.75	448.00	3¾'	Branch from internal	X.	A
S.13	452.75	441.50	11¼'		Z	A
S.14	452.00	443.80	8'		Z	B.
S.15	449.50	446.00	3½'		X.	B.
S.16	451.16	447.00	4'		X.	B.
S.161	451.50	449.00	2½'		X.	B.
S.17.	452.00	448.00	4'		X.	B.
S.18.	456.50	449.00	7½'		Z.	B
S.19	460.00	450.00	10'	Branch drops from 456.00	Z	B.
S.191	466.00	458.00	7'		Z	C.
S.192	466.00	461.75	4¼'		X.	A
S.193	466.75	463.25	3½'		X.	A.
S.1931	467.00	465.00	2'		X.	A.
S.194	467.00	464.25	2¾'		X.	A
S.195	467.10	465.25	2'		X.	A.
S.196	468.00	466.00	2'		X	A
S.197	468.26	466.25	2'		X.	A
S.198	470.25	468.50	1¾'		X.	A
S.110	465.75	451.00	14¾'	Main run drops from 453.25	Z.	A
S.1101	461.25	453.00	8¼'		Z.	A
S.1102	464.00	464.50	9½'		Z.	B.
S.1103	464.00	455.50	8½'		Z	B.
S.1104	464.00	456.50	7½'		Z.	B.
S.1105	464.00	457.50	6½'		Z.	B.
S.1106	464.00	458.60	5½'		X.	B
S.1107	469.00	462.75	6¼'		Z.	B.
S.1108	469.00	463.00	6'		X.	A
S.1109	468.50	464.67	4'		X.	B.
S.111	467.25	453.75	13½'		Z.	B.
S.1111	467.00	456.00	11'		Z.	A
S.112	470.00	455.00	15'	Branch drops from 465.00	Z.	B.
S.1121	468.36	464.00	4½'		X.	A
S.1122	469.00	466.00	3'		X	A.
S.1123	469.25	467.00	2¼'		X.	A.
S.21	445.00	435.25	9¾'		Z	B.
S.22	452.00	436.00	16'		Z.	B.
S.23	449.00	436.75	12¼'		Z	B.
S.231.	448.00	436.00	12'		Z	B.
S.24.	448.00	437.50	10½'	Main run drops from 448.00	Z.	B
S.241.	448.00.	437.95	10'		Z.	B.
S.242.	448.00	438.60	9½'		Z	B
S.243.	448.00	439.25	8¾'		Z	B.
S.25.	455.00	452.00	3'		X.	B.
S.26	460.25	453.50	6¾'		Z	A
S.27.	459.00	455.00	4'		X	B.
S.271.	460.50	457.00	3½'		X	B.
S.28.	460.00	455.50	4½'		X.	B.
S.29.	462.30	458.00	4¼'		X.	A.
S.210.	463.69	459.00	4½'		X.	A.
S.118.	470.25	466.00	4¼'		X	A
S.114	469.25	466.00	3¼'		X	A
S.115	472.00	468.00	4'		X	C

AMENDMENTS - 16.FEB.66. WKB
TO COVER LEVELS - S.231, S.24, S.241, S.242, S.243, & F.231, F.24, F.241, F.242, F.243, S.13, F.13.
TO INVERTS - F.183, F.184, F.185, F.186

ISS	REVISION	DATE

C B PEARSON SON & PARTNERS

BARNSLEY
DEVELOPMENT OF THE
ST. HELEN HOSPITAL

SITE LAYOUT
FOUL & SURFACE WATER EXTERNAL DRAINAGE.

scale	drawn
32' TO 1"	WKB.
date	checked

job no	sheet	drg no
894	1 o 2	IVD EXT.5

B 000 2

D. Source Control Results

D.1 Source Control Take Off

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	133.656	0.356	24.8	48.1	O K
30 min Summer	133.724	0.424	25.2	57.2	O K
60 min Summer	133.754	0.454	25.2	61.3	O K
120 min Summer	133.720	0.420	25.1	56.7	O K
180 min Summer	133.665	0.365	24.8	49.3	O K
240 min Summer	133.614	0.314	24.3	42.4	O K
360 min Summer	133.542	0.242	23.2	32.7	O K
480 min Summer	133.506	0.206	21.0	27.8	O K
600 min Summer	133.484	0.184	18.5	24.9	O K
720 min Summer	133.469	0.169	16.6	22.7	O K
960 min Summer	133.448	0.148	13.7	20.0	O K
1440 min Summer	133.424	0.124	10.3	16.7	O K
2160 min Summer	133.403	0.103	7.6	14.0	O K
2880 min Summer	133.391	0.091	6.1	12.3	O K
4320 min Summer	133.377	0.077	4.4	10.3	O K
5760 min Summer	133.368	0.068	3.5	9.1	O K
7200 min Summer	133.362	0.062	3.0	8.3	O K
8640 min Summer	133.357	0.057	2.6	7.7	O K
10080 min Summer	133.354	0.054	2.3	7.2	O K
15 min Winter	133.705	0.405	25.1	54.6	O K
30 min Winter	133.779	0.479	25.3	64.6	O K
60 min Winter	133.801	0.501	25.3	67.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	125.869	0.0	61.1	15
30 min Summer	84.215	0.0	81.9	24
60 min Summer	53.779	0.0	104.8	42
120 min Summer	33.180	0.0	129.3	76
180 min Summer	24.659	0.0	144.2	108
240 min Summer	19.841	0.0	154.7	138
360 min Summer	14.545	0.0	170.1	196
480 min Summer	11.669	0.0	181.9	254
600 min Summer	9.828	0.0	191.5	314
720 min Summer	8.537	0.0	199.6	372
960 min Summer	6.830	0.0	212.9	492
1440 min Summer	4.978	0.0	232.7	736
2160 min Summer	3.621	0.0	254.1	1100
2880 min Summer	2.885	0.0	270.0	1468
4320 min Summer	2.092	0.0	293.4	2200
5760 min Summer	1.663	0.0	311.2	2936
7200 min Summer	1.391	0.0	325.3	3640
8640 min Summer	1.201	0.0	337.3	4352
10080 min Summer	1.063	0.0	347.9	5096
15 min Winter	125.869	0.0	68.5	16
30 min Winter	84.215	0.0	91.7	26
60 min Winter	53.779	0.0	117.4	46

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
120 min Winter	133.732	0.432	25.2	58.3	O K
180 min Winter	133.645	0.345	24.7	46.6	O K
240 min Winter	133.575	0.275	23.8	37.1	O K
360 min Winter	133.503	0.203	20.7	27.4	O K
480 min Winter	133.473	0.173	17.2	23.4	O K
600 min Winter	133.455	0.155	14.7	20.9	O K
720 min Winter	133.442	0.142	12.8	19.1	O K
960 min Winter	133.424	0.124	10.3	16.7	O K
1440 min Winter	133.403	0.103	7.6	14.0	O K
2160 min Winter	133.387	0.087	5.6	11.7	O K
2880 min Winter	133.377	0.077	4.4	10.3	O K
4320 min Winter	133.365	0.065	3.2	8.7	O K
5760 min Winter	133.357	0.057	2.6	7.7	O K
7200 min Winter	133.352	0.052	2.2	7.0	O K
8640 min Winter	133.348	0.048	1.9	6.5	O K
10080 min Winter	133.345	0.045	1.6	6.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
120 min Winter	33.180	0.0	144.8	82
180 min Winter	24.659	0.0	161.5	114
240 min Winter	19.841	0.0	173.2	142
360 min Winter	14.545	0.0	190.5	198
480 min Winter	11.669	0.0	203.8	256
600 min Winter	9.828	0.0	214.5	314
720 min Winter	8.537	0.0	223.6	376
960 min Winter	6.830	0.0	238.5	498
1440 min Winter	4.978	0.0	260.7	736
2160 min Winter	3.621	0.0	284.6	1100
2880 min Winter	2.885	0.0	302.4	1456
4320 min Winter	2.092	0.0	328.7	2192
5760 min Winter	1.663	0.0	348.5	2888
7200 min Winter	1.391	0.0	364.4	3624
8640 min Winter	1.201	0.0	377.8	4336
10080 min Winter	1.063	0.0	389.7	4984

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	19.000	Shortest Storm (mins)	15
Ratio R	0.360	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.260

Time (mins) From:	To:	Area (ha)
0	4	0.260

Model Details

Storage is Online Cover Level (m) 135.000

Tank or Pond Structure

Invert Level (m) 133.300

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	135.0	0.500	135.0	0.501	0.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0210-2530-1700-2530
Design Head (m)	1.700
Design Flow (l/s)	25.3
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	210
Invert Level (m)	133.300
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1800

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.700	25.3	Kick-Flo®	1.100	20.5
Flush-Flo™	0.503	25.3	Mean Flow over Head Range	-	21.9

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	7.2	1.200	21.4	3.000	33.2	7.000	50.0
0.200	20.3	1.400	23.0	3.500	35.8	7.500	51.7
0.300	24.2	1.600	24.6	4.000	38.1	8.000	53.3
0.400	25.1	1.800	26.0	4.500	40.4	8.500	54.9
0.500	25.3	2.000	27.3	5.000	42.5	9.000	56.5
0.600	25.2	2.200	28.6	5.500	44.5	9.500	58.0
0.800	24.4	2.400	29.8	6.000	46.4		
1.000	22.5	2.600	31.0	6.500	48.2		