



Sustainable Drainage System Strategy

Site Address

Land at Bollands Hill
Seend
Wiltshire
SN12 6NQ

Client

Marc Adams
MG Adams Plumbing & Heating Ltd

Report Reference

SWDS – 2025 – 000036

Prepared By

STM Environmental Consultants Ltd

Date

27/11/2025



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1 Document Control

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2 Abbreviations

Abbreviation	Description
STM	STM Environmental Consultants Limited
BGS	British Geological Survey
EA	Environment Agency
OS	Ordnance Survey of Great Britain
FRA	Flood Risk Assessment
NPPF	National Planning Policy Framework
FWD	Floodline Warning Direct
FRMS	Flood Risk Management Strategy
LLFA	Lead Local Flood Authority
SWMP	Surface Water Management Plan
SFRA	Strategic Flood Risk Assessment
CDA	Critical Drainage Area
SuDS	Sustainable Drainage Systems
GWSPZ	Groundwater Source Protection Zone

3 Disclaimer

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4 Executive Summary

BACKGROUND			
Location	Land at Bollands Hill, Seend, Wiltshire, SN12 6NQ Grid reference: 393922, 161322		
Site Area	8,458m ²		
Proposed Development	Rough stone track through a private field with the erection of a timber slatted agricultural barn.		
Current Site and Surrounding Uses	The site is currently a private field located along Bollands Hill, which is formed from a mixture of field, residential and educational land uses.		
Topography	58.43mAOD (north) to 83.94mAOD (southeast).		
Hydrology	No statutory main rivers were identified within 250m of the site. The Kennet Avon Canal is located approximately 70m north of the site.		
Geology	The superficial deposits consist of Head (Unlithified Clay, Silt, Sand and Gravel) while the bedrock geology consists of Lower Greensand Group (Sandstone), Newton Clay Member (Mudstone, Sandy) and Hazelbury Bryan Formation (Sandstone).		
Source Protection Zone	The site is not located within a Source Protection Zone.		
Hydrogeology	The site is situated upon an Secondary (undifferentiated) superficial and Unproductive and Secondary A bedrock aquifers.		
Permeability	BGS information indicates that the superficial deposits have highly variable permeability and the bedrock is classified as free draining (Sandstone) and poorly draining (Mudstone).		
Infiltration Potential	On site infiltration testing was completed in 6no trial pit locations across the site. The infiltration testing was variable and was undertaken in part accordance with the BRE 365 DG methodology. The infiltration rates, ascertained from the first drainage cycle within in each test location, ranged from 2.58×10^{-5} to 6.94×10^{-6} m/s.		
Fluvial Flood Risk	Low – The site is located within Flood Zone 1.		
Surface Water Flood Risk	Low - The site is at 'Low' risk of witnessing flood depths of less than 0.2m during the Climate Change (2040 – 2060) modelled event.		
Groundwater Flood Risk	Low - There is limited potential for groundwater flooding to occur and the groundwater depth ranges between less than 3mgbI (north) and greater than 5mgbI (south).		
Existing and Proposed Site Layout	Ground Cover	Existing (m ²)	Proposed (m ²)
	Buildings	0	262
	Driveways/Patio	0	1,714 (1,555 = Track)
	Gardens / Soft landscaping	8,458	6,482
	Total Impermeable Area	0	421
Changes in Impermeable	Without SuDS, the proposed development would increase the impermeable area of the site and therefore increase the post development runoff rate and volume. The rough track forms a large proportion of the development all of which will be designed to be permeable.		

PROPOSED SUDS			
Run-Off Rates	IH24 Greenfield (GF) (l/s)	MRM Pre-Development Without SuDS (l/s)	MRM Post-Development Without SuDS (l/s)
Qbar	3.0		
1 in 1	8.3	2.2	0.50
1 in 30	11.1	5.8	1.30
1 in 100	3.0	7.2	1.60
Requirement	The proposal must ensure no increase in local flood risk and no stormwater discharges onto the highway.		
Drainage Hierarchy	All stormwater will be intercepted onsite and will discharge to ground.		
Storage	The proposal provides a minimum of 137m ³ of dedicated stormwater storage.		
SuDS Strategy	The drainage strategy has been developed to reflect the existing natural drainage conditions as closely as is practicable. Although infiltration potential varies across the site, testing confirms that infiltration is viable, and therefore a site-wide retention and infiltration approach will be adopted. Blue-green SuDS features will collect and attenuate stormwater onsite, with a permeable track and adjoining swale forming the primary conveyance route to prevent runoff leaving the site or discharging onto the highway. Given the 9.5% slope along sections of the track, a thick permeable sub-base supported by baffles at 7–10m intervals will control sub-surface flows, enabling water to infiltrate into the underlying geology. To further manage variable ground conditions and potential offsite overland flow, the track will be supported by filtration strips/swales which will receive flows from sub-base outlets, providing linear infiltration capacity and improved water quality treatment. Surface water draining from the proposed barn will be directed to bio-retention areas, where it will be stored, treated, and allowed to infiltrate to ground, ensuring that runoff remains contained within the site.		
Conclusion	With the proposed SuDS mitigation measures, which have been outlined in this report, we believe that the proposed development will reduce local flood risk and therefore be in compliance with the LLFA's current planning policy and the NPPF.		

5 Introduction

STM Environmental Consultants Limited have been appointed by Marc Adams of MG Adams Plumbing & Heating Ltd to undertake a Sustainable Drainage System (SuDS) Strategy for a proposed development at Land at Bollands Hill, Seend, Wiltshire, SN12 6NQ.

5.1 Proposed Development

The SuDS report is required to support a planning application (Reference: PL/2024/07323) for a rough stone track through a private field with the erection of a timber slatted agricultural barn.

The planning condition states as follows:

Condition 9. No development shall commence on site until a detailed surface water drainage strategy has been submitted to and approved in writing by the Local Planning Authority that:

- 1) demonstrating that there is no increase in local flood risk because of the development; and
- 2) including details of how runoff from the proposed tracks will be prevented from entering the public highway.

The development shall not be first brought into use until surface water drainage has been constructed in accordance with the approved scheme.

REASON: To ensure that the development can be adequately drained.

Condition 10. The proposed development shall not be first brought into use until works have been implemented to avoid surface water from entering the highway.

REASON: To ensure that the highway is not inundated with surface water.

Copies of the development plans are presented in [Appendix 1](#).

5.2 Report Aims and Objectives

This report sets out the drainage strategy that will be employed in the designs to meet the requirements of the planning condition.

5.3 Legislative and Policy Context

5.3.1 Legislative Context

Section H3 of the Building Regulations 2010 requires that adequate provision is made for rainwater to be carried from the building roofs and paved areas, and be preferentially discharged to soakaways or some other adequate infiltration system. Where that is not reasonably practicable, a watercourse; or sewer can be used.

The Flood and Water Management Act was introduced in 2010. The Act defines the role of lead local flood authority (LLFA) for an area. All LLFA are required to develop, maintain, apply and monitor a strategy for local flood risk management in its area, called “local flood risk management strategy”.

Alongside the Act, Flood Risk Regulations (2009) outline the roles and responsibilities of the various authorities, which include preparing Flood Risk Management Plans and identifying how significant flood risks are to be mitigated.

5.3.2 Policy Context

The National Planning Policy Framework (NPPF) sets out the Government's economic, environmental and social planning policies for England. The policies set out in this framework apply to the preparation of local and neighbourhood plans and to decisions on planning applications.

The latest version of the NPPF can be view online [here](#).

Applications which could affect drainage on or around the site should incorporate sustainable drainage systems to control flow rates and reduce volumes of runoff, and which are proportionate to the nature and scale of the proposal. These should provide

multifunctional benefits wherever possible, through facilitating improvements in water quality and biodiversity, as well as benefits for amenity. Sustainable drainage systems provided as part of proposals for major development should:

-  a) take account of advice from the Lead Local Flood Authority;
-  b) have appropriate proposed minimum operational standards; and
-  c) have maintenance arrangements in place to ensure an acceptable standard of operation for the lifetime of the development.

A major development is defined as:

-  a residential development: 10 dwellings or more or residential development with a site area of 0.5 hectares or more where the number of dwellings is not yet known;
-  a non-residential development: provision of a building or buildings where the total floor space to be created is 1000 square metres or more or where the floor area is not yet known, a site area of 1 hectare or more.

Footnote 62 - This includes householder development, small non-residential extensions (with a footprint of less than 250m²) and changes of use; except for changes of use to a caravan, camping or chalet site, or to a mobile home or park home site, where the sequential and exception tests should be applied as appropriate.

Footnote 63 - A site-specific flood risk assessment should be provided for all development in Flood Zones 2 and 3. In Flood Zone 1, an assessment should accompany all proposals involving: sites of 1 hectare or more; land which has been identified by the Environment Agency as having critical drainage problems; land identified in a strategic flood risk assessment as being at increased flood risk in future; or land that may be subject to other sources of flooding, where its development would introduce a more vulnerable use.

Footnote 64 - As required by the Marine and Coastal Access Act 2009.

5.4 Wiltshire Council

Core Policy 67

Flood Risk

Development proposed in Flood Zones 2 and 3 as identified within the Strategic Flood Risk Assessment will need to refer to the Strategic Housing Land Availability Assessment when providing evidence to the local planning authority in order to apply

the sequential test in line with the requirements of national policy and established best practice.

All new development will include measures to reduce the rate of rainwater run-off and improve rainwater infiltration to soil and ground (sustainable urban drainage) unless site or environmental conditions make these measures unsuitable.

6 Site Characteristics

6.1 Location and Area

The site is centred at national grid reference 393922, 161322 and has an area of 8,458m² within the redline boundary.

It falls within the jurisdiction of Wiltshire Council (WC) in terms of the planning consultation process on flood risk and surface water management. The LLFA is also WC.

Figure 1 provides the site location map and aerial imagery.

6.2 Current Site and Surrounding Uses

The site is currently a private field located along Bollands Hill, which is formed from a mixture of field, residential and educational land uses.

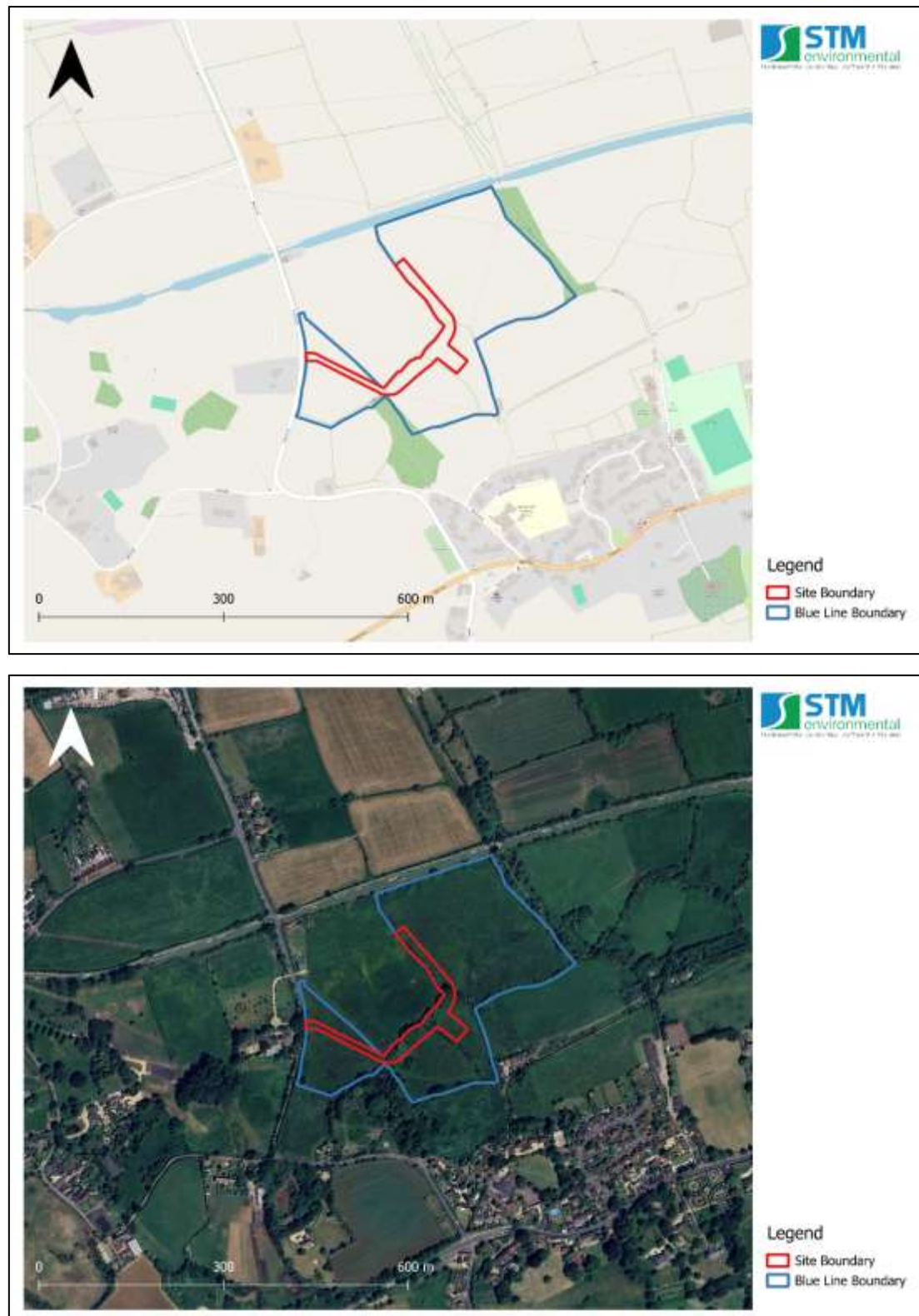


Figure 1 Site location map and aerial photo

6.3 Site Topography

The mapping provided in [Appendix 2](#) shows the 1m LiDAR DTM(2022) ground elevations within the site. A topographical survey was not available.

The redline boundary is an irregular shape. It forms a “U” shape, which is orientated towards the northwest and situated upon a north-facing slope.



Figure 2 LiDAR DTM Topography within the red line boundary

The site is accessed via Bollands Hill. Bollands Hill forms a long straight roadway which follows the aforementioned north-facing slope towards the Kennet Avon Canal and the A365.

The northwest of the site adjoins to Bollands Hill at a low of 66mAOD, at which point Bollands Hill (Road) is at a gradient of approximately 20%. As such, any flow routes out of the entranceway must be prevented to ensure no highways flooding occurs during or post development.

Traversing into the site, along the proposed track, the ground level rises from 66mAOD to a high of 83mAOD in the position of the proposed barn. The track leading to the proposed barn has an average slope of 9.6%.

Continuing along the proposed track, the ground level decreases to 58mAOD at the site of the proposed cesspit.

Overall, the site lies across a band of higher topography to the south, which ranges between 71m and 99m, and a band of lower topography to the north, which ranges between 43m and 71m. The area to the south forms an elongated hill stretching from southwest to northeast, with the site lying on the northwestern face of the hill.

In the wider area, the topography increases from a low of 44mAOD, towards Parsley Cottage to the northwest of the site on the other side of the canal, to a high of 99mAOD, towards Hill View to the south of the site on the other side of Seend Hill.



Figure 3 LIDAR DTM Topography within the wider area

6.4 Geological and Hydrogeological Summary

6.4.1 Nearby Boreholes

There are no records of groundwater being encountered in any nearby boreholes.

6.5 Hydrological Setting

The site is located in Flood Zone 1 with no statutory main rivers identified within 250m of the site.

It should be noted that the Kennet Avon Canal is located immediately adjacent to the north blueline boundary, which is approximately 70m north of the redline boundary.

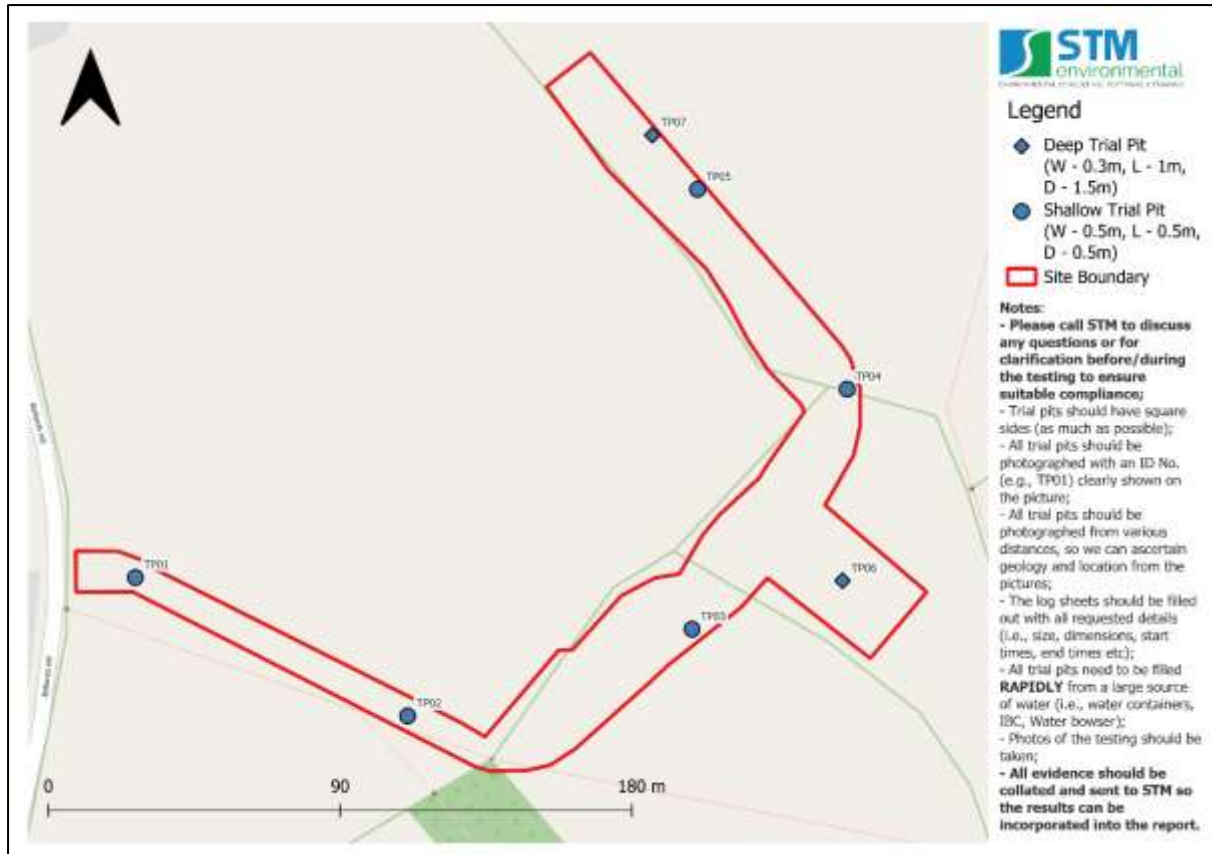
6.6 Site Investigation Summary

The ground investigation works were carried out by Marc Adams on the October 18th and 19th as well as November 8th.

3no. shallow and 2no. deep trial pits were excavated to a maximum depth of 0.5mbgl and 1.5mbgl, respectively, for the purpose of undertaking infiltration testing in general accordance with the BRE 365 DG methodology.

Testing was not undertaken in TP01 and TP04.

TP03 was the only trial pit to be completed in full accordance with the BRE 365 methodology. Nevertheless, infiltration rates were calculated from the first drainage cycles completed within the rest of the site to infer the drainage characteristics.



6.6.1 Geological Findings

Table 1 Summary of geology encountered onsite

Trial Pit	Geology Encountered
02	Sand / Clay
03	Sand
05	N/A
06	Clay
07	Mudstone

6.6.2 Infiltration Testing

Table 2 Summary of infiltration rates achieved onsite

Trial Pit	Infiltration Rate (m/hr)	Infiltration Rate (m/s)
02	0.05	1.26×10^{-5}
03*	0.1	1.46×10^{-4}
05	0.03	6.94×10^{-6}
06	0.05	5.09×10^{-4}
07	N/A	N/A

*Undertaken following BRE 365 DG guidance – three full drainage cycles were completed.

6.7 Flood Risk Summary

The overall flood risk to the site is considered to be 'Low'. No main source of flood risk to the development site was identified.

6.7.1 Fluvial – Rivers and Sea

As the site is located within Flood Zone 1, the risk of fluvial flooding is considered to be 'Low'.

6.7.2 Pluvial – Precipitation Events

As the site is at 'Low' risk of witnessing flood depths of less than 0.2m during the Climate Change (2040 – 2060) modelled pluvial event, the risk of pluvial flooding is considered to be 'Low'.

6.7.3 Groundwater

Given that there is limited potential for groundwater flooding to occur and the groundwater depth ranges between less than 3mgb (north) and greater than 5mgb (south), the risk of groundwater flooding is considered to be 'Low'.

6.7.4 Artificial – Canals Reservoirs

The EA indicates that 'Flooding from reservoirs is unlikely in this area'. The LLFA indicates that 'the risk of reservoir flooding is extremely low'. The flood risk maps area available in [Appendix 3](#).

6.8 Existing Surface Water Drainage Features

No stormwater or foul water sewers are available within the vicinity of the site.

6.8.1 Highways drainage

No private site drainage should discharge onto the highways or into their drainage system.

7 Hydrological Run-off Assessment

To minimise the impact of the new development on local flood risk, the NPPF requires that the water drainage arrangements for any development site are that the volumes and peak flow rates leaving the site post-development are improved upon those of the existing conditions. The following run-off assessment predicts the Greenfield, pre- and post-development run-off rates and provides the required SuDS necessary for complying with the relevant planning policies.

7.1 Existing and Proposed Ground Cover

Table 3 Breakdown of Ground Cover in the Proposed Development (without SuDS)

Ground Cover	Existing Development Area		Proposed Development Area		Difference (m ²)
	m ²	%	m ²	%	
Buildings	0	0.0	262	3.1	262
Impermeable Landscaping	0	0.0	1,714	20.3	1,714
Permeable Landscaping	8,458	100.0	6,482	76.6	-1,976
Total	8,458	100	8,458	100	

The proposed development increases the existing impermeable area of the site by 23% to 1,976m² when including the formation of the new rough stone track.

The rough stone track has a total area of 1,555m² and will be designed to be entirely permeable with a permeable aggregate subbase and direct contact to the underlying sub-grade material.

Table 4 Breakdown of Ground Cover in the Proposed Development (with SuDS)

Ground Cover	Existing Development Area		Proposed Development Area		Difference (m ²)
	m ²	%	m ²	%	
Buildings	0	0.0	262	3.1	262
Hard Standing	0	0.0	159	1.9	159
Soft landscaping	8,458	100.0	8,037	95.0	-421
Total	8,458	100	8,458	100	

Table 5 Summary of Permeable and Impermeable Areas

	Impermeable Area		Permeable Area		Total Area
	m ²	%	m ²	%	m ²
Existing Site	0	0.0	8,458	100.0	8,458
Proposed Site	421	5.0	8,037	95.0	8,458
Difference	421	5.0	-421	-5.0	

When taking this into account, the proposal development only has a minor impact on the total positive catchment area. The proposed development increases the total impermeable area of the site by 421m² when taking into account the hardstanding at the entrance and around the cesspit.

The increase in stormwater from the proposed hardstanding and potential exceedance runoff from the rough stone track roadway will be dealt with via SuDS.

7.2 Peak Flow Control

With regard to peak flow control, the non-statutory technical standards for sustainable drainage systems state that:

-  S2 For greenfield developments, the peak runoff rate from the development to any highway drain, sewer or surface water body for the 1 in 1 year rainfall event and the 1 in 100 year rainfall event should never exceed the peak greenfield runoff rate for the same event.

7.3 Volume Control Requirements

With regard to volume control, the non-statutory technical standards for sustainable drainage systems state that:

-  S4 Where reasonably practicable, for greenfield development, the runoff volume from the development to any highway drain, sewer or surface water body in the 1 in 100 year, 6 hour rainfall event should never exceed the greenfield runoff volume for the same event.
-  S6 Where it is not reasonably practicable to constrain the volume of runoff to any drain, sewer or surface water body in accordance with S4 or S5 above, the runoff volume must be discharged at a rate that does not adversely affect flood risk.

7.4 Run-off and Storage Calculations

The FEH method was applied to calculate the Greenfield, pre and post-development run-off rates including allowances for climate change. The full calculations and results are presented in [Appendix 4](#). The table below gives a summary of the results:

Table 6 Calculation of pre- and post-development run-off rates

	FEH Greenfield (l/s)	MRM Pre - Development (l/s)	MRM Post Development (l/s)
Qbar	3.1	-	-
1 in 1 or 1 in 2	3.0	2.2	0.50
1 in 30	8.3	5.8	1.30
1 in 100	11.1	7.2	1.60
1 in 100 + CC	-	-	-

Without mitigation measures, the proposed development has potential to increase the stormwater runoff rate by 7.2l/s. The proposal must not increase the surface water runoff rates from the site.

8 SuDS

8.1 SuDS Hierarchy

The SuDS Hierarchy sets out the preferred method of selecting which Sustainable Drainage System should be used.

-  Rainwater use as a resource (for example rainwater harvesting, blue roofs for irrigation);
-  Rainwater infiltration to ground at or close to source;
-  Rainwater attenuation in green infrastructure features for gradual release (for example green roofs, rain gardens);
-  Rainwater discharge direct to a watercourse (unless not appropriate);

8.2 Drainage Hierarchy Discussion

8.2.1 Rainwater Harvesting

The development has potential to provide rainwater harvesting. As such, this is recommended in the form of rainwater harvesting tanks.

The proposal will require water for washing down of equipment, toilet flushing and general cleaning. As such, a 5m³ rainwater tank will collect part of the rooftop runoff from the barn.

The excess from the rainwater harvesting tank will be discharged into the rough track and associated blue and green SuDS features.

8.2.2 Infiltration To Ground

Onsite infiltration testing, although not strictly completed to BRE 365 DG methodology within all locations, indicates that infiltration is suitable onsite.

Given the indicative results indicate good, but variable infiltration potential, it is recommended that infiltration to ground is the priority utilised on site.

8.2.3 Permeable Surfaces and Filter Drains

The rough stone track forms the majority of the works within the site. This will be formed from an alternative permeable surface that will allow for infiltration into the ground. Due to the sloping nature of the site, baffles and additional SuDS measures will be introduced parallel to the track.

8.3 SuDS Strategy

8.3.1 SuDS Options

The drainage strategy will mimic the natural drainage conditions as much as feasibly possible.

The infiltration has been indicated to be successful, but variable across the site. Given the vast size of the blue line boundary, the proposal will implement a bespoke water retention and infiltration system.

The proposal will introduce blue and green SuDS features across the site to intercept stormwater and retain it within the site.

The track and swale will form a conveyance route around the site, ensuring storm water is retained within the site and prevent any excess from discharging onto the highway.

Due to the sloping nature (9.5% slope) of the track towards the roadway and cesspit, the rough track will have a thick permeable sub-base that will be supported by regular baffles at 7 – 10m intervals.

The proposed track will not be designed to capture excess storm flows from additional hardstanding. As such, all storm water will disperse naturally into the underling permeable geology.

However, due to nature of the steeply sloping site, variable geology and potential interception of overland flows from offsite, additional measures will be introduced. The large permeable track will be supported by filtration strips / swales running parallel to the downslope side of the track. When baffles are introduced, regular outlets from the permeable sub-base will connect into the side of the supporting swale.

This will form large supplementary linear infiltration areas whilst ensuring the velocity of any stormwater generated on site is significantly reduced and water quality benefits are achieved.

All excess stormwater from the proposed barn will discharge into large bio-retention areas situated around the structure and will discharge to ground via infiltration.

The combination of the modelled SuDS measures introduced will provide 12.8m³ of attenuation. Details are outlined in the table below.

Table 7 Proposed SuDS

Location	Proposed Area (m ²)	SuDS Option	Estimated Storage Provided (m ³)
Permeable Track	1555	300mm Sub-base	70.0
Barn Area	-	Rainwater Harvesting Tank	5*
Barn Area	50	Permeable Sub-base / Well Draining topsoil / Geocellular Storage	17.8
Swales with Check Dams	675	shallow gravel infilled swales	50.0
Total			137.8

*Not included in model.

The drainage layout, model sections and model results are available in [Appendix 7](#).

The descriptions of the proposed SuDS and how they interact with the different features is outlined below.

8.3.2 Rainwater Harvesting Tanks

The rainwater harvesting tank will provide 5m³ of water storage. It will provide approximately 100% volume for rainwater recycling within the site for toilet flushing and other non-potable uses (e.g. washing down of machinery and laundry).

The excess storm water will discharge via the gravity drainage outlet into the surrounding permeable sub-base of the rough stone track that surrounds the barn.

8.3.3 Bioretention Area / Geocellular Storage

A 50m² bioretention area will be formed within the soft landscaping, downslope from the proposed barn and access track.

It will accept all surface water runoff from the new barn (260m²) in addition to the excess discharged from the rainwater harvesting unit described above. It will provide approximately 12.8m³ of attenuation based on the variable construction materials.

The bioretention area will be formed from a well-draining (0.5m thick) loamy-sandy topsoil that will provide a high level of water retention and filtration for all stormwaters. It will be underlain by a 0.15m thick MOT Type 3 sub-base, this will cover the entire base of the area.

To provide additional storage, 25m² of the area will be supported by 0.4m thick geocellular storage crates. This will provide 9.0m³ of stormwater attenuation and will discharge directly to ground.

The bio-retention areas will be planted with plants that can withstand waterlogging for up to 48 hours at a time, but would typically drain completely within 12 - 24 hours. This would depend on the drainage capacity of the shallow soils. The shallow soils were shown to have a good infiltration rate of 2.58x10⁻⁵m/s (0.1m/hr).

A range of different plants can be included within the garden whilst more drought-tolerant plants will be suitable towards the edges. During a storm, water fills the depression and then drains.

8.3.4 Rough Track and Supporting Swales

The development consists of a large rough stone permeable track that allows vehicles to freely enter and exit the site.

The proposed rough track is locally steep, with sections reaching an average longitudinal gradient of approximately 9.6% towards the public highway. Without

additional controls, surface water runoff could accelerate along the track and discharge onto the highway or offsite, increasing the risk of erosion and uncontrolled flows.

To mitigate this, the track will be constructed as a permeable gravel surface over a permeable aggregate sub-base. Regular internal baffles will be provided within the sub-base at approximately 7 - 10 m intervals. These baffles will limit longitudinal flow within the construction; promote infiltration and temporary storage; and reduce the potential for erosion of the track surface or uncontrolled discharge onto the public highway.

To ensure stormwater doesn't discharge onto the highway, further mitigation measures are proposed alongside the downslope side of the track.

A shallow gravel-infilled swale will run parallel to the permeable track to manage surface water runoff and reduce the risk of erosion or uncontrolled discharge downslope.

Swales are shallow, flat bottomed, vegetated open channels designed to convey, treat, and attenuate surface water runoff. A standard swale is broad, shallow and covered by vegetation to slow the flow of water, allowing for sedimentation, filtration through the roots zone and soil matrix, evapotranspiration and infiltration into the underlying soil.

The swale will be designed as a mitigation measure for extreme rainfall events as well as provide additional attenuation and a filtration medium that will allow direct infiltration. The swale will have check dams along the route to allow for ponding that will increase pollutant retention, evapotranspiration, infiltration, and decrease overall flow velocity.

The swale has a total formed width of approximately 3.0m, comprising a 0.50m wide gravelled invert with 1.25m vegetated side slopes either side at a gradient of 1:3.

The base will consist of a 200mm permeable gravel sub-base, separated by a geotextile membrane and overlain with approximately 150mm of topsoil to support vegetation, creating both storage and infiltration capacity.

The total depth will range between 600–700mm, enabling runoff to be intercepted, slowed and filtered before infiltrating locally.

Full-width timber check dams will be installed across the swale at approximately 15m intervals to reduce flow velocity, form shallow attenuation pockets and minimise erosion along the swale channel.

Please note, as the roadway and swales do not accept additional flows, they have not been included in the drainage model.

8.3.5 Surface Water Discharge Points

All stormwater will be intercepted and retained on site, and will then discharge to ground via infiltration.

8.4 Water Quality Assessment

8.4.1 Treatment of Run-off

Treatment of roof water runoff will be provided through the provision of the permeable paving and bioretention areas to intercept gross solids and sediment. Guidance will be provided to the developer on appropriate maintenance.

8.4.2 Exceedance Flows

The topography increases from a low of 58.4mAOD (north), towards the proposed cesspit, to a high of 83.9mAOD (southeast), towards the proposed barn.

The exceedance flow events onsite will be captured within the rough stone track and the supporting shallow swale that follows the roadway. The baffles and check dams located at regular intervals within the structures will ensure that the exceedance events

are captured within the site and retained within proposed structures and can gradually discharge.

8.5 Maintenance and Adoption of SuDS

All SuDS features will be properly installed by competent persons. They will be maintained regularly to ensure that their design capacity and attenuation characteristics provide the required storage volume.

Landscaping and adjacent areas will be designed such that they do not cause soil, mulch and other materials to be washed onto the permeable surfaces and into drains causing clogging.

Owners of the properties/persons responsible for maintenance of SuDS components will be provided with operation and maintenance manuals which will include information such as:

-  The location of SuDS components;
-  An explanation of design intent and objective of the SuDS;
-  The requirements for regular and occasional inspection and maintenance;
-  Visual indicators that may trigger maintenance.

Regular maintenance of SuDS components is relatively straightforward with the main tasks consisting of:

-  Regular visual inspections – checking inlets are not blocked and verifying that clogging has not occurred;
-  Litter and debris removal;
-  Grass cutting;
-  Preventive sweeping;
-  Weeding and invasive plant control;
-  Oil and stain removal.

Occasional maintenance activities to ensure the long-term performance of the SuDS features include:

-  Sediment removal;
-  Vegetation and plant replacement.

These simple measures will ensure that the storage capacity of the system is maintained and that the need for reconstruction and replacement of components is minimised.

Further details on SuDS maintenance measures that will be employed at the site can be found in [Appendix 8](#).

9 Conclusion and Recommendations

With the proposed SuDS mitigation measures in place, it is considered that the proposed development will reduce local flood risk and enhance the local environment and will therefore be in compliance with the LLFA's current planning policy and the NPPF.

10 References

1. Communities and Local Government - National Planning Policy Framework NPPF, 2019.
2. The London Plan – The Spatial Development Strategy for Greater London - March 2021
3. CIRIA, Defra, Environment Agency – UK SuDS Manual, 2015.
4. Wiltshire Council – Wiltshire Core Strategy, January 2015.
5. Wiltshire Council, JBA Consulting – Wiltshire Council Level 1 Strategic Flood Risk Assessment, November 2024.

11 Appendices

11.1 Appendix 1 – Development Plans & Photos

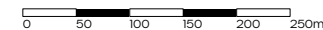
11.1.1 Development Plans

See next page.

This is for information only and is not intended for precise dimensions. Do not scale from drawing for site purposes



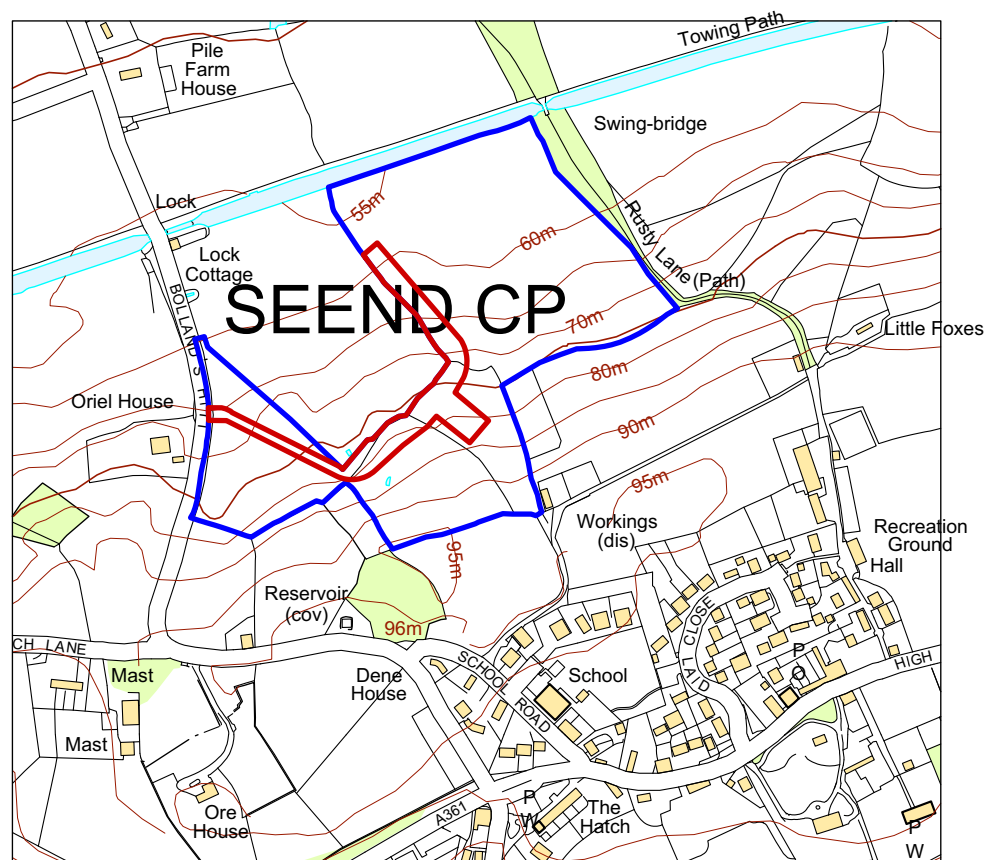
Scale bar:



Revisions:

No	Date	Notes
P00	02/08/24	Submitted for planning
P01	15/08/24	Boundary lines updated

-  Proposed Site Area
-  Land owned that is not part of the application



Project: New Access & Barn to Field

Address: Bollands Hill
Seend, Wiltshire
SN12 6NQ

Client: Marc Adams

Drawn by: EHa

Date: 13/05/2024

Scale @ a3: 1:5000

Status: PLANNING

Title: Location Plan

Dwg No: 15156-EDA-XX-XX-DR-A-1000

Rev: P01

Location: Northumberland Office
The Kings Head
85 Bridge Street
Blyth
Northumberland
NE24 3AE

Tel: 01670 361 856

Email: studio@edablearchitecture.co.uk

This is for information only and is not intended for precise dimensions. Do not scale from drawing for site purposes

Scale bar

0 20 40 60 80 100m

Revisions:

No	Date	Notes
P00	02/08/24	Submitted for planning
P01	15/08/24	Boundary lines updated
P02	29/01/25	Section line and public right of way corrected.

- Proposed Site Area
- Land owned that is not part of the application



Project: New Access & Barn to Field

Address: Bollands Hill
Seend, Wiltshire
SN12 6NQ

Client: Marc Adams

Drawn by: BHa

Date: 13/05/2024

Scale @ a3: 1:2000

Status: PLANNING

Title: Existing Site Plan

Dwg No: E156-EDA-XX-XX-DR-A-1100

Rev: P02

Location: Northumberland Office
The Kings Head
85 Bridge Street
Blyth
Northumberland
NE24 3AE

Tel: 01670 361 856

Email: studio@edablearchitecture.co.uk

1100

Existing Site Plan
Scale: 1:2000

EDable
ARCHITECTURE

This is for information only and is not intended for precise dimensions. Do not scale from drawing for site purposes



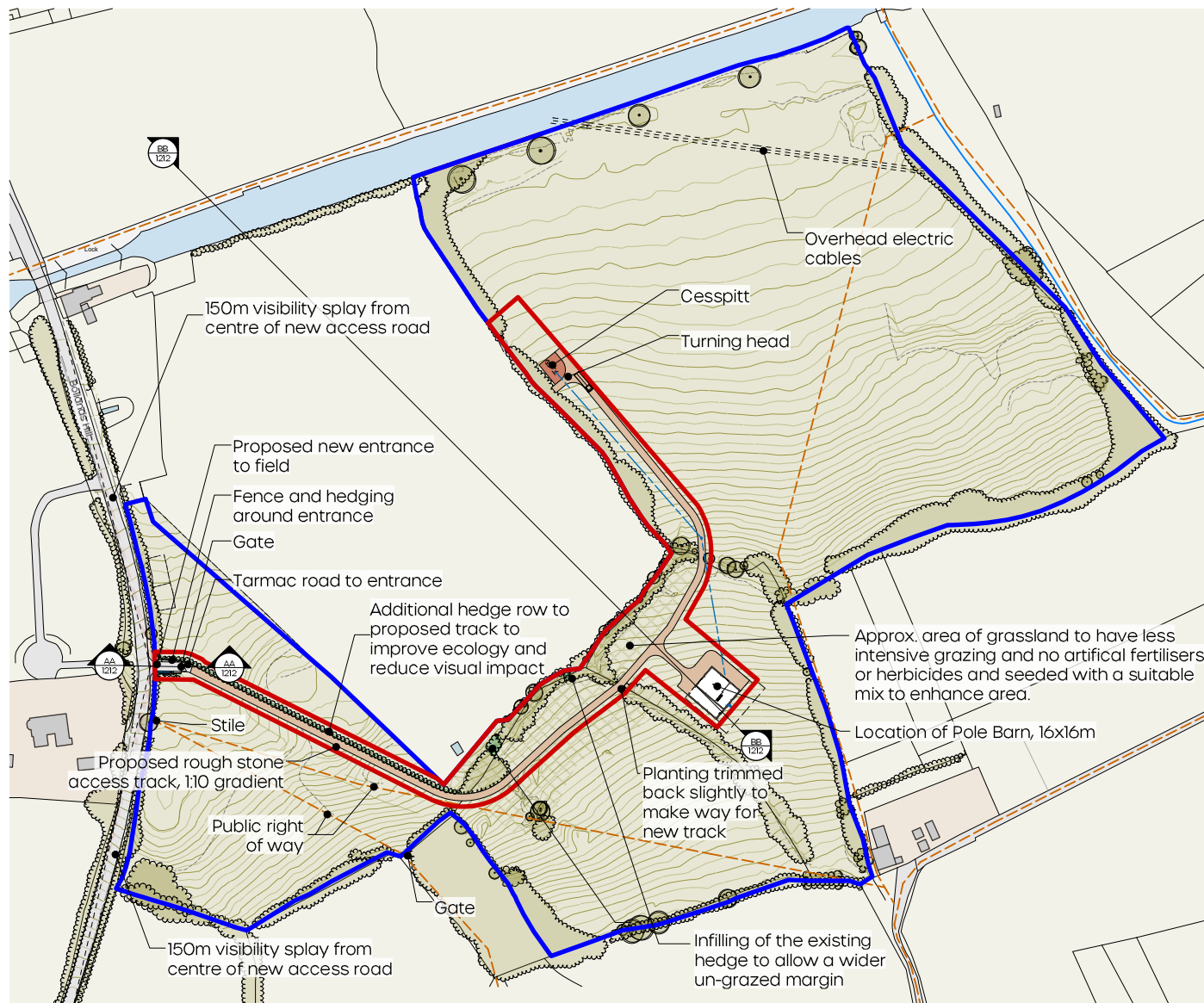
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Revisions:

No	Date	Notes
P00	02/08/24	Submitted for planning
P01	15/08/24	Boundary lines updated
P02	21/01/25	Section line and public right of way corrected.
P03	28/05/25	Sewage Treatment Plant changed to a Cesspitt.

- Proposed Site Area
- Land owned that is not part of the application



Project: New Access & Barn to Field

Address: Bollands Hill
Seend, Wiltshire
SN12 6NQ

Client: Marc Adams

Drawn by: BHa

Date: 13/05/2024

Scale @ a3: 1:2000

Status: PLANNING

Title: Proposed Site Plan

Dwg No: E156-EDA-XX-XX-DR-A-1200

Rev: P03

Location: Northumberland Office
The Kings Head
85 Bridge Street
Blyth
Northumberland
NE24 3AE

Tel: 01670 361 856

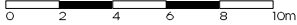
Email: studio@edablearchitecture.co.uk

1200 **Proposed Site Plan**
Scale: 1:2000

EDable
ARCHITECTURE

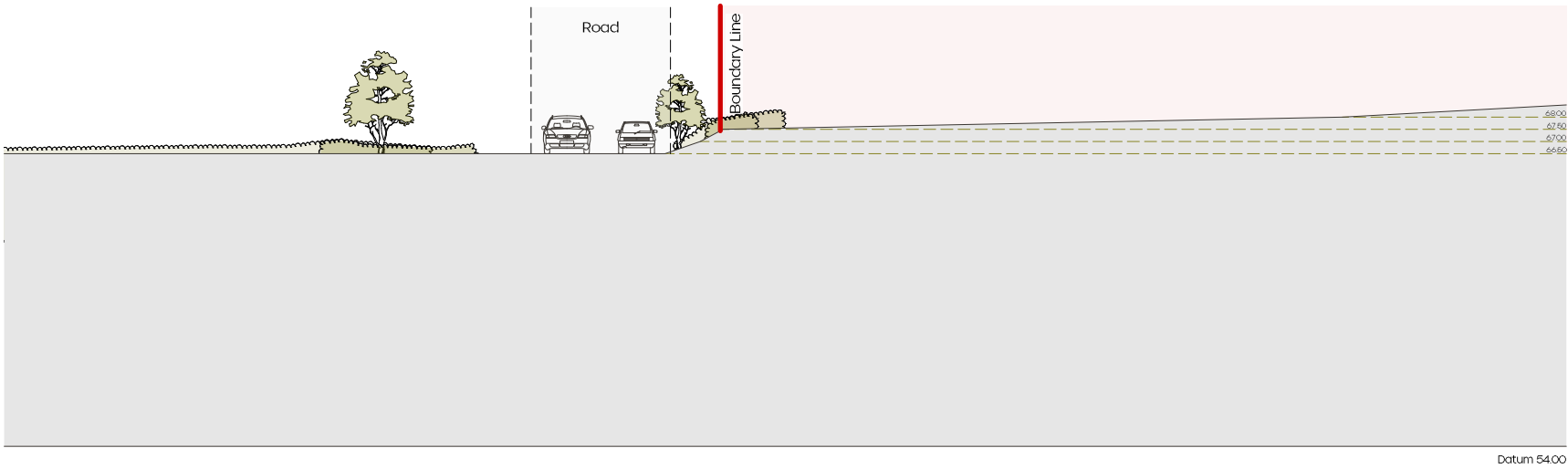
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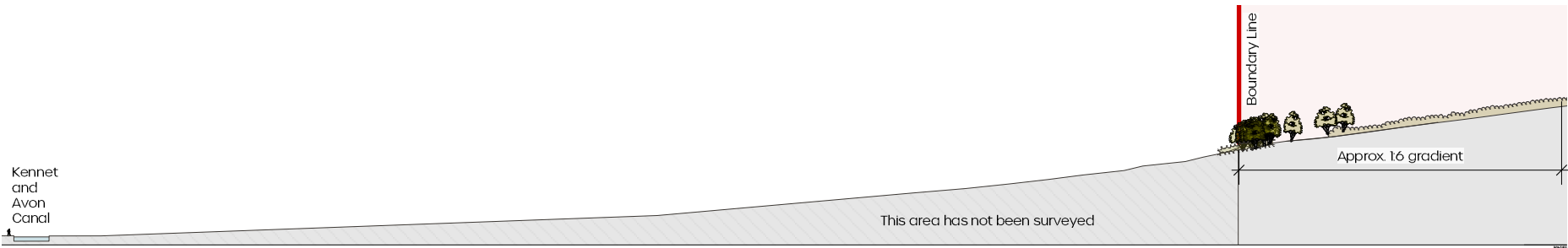


Revisions:

No	Date	Notes
P00	02/08/24	Submitted for planning
P01	29/01/25	Section BB corrected to line shown on Site Plan.



1110-A Existing Section AA
Scale: 1:200



1110-B Existing Section BB
Scale: 1:1000

Project: New Access & Barn to Field

Address: Bollands Hill
Seend, Wiltshire
SN12 6NQ

Client: Marc Adams

Drawn by: BHa

Date: 03/06/2024

Scale @ a3: 1:100

Status: PLANNING

Title: Existing Site Sections

Dwg No: 15156-EDA-XX-XX-DR-A-1110
Rev: P01

Location: Northumberland Office
The Kings Head
85 Bridge Street
Blyth
Northumberland
NE24 3AE

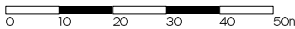
Tel: 01670 361 856

Email: studio@edablearchitecture.co.uk

EDable
ARCHITECTURE

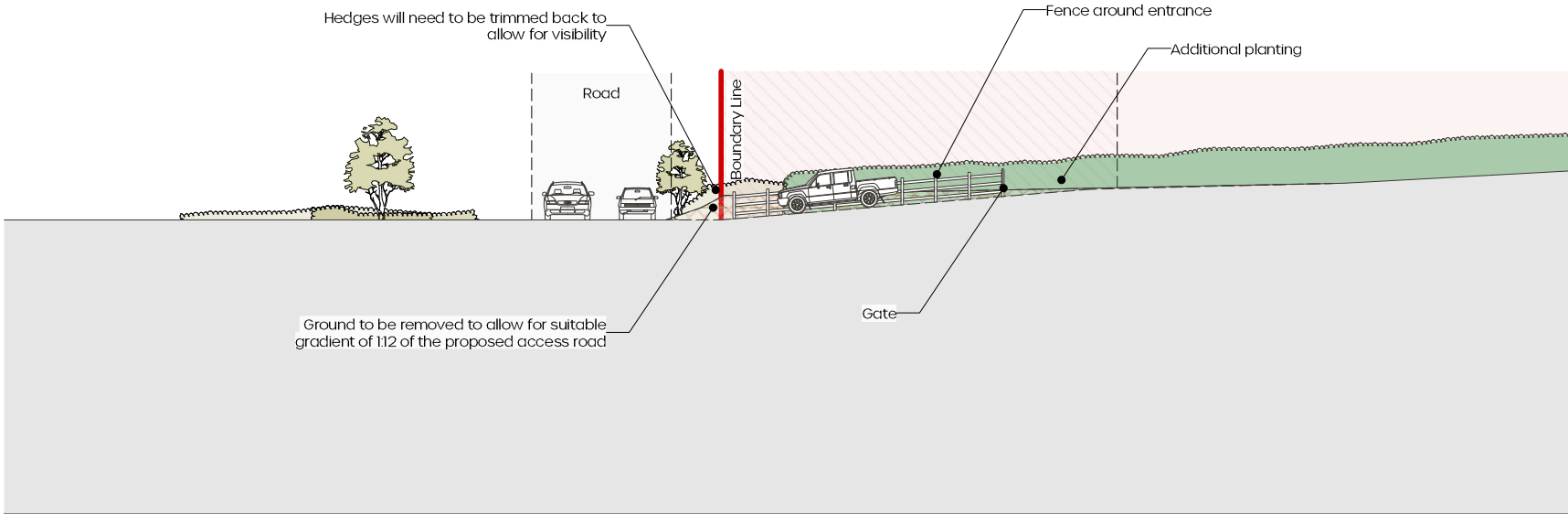
This is for information only and is not intended for precise dimensions. Do not scale from drawing for site purposes

Scale bar:



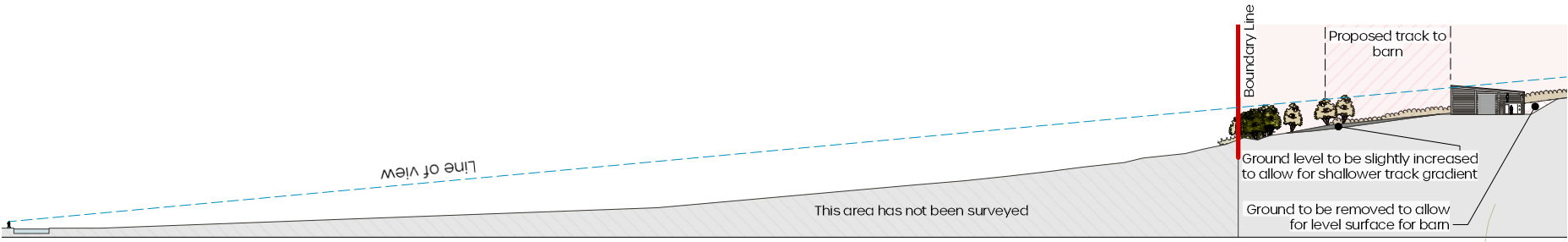
Revisions:

No	Date	Notes
P00	02/08/24	Submitted for planning
P01	21/01/25	Section BB amended to match section line on Proposed Plan.



Datum 54.00

1210-A Proposed Section AA
Scale: 1:200



1210-B Proposed Section BB
Scale: 1:1000

Project: New Access & Barn to Field

Address: Bolland's Hill
Seend, Wiltshire
SN12 6NQ

Client: Marc Adams

Drawn by: BHA

Date: 03/06/2024

Scale @ a3: 1:100

Status: PLANNING

Title: Proposed Site Sections

Dwg No: 15156-EDA-XX-XX-DR-A-1210

Rev: P01

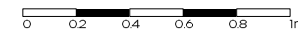
Location: Northumberland Office
The Kings Head
85 Bridge Street
Blyth
Northumberland
NE24 3AE

Tel: 01670 361 856

Email: studio@edablearchitecture.co.uk

EDable
ARCHITECTURE

Scale bar



Revisions

No	Date	Notes
P01	25/05/25	Submitted for planning

New hedgerow planting to some edges of the track, see site plan for extent. Other areas have less intensive grazing to the grassland with no artificial fertilisers or herbicides and seeded with a grassland mix to enhance area.

Cut (orange) and fill (green) to be carried out to each side of the track route to create fairly level trackway. All soil to remain on site.

Existing profile of ground at section shown dotted.

Finer material to form top surface, cambered to shed surface water to sides.

150mm hardcore

geotextile membrane to base of excavation.

Project: New Access & Barn to Field

Address: Bolland's Hill
Seend, Wiltshire
SN12 6NQ

Client: Marc Adams

Drawn by: CM

Date: 03/06/2024

Scale @ a3: 120

Status: PLANNING
Title: Proposed Site Section through track

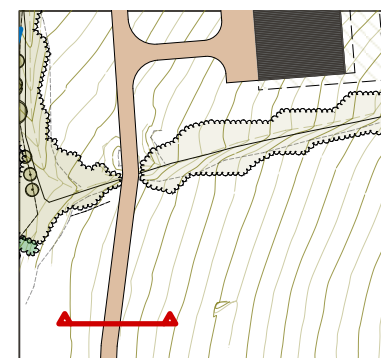
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Rev: P01

Location: Northumberland Office
The Kings Head
85 Bridge Street
Blyth
Northumberland
NE24 3AE

Tel: 01670 301 856

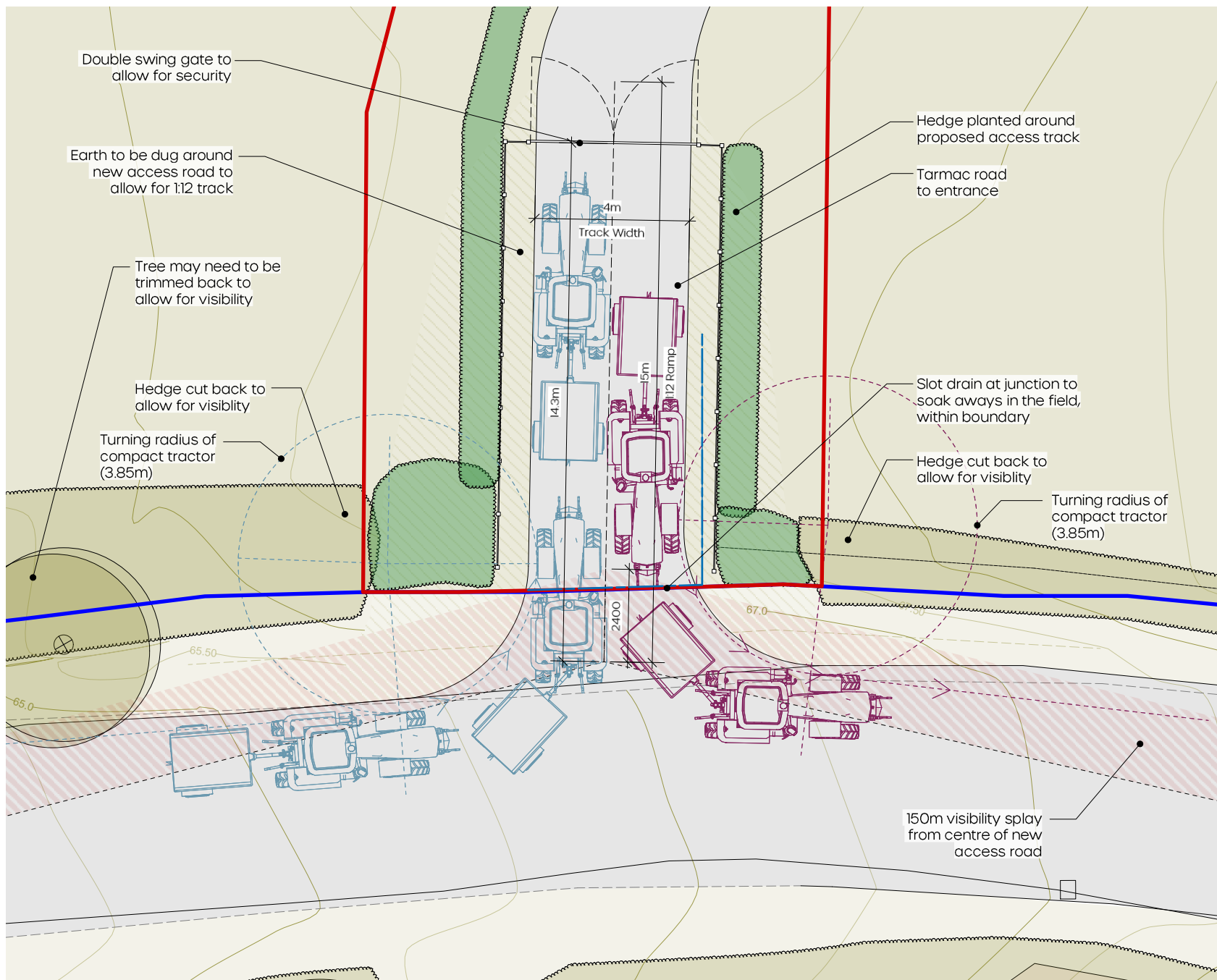
Email: studio@edablearchitecture.co.uk



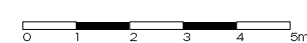
Location of typical cross section.

1211

Proposed Cross Section through the track
Scale: 1:20



Scale bar



Revisions:

No	Date	Notes
P00	02/09/24	Submitted for planning
P01	15/08/24	Boundary lines updated
P02	16/05/25	Entrance width increased to 4m in line with comments from Highways

 Proposed Site Area

 Land owned that is not part of the application

Project: New Access & Barn to Field

Address: Bollands Hill
Seend, Wiltshire
SN12 6NQ

Client: Marc Adams

Drawn by: MChd

Date: 16/05/2025

Scale @ a3: 1:100

Status: PLANNING

Title: Proposed Entrance Plan

Dwg No: E156-EDA-XX-XX-DR-A-1202

Rev: P02

Location: Northumberland Office
The Kings Head
85 Bridge Street
Blyth
Northumberland
NE24 3AE

Tel: 01670 301 856

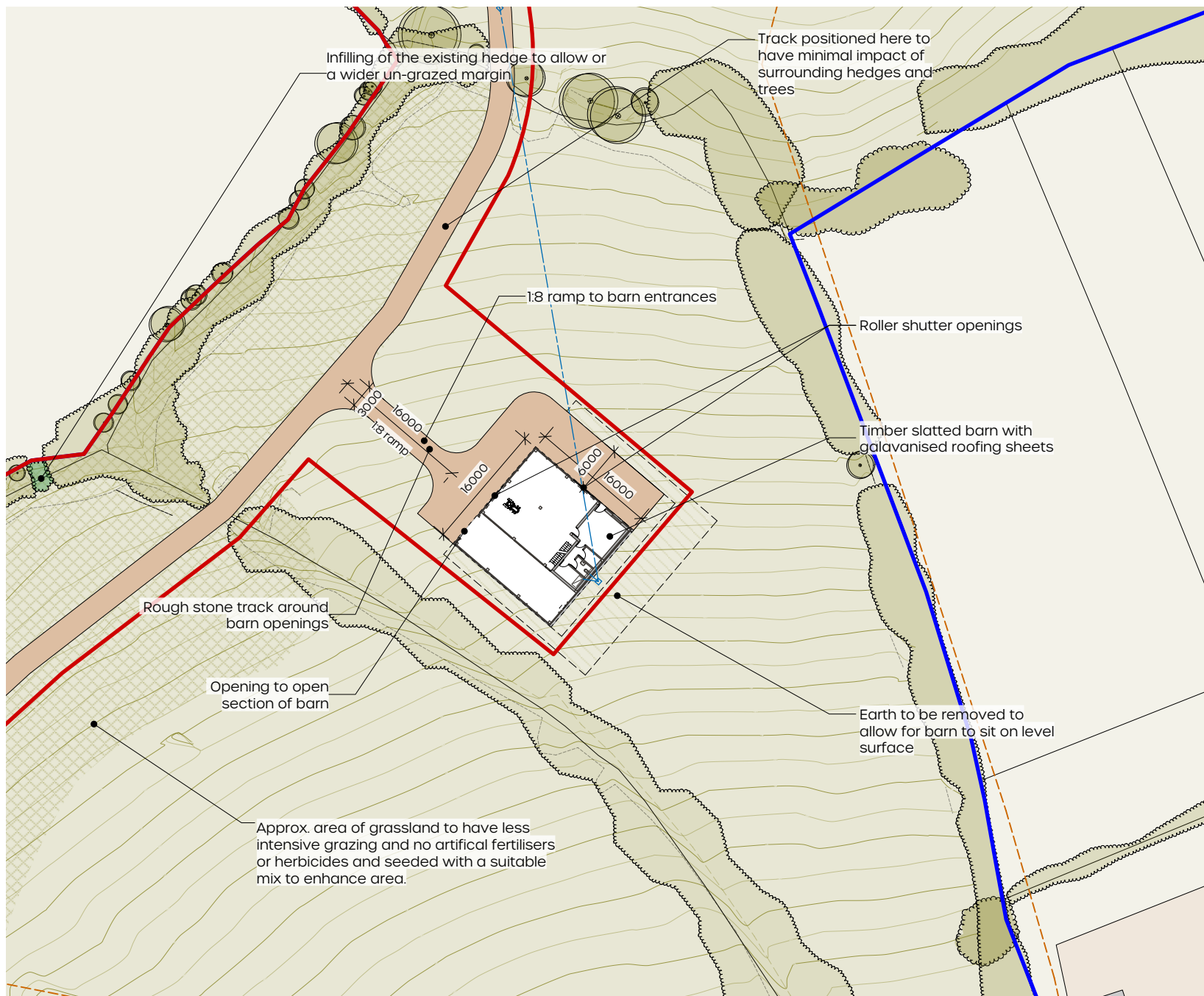
Email: studio@edablearchitecture.co.uk

1202

Proposed Entrance Plan

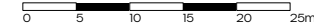
Scale: 1:100

EDable
ARCHITECTURE



This is for information only and is not intended for precise dimensions. Do not scale from drawing for site purposes

Scale bar:



Revisions:

No	Date	Notes
P00	02/08/24	Submitted for planning
P01	15/08/24	Boundary lines updated

- Proposed Site Area
- Land owned that is not part of the application

Project: New Access & Barn to Field

Address: Bollands Hill
Seend, Wiltshire
SN12 6NQ

Client: Marc Adams

Drawn by: EHa

Date: 13/05/2024

Scale @ a3: 1:1000

Status: PLANNING

Title: Proposed Barn Site Plan

Dwg No: 15156-EDA-XX-XX-DR-A-1203

Rev: P01

Location: Northumberland Office
The Kings Head
85 Bridge Street
Blyth
Northumberland
NE24 3AE

Tel: 01670 361 856

Email: studio@edablearchitecture.co.uk

1203 **Proposed Barn Site Plan**
Scale: 1:500

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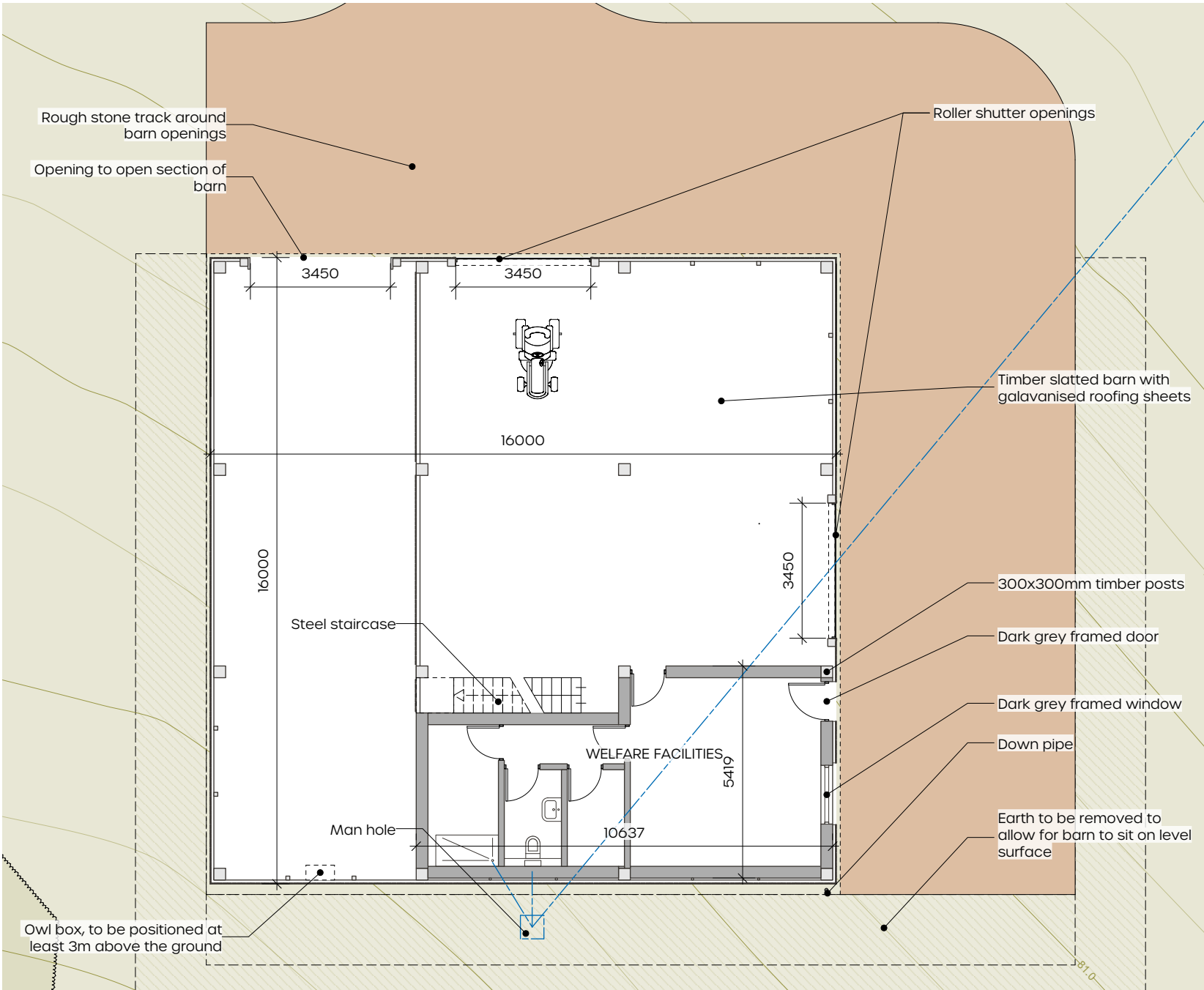


Scale bar:



Revisions:

No	Date	Notes
P00	02/08/24	Submitted for planning



Project: New Access & Barn to Field

Address: Bollands Hill
Seend, Wiltshire
SN12 6NQ

Client: Marc Adams

Drawn by: EHa

Date: 03/06/2024

Scale @ a3: 1:100

Status: PLANNING

Title: Proposed Barn Plan

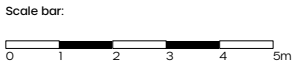
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Rev: P00

Location: Northumberland Office
The Kings Head
85 Bridge Street
Blyth
Northumberland
NE24 3AE

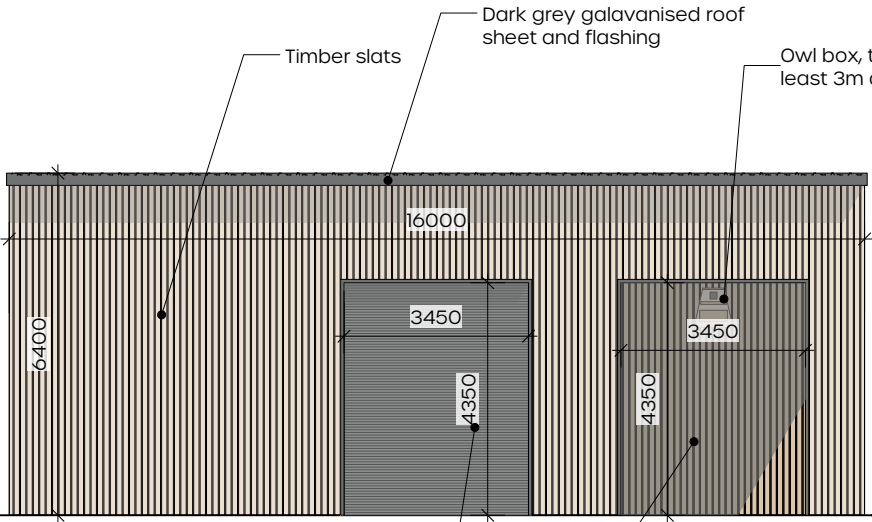
Tel: 01670 361 856

Email: studio@edablearchitecture.co.uk

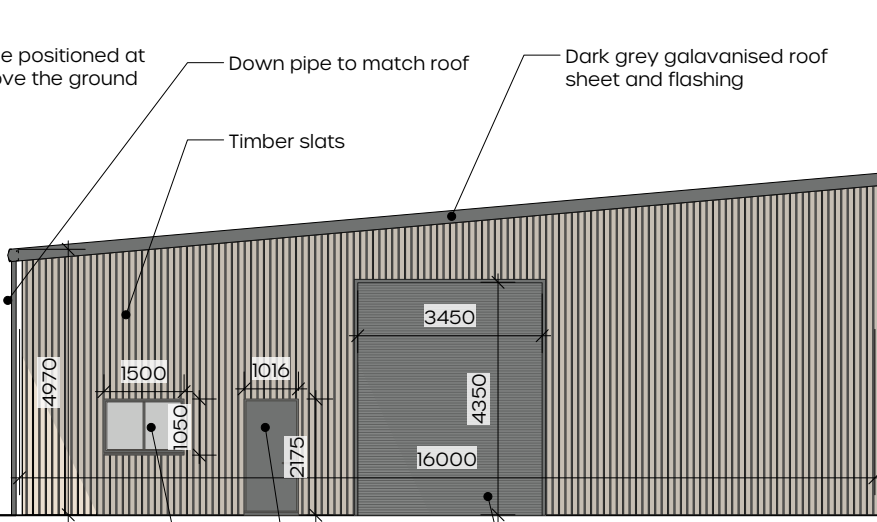
1220 Proposed Barn Ground Floor Plan
Scale: 1:100



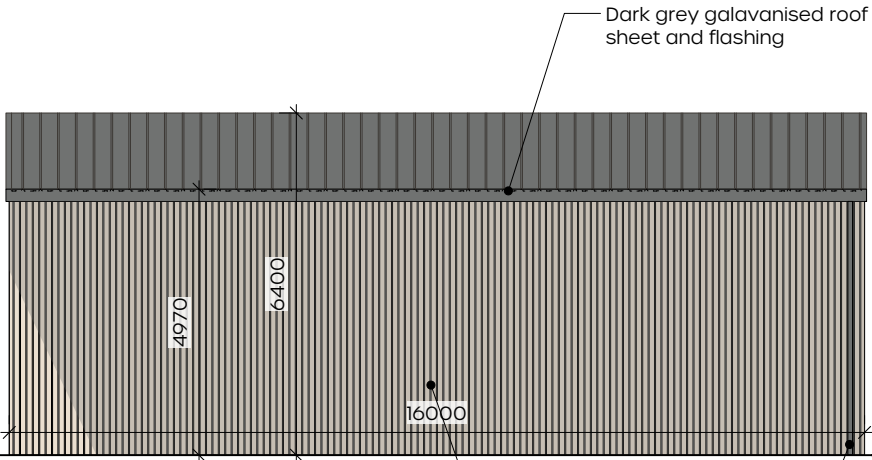
Revisions:		
No	Date	Notes
P00	02/08/24	Submitted for planning



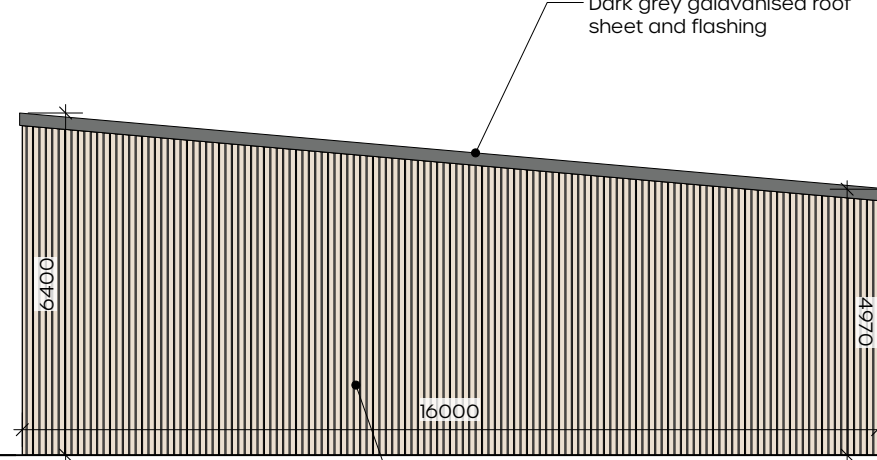
North Elevation



East Elevation



South Elevation



West Elevation

Project: New Access & Barn to Field

Address: Bollands Hill
Seend, Wiltshire
SN12 6NQ

Client: Marc Adams

Drawn by: EHa

Date: 03/06/2024

Scale @ a3: 1:100

Status: PLANNING

Title: Proposed Barn Elevations

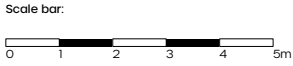
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Rev: P00

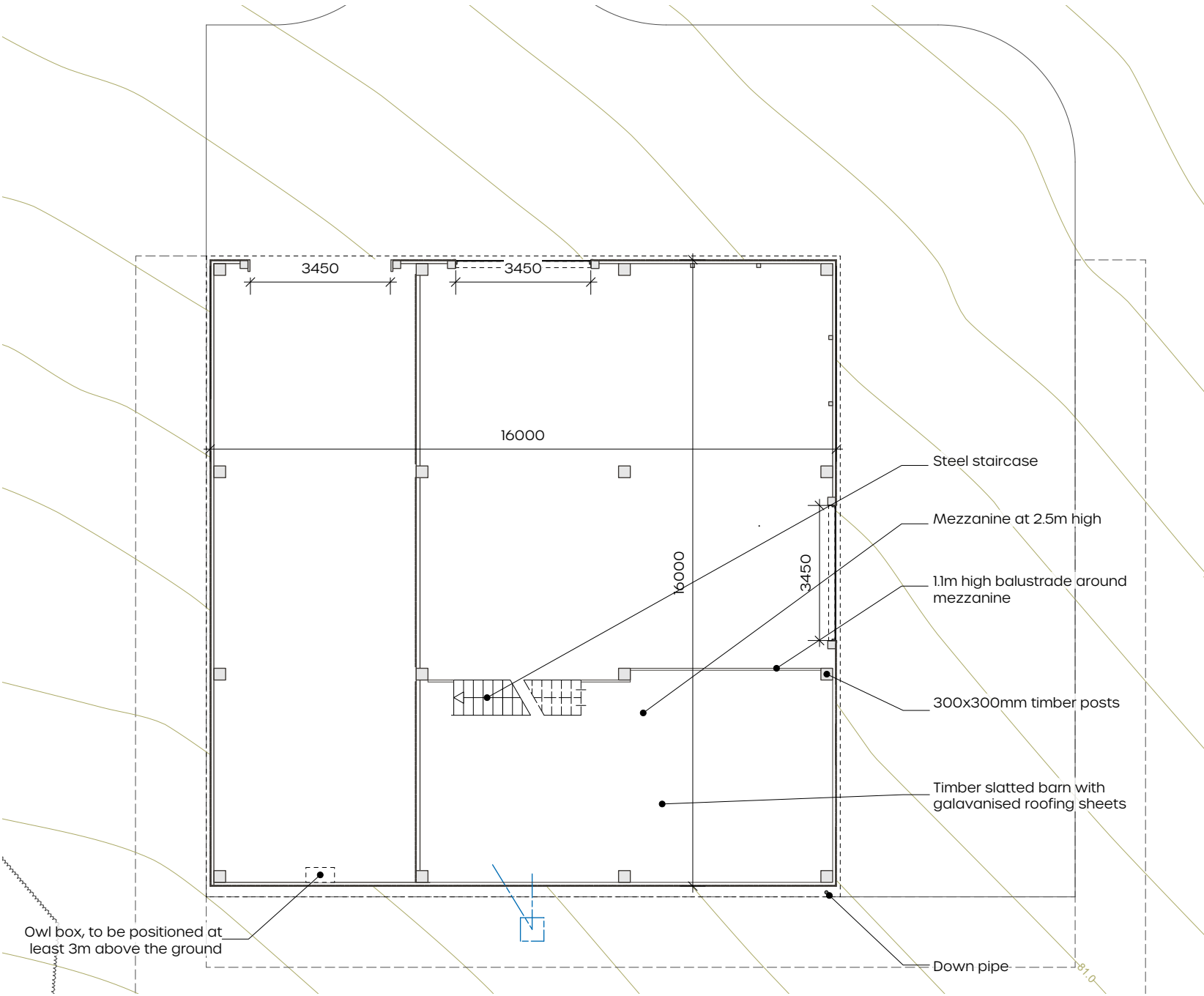
Location: Northumberland Office
The Kings Head
85 Bridge Street
Blyth
Northumberland
NE24 3AE

Tel: 01670 361 856

Email: studio@edablearchitecture.co.uk



Revisions:		Notes
No	Date	
P00	02/08/24	Submitted for planning



Owl box, to be positioned at least 3m above the ground

1221 **Proposed Barn Mezzanine Plan**
Scale: 1:100

Project: New Access & Barn to Field

Address: Bollands Hill
Seend, Wiltshire
SN12 6NQ

Client: Marc Adams

Drawn by: EHa

Date: 03/06/2024

Scale @ a3: 1:100

Status: PLANNING

Title: Proposed Barn Mezzanine Plan

Dwg No: 15156-EDA-XX-XX-DR-A-1221

Rev: P00

Location: Northumberland Office
The Kings Head
85 Bridge Street
Blyth
Northumberland
NE24 3AE

Tel: 01670 361 856

Email: studio@edablearchitecture.co.uk

Scale bar:



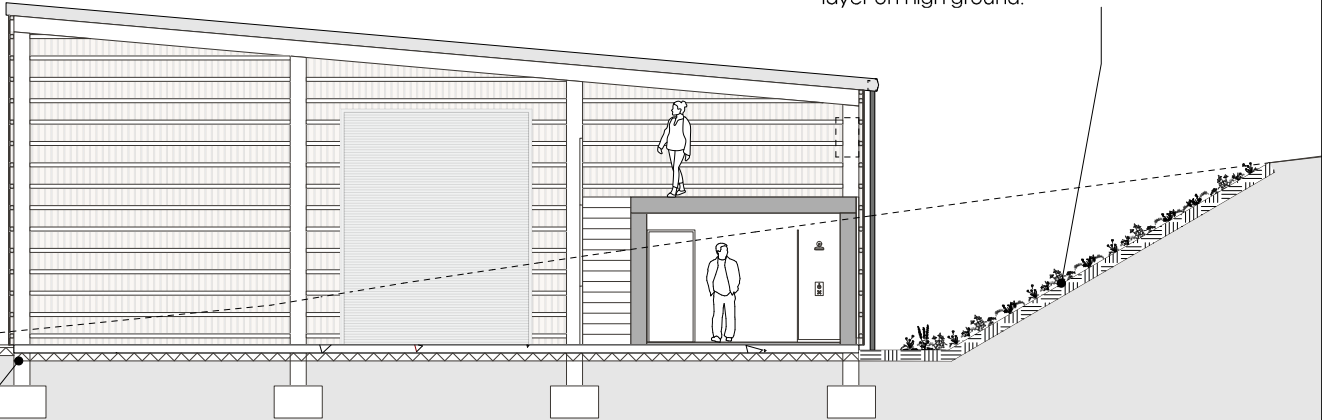
Revisions:

No	Date	Notes
P01	25/03/25	Submitted for planning

An area of ground will be built up to form the new access track at a gradient of 1:8. The construction of the track will consist of well compacted aggregate (hardcore) to a depth of at least 150mm, the top of the track finished with a finer material to a depth of 25mm to 50mm - compacted to a convex camber to direct any track runoff on to the grassland either side.

Rear bank to be left at angle of repose. Cut areas to be redistributed on site as a thin layer on high ground.

Barn to be sited on level ground formed with cut and fill and moving the soil to higher ground.



Project: New Access & Barn to Field

Address: Bolland's Hill
Seend, Wiltshire
SN12 6NQ

Client: Marc Adams

Drawn by: CM

Date: 03/06/2024

Scale @ a3: 1:100

Status: PLANNING

Title: Proposed Barn Section

Dwg No: 15156-EDA-XX-XX-DR-A-1241
Rev: P01

Location: Northumberland Office
The Kings Head
85 Bridge Street
Blyth
Northumberland
NE24 3AE

Tel: 01670 361 856

Email: studio@edablearchitecture.co.uk

1241

Proposed Barn Section
Scale: 1:100

11.1.2 Existing Development

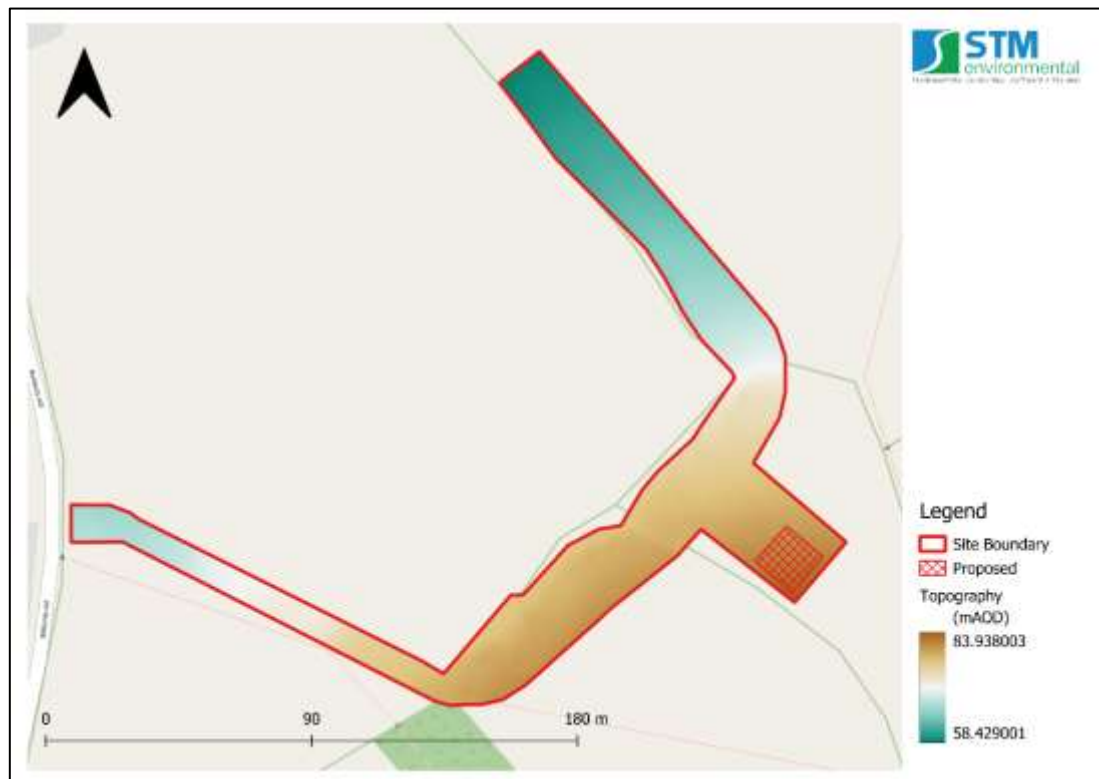


11.1.3 Proposed (No Additional SuDS)



11.2 Appendix 2– Site Topography and Drainage Characteristics

11.2.1 LIDAR Mapping showing Site Topography - (Source: LiDAR DTM 2022)



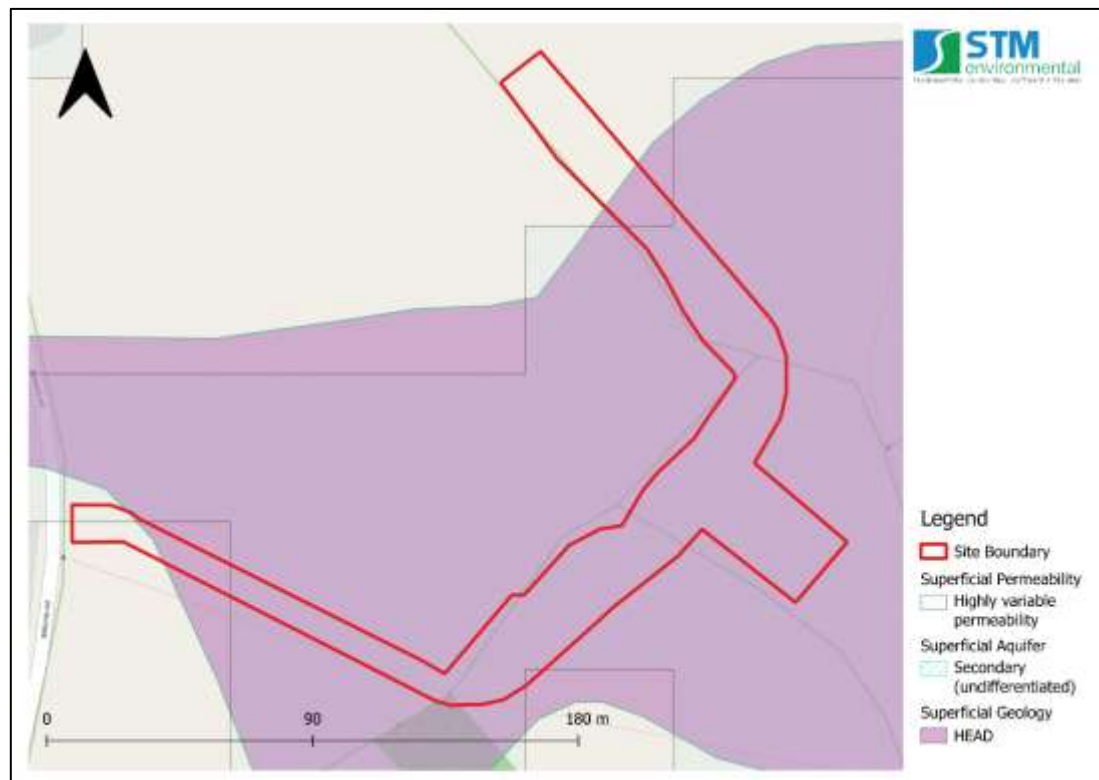
11.2.2 Hydrology Map



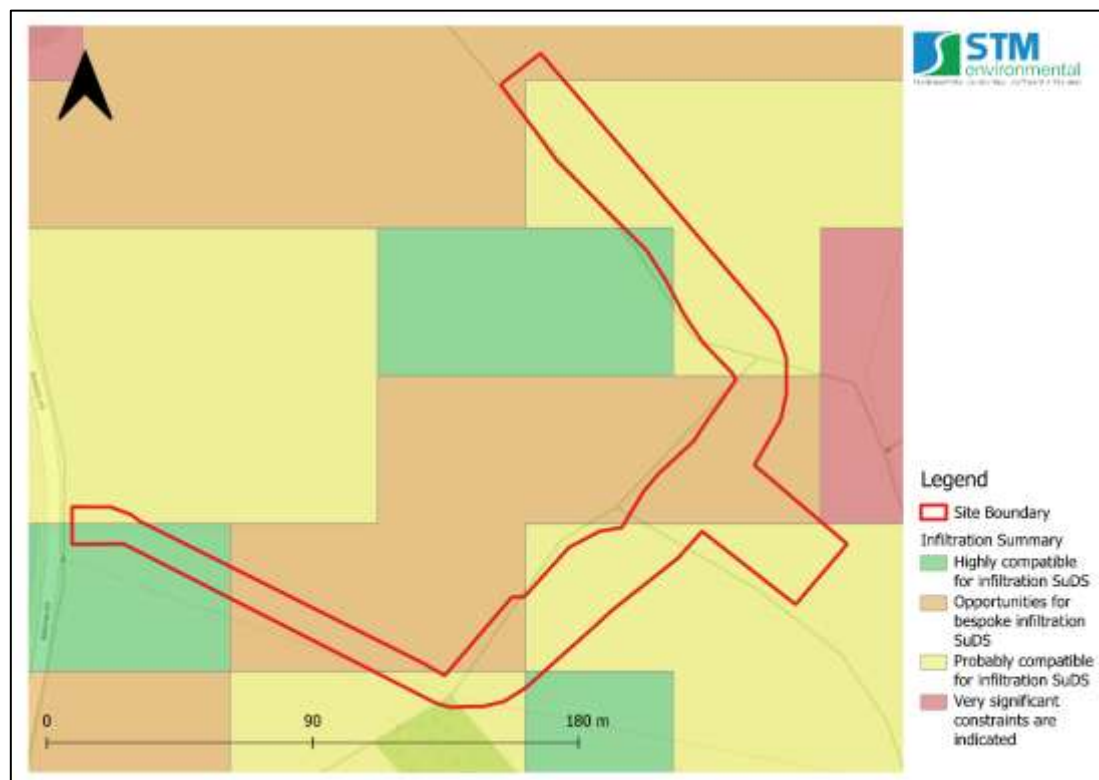
11.2.3 Bedrock Geology, Hydrogeology & Permeability (Source: BGS, 2016)



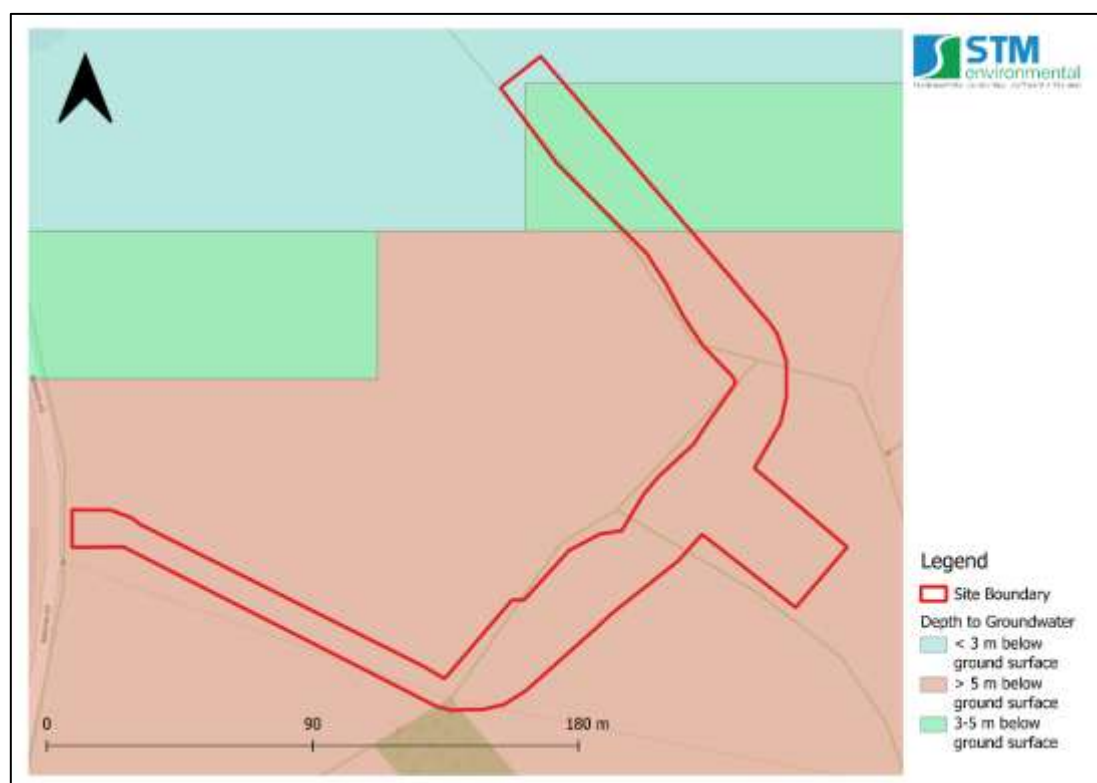
11.2.4 Superficial Deposits, Hydrogeology, & Permeability (Source: BGS, 2016)



11.2.5 Infiltration Drainage Potential (Source: BGS, 2016)



11.2.6 Groundwater Table Depth (Source: BGS 2016)

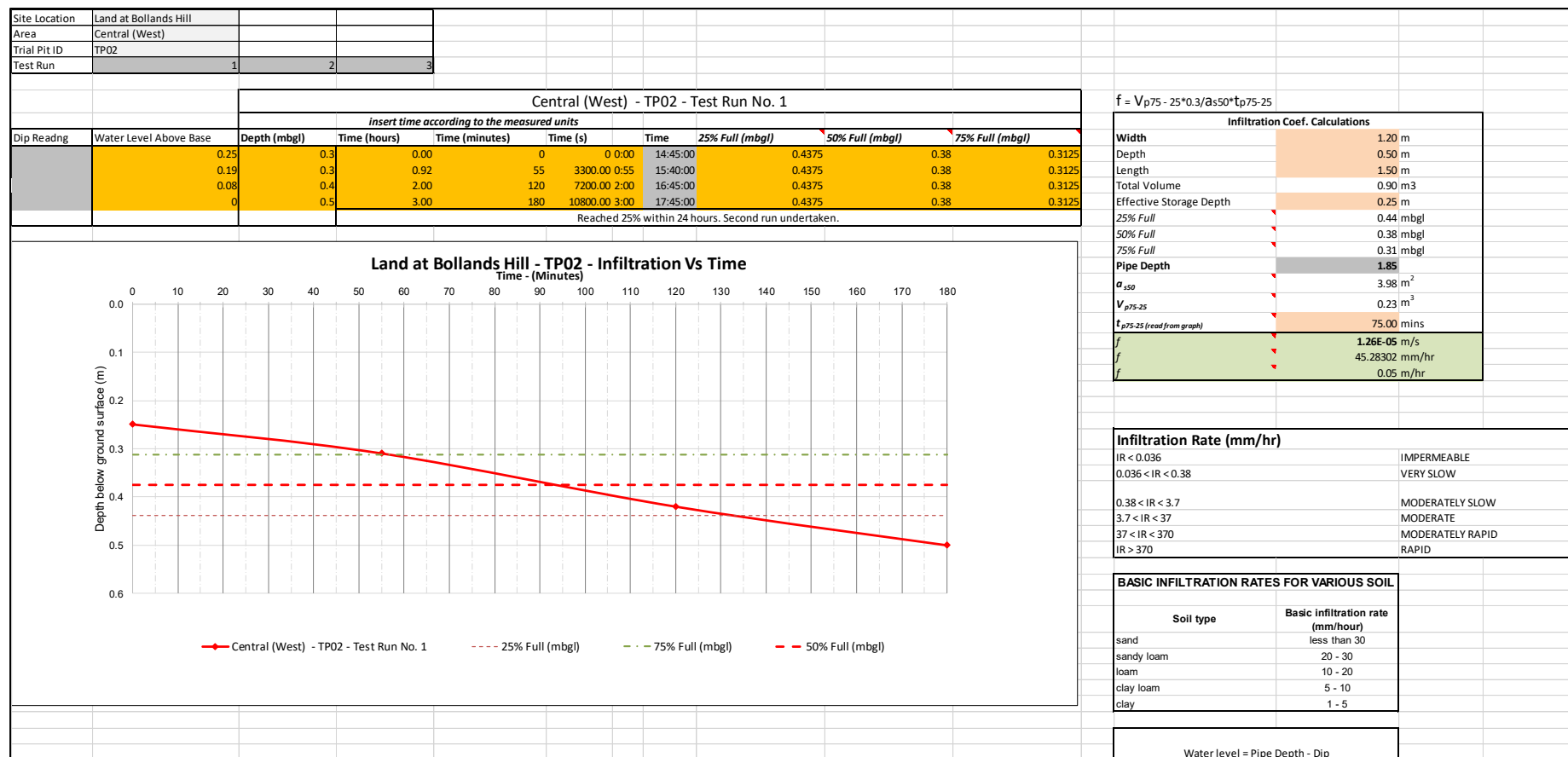


11.2.7 Site Investigation Photos

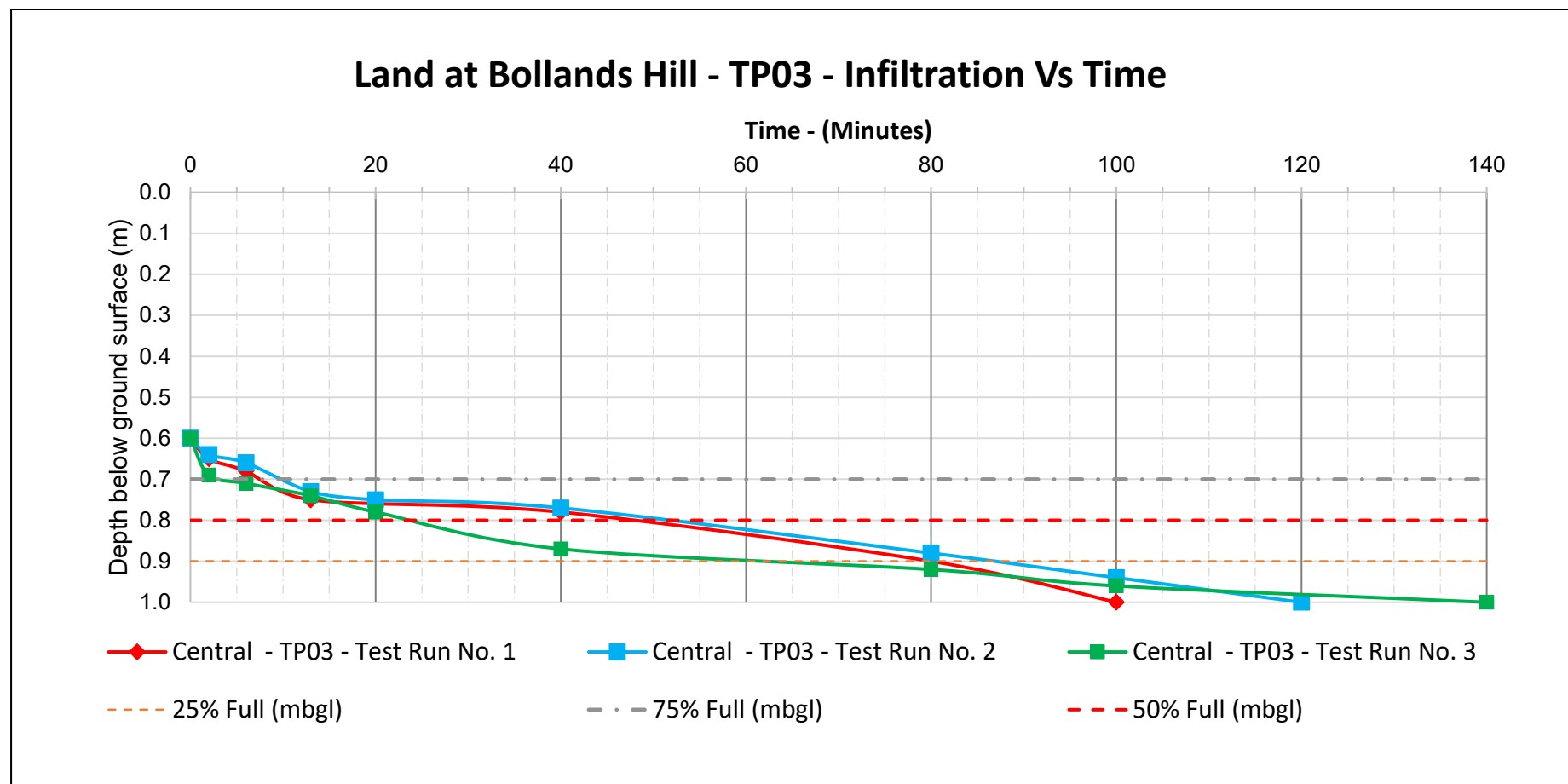




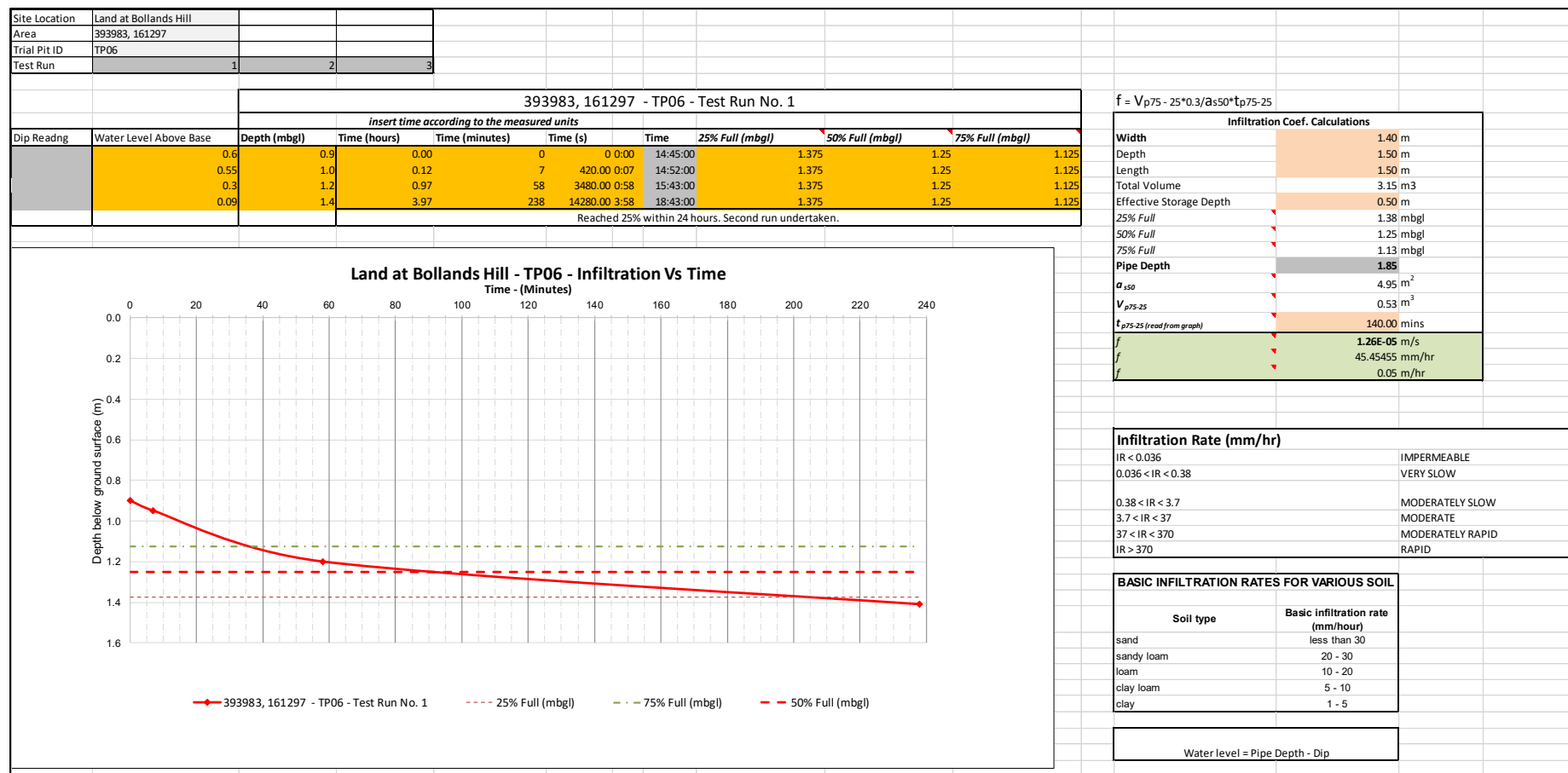
11.2.8 Infiltration Testing Graph – TP02



11.2.9 Infiltration Testing Graph – TP03



11.2.12 Infiltration Testing Graph – TP06



Site Location	Land at Bollands Hill
Area	North West
Trial Pit ID	TP07
Test Run	1 2 3

North West - TP07 - Test Run No. 1									
<i>Insert time according to the measured units</i>									
Dip Reading	Water Level Above Base	Depth (mbgl)	Time (hours)	Time (minutes)	Time (s)	Time	25% Full (mbgl)	50% Full (mbgl)	75% Full (mbgl)
	0.6	0.9	0.00	0	0 0:00	10:45:00	1.35	1.20	1.05
	0.5	1.0	0.67	40	2400.00 0:40	11:25:00	1.35	1.20	1.05
	0.5	1.0	1.50	90	5400.00 1:30	12:15:00	1.35	1.20	1.05
	0.46	1.0	2.50	150	9000.00 2:30	13:15:00	1.35	1.20	1.05
	0.29	1.2	5.00	300	18000.00 5:00	15:45:00	1.35	1.20	1.05
	0.29	1.2	6.00	360	21600.00 6:00	16:45:00	1.35	1.20	1.05
Reached 25% within 24 hours. Second run undertaken.									

Land at Bollands Hill - TP07 - Infiltration Vs Time

Time - (Minutes)

Depth below ground surface (m)

— North West - TP07 - Test Run No. 1 --- 25% Full (mbgl) - - - 75% Full (mbgl) - - - 50% Full (mbgl)

$$f = V_{p75} - 25 \times 0.3 / a_s \times 50 \times t_{p75-25}$$

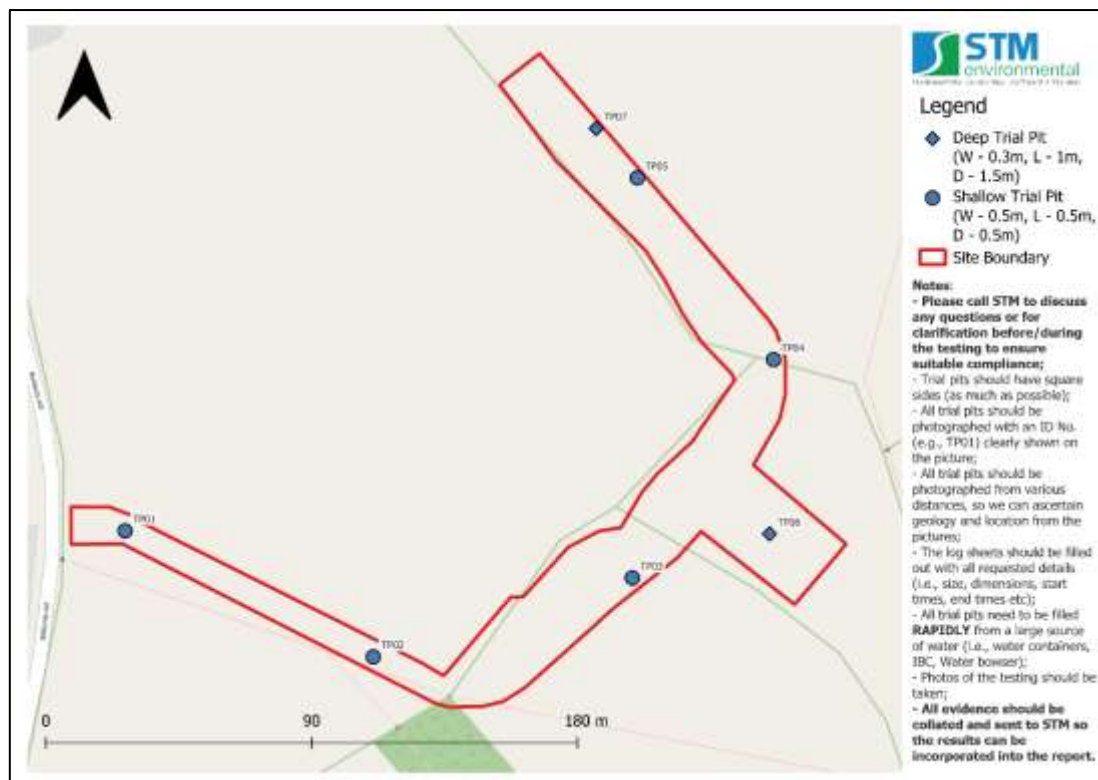
Infiltration Coef. Calculations	
Width	1.20 m
Depth	1.50 m
Length	1.60 m
Total Volume	2.88 m ³
Effective Storage Depth	0.60 m
25% Full	1.35 mbgl
50% Full	1.20 mbgl
75% Full	1.05 mbgl
Pipe Depth	1.85
a _{sso}	4.80 m ²
V _{p75-25}	0.58 m ³
t _{p75-25} (read from graph)	N/A mins
f	#VALUE! m/s
f	#VALUE! mm/hr
f	#VALUE! m/hr

Infiltration Rate (mm/hr)	
IR < 0.036	IMPERMEABLE
0.036 < IR < 0.38	VERY SLOW
0.38 < IR < 3.7	MODERATELY SLOW
3.7 < IR < 37	MODERATE
37 < IR < 370	MODERATELY RAPID
IR > 370	RAPID

BASIC INFILTRATION RATES FOR VARIOUS SOIL	
Soil type	Basic infiltration rate (mm/hour)
sand	less than 30
sandy loam	20 - 30
loam	10 - 20
clay loam	5 - 10
clay	1 - 5

Water level = Pipe Depth - Dip

11.2.14 Soakaway Test Location Map



11.3 Appendix 3 – Flood Risk Mapping

11.3.1 Flood Map For Planning (EA)

PDF to follow this page.

Flood map for planning

Your reference	Location (easting/northing)	Created
Unspecified	393954/161350	29 September 2025 12:01

Your selected location is in flood zone 1, an area with a low probability of flooding.

You will need to do a flood risk assessment if your site is **any of the following**:

- bigger than 1 hectare (ha)
- in an area with critical drainage problems as notified by the Environment Agency
- identified as being at increased flood risk in future by the local authority's strategic flood risk assessment
- at risk from other sources of flooding (such as surface water or reservoirs) and its development would increase the vulnerability of its use (such as constructing an office on an undeveloped site or converting a shop to a dwelling)

Notes

The flood map for planning shows river and sea flooding data only. It doesn't include other sources of flooding. It is for use in development planning and flood risk assessments.

This information relates to the selected location and is not specific to any property within it. The map is updated regularly and is correct at the time of printing.

Flood risk data is covered by the Open Government Licence which sets out the terms and conditions for using government data. <https://www.nationalarchives.gov.uk/doc/open-government-licence/version/3>

Use of the address and mapping data is subject to Ordnance Survey public viewing terms under Crown copyright and database rights 2025 AC0000807064. <https://flood-map-for-planning.service.gov.uk/os-terms>



Flood map for planning

Your reference

Unspecified

Location (easting/northing)
393954/161350

Scale
1:2,500

Created
29 Sep 2025 12:01

-  Selected area
-  Flood zone 3
-  Flood zone 2
-  Flood zone 1
-  Flood defence
-  Main river
-  Water storage area



0 20 40 60m

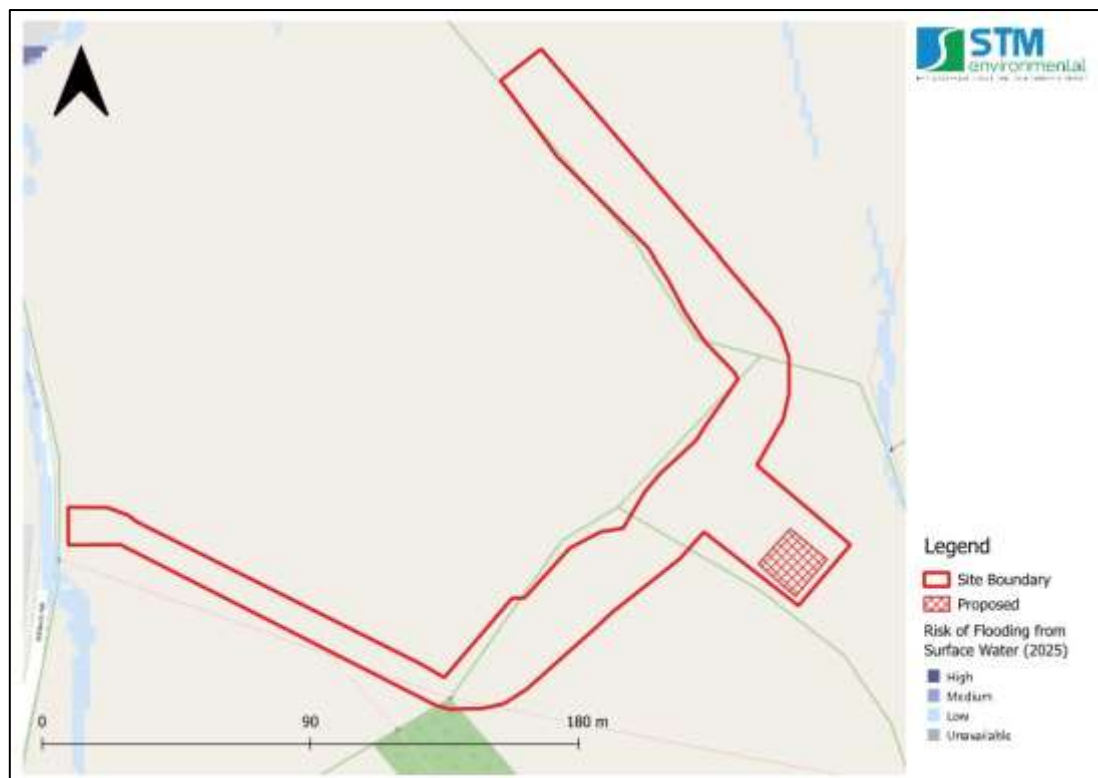
11.3.2 Long Term Pluvial Flood Risk Map – Present Day (2025)



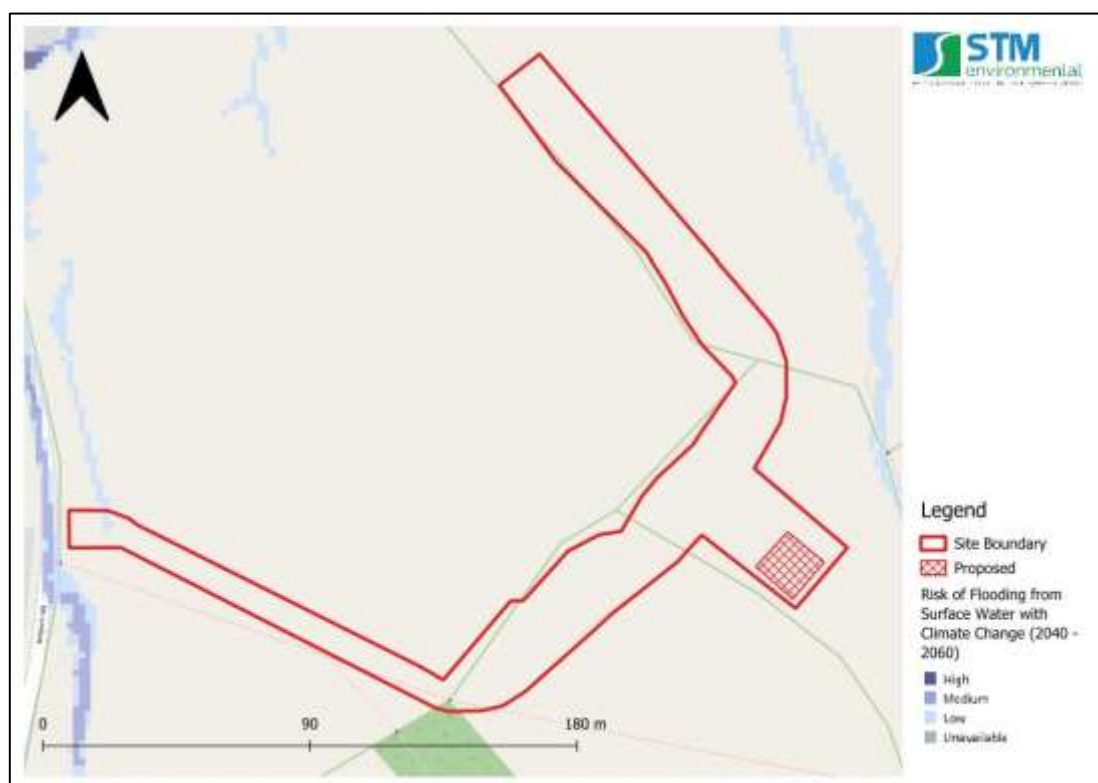
11.3.3 Long Term Pluvial Flood Risk Map – Climate Change (2040 – 2060)



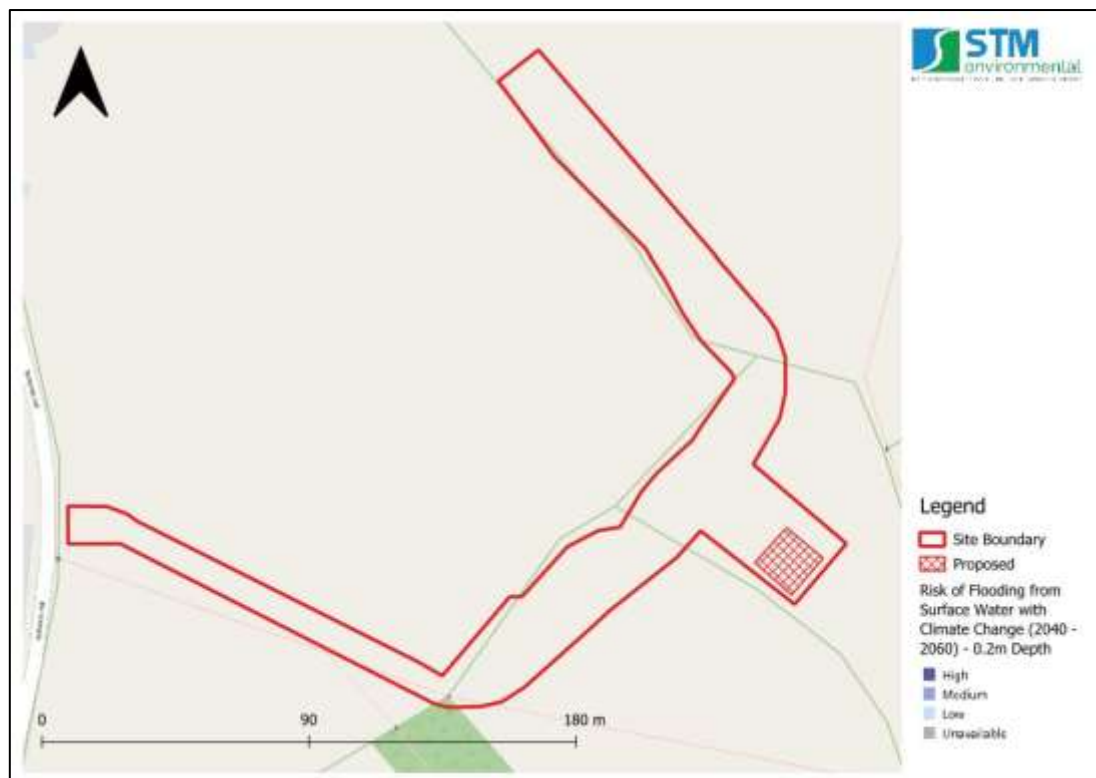
11.3.4 Surface water flood depth – Present Day (2025)



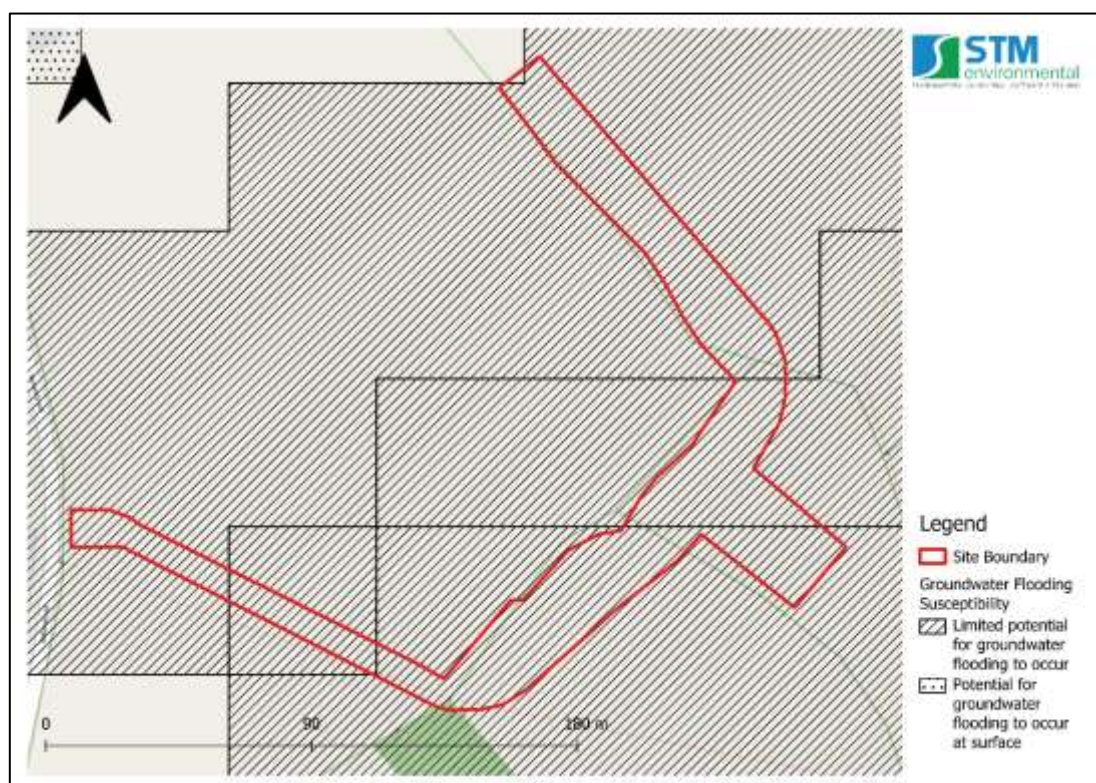
11.3.5 Surface water flood depth – Climate Change (2040 – 2060)



11.3.6 Surface water flood depth – Climate Change (2040 – 2060) – 0.2m Depth



11.3.7 Groundwater flooding susceptibility (Source: BGS, 2016).



11.4 Appendix 4 – Runoff Rate and Storage Calculations

11.4.1 FEH Method

Pre-development discharge

Site Makeup: Greenfield

Greenfield Method: FEH

Positively Drained Area (ha): 0.846

SAAR (mm): 688

Host: 1

BFIHost: 0.409

Region: 6

QBar/QMed conversion factor: 1.136

Betterment (%): 0

Calc

QMed (l/s): 3.1

QBar (l/s): 3.5

Load

Return Period (years)	Growth Factor	Q (l/s)
1	0.85	3.0
30	2.40	8.3
100	3.19	11.1

11.4.2 MRM (No SuDS)

Pre-development discharge

Site Makeup	Brownfield	OK
Brownfield Method	MRM	Cancel
Contributing Area (ha)	0.845	
PIMP (%)	23	
CV	0.750	
Time of Concentration (mins)	5.00	
Betterment (%)	0	
	Calc	

Return Period (years)	Q (l/s)
2	2.2
30	5.8
100	7.2

Note: FEH point downloaded from
Only XML file for
FEH-22 is the correct
this should be used
ReFH2 legacy
ReFH2 – Cont

11.4.3 MRM (SuDS)

Pre-development discharge

Site Makeup	Brownfield	OK
Brownfield Method	MRM	Cancel
Contributing Area (ha)	0.845	
PIMP (%)	5	
CV	0.750	
Time of Concentration (mins)	5.00	
Betterment (%)	0	
	Calc	

Return Period (years)	Q (l/s)
2	0.5
30	1.3
100	1.6

Note: FEH point downloaded from
Only XML file for
FEH-22 is the correct
this should be used
ReFH2 legacy
ReFH2 – Cont

11.5 Appendix 5 – Drainage Asset Search

No sewers available.

11.6 Appendix 6 – Details of Proposed Of SuDS

11.6.1 Rainwater Harvesting

See next page.

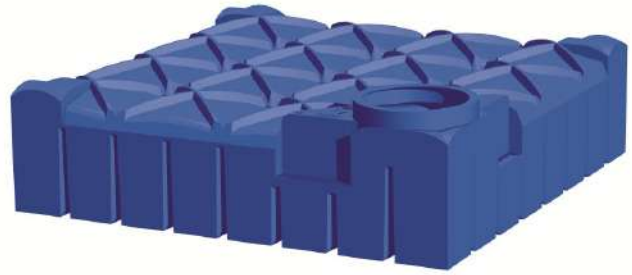
Installation Manual for the F-Line underground tank

1,500 litre

3,000 litre

5,000 litre

7,500 litre





Tank Dimensions and inverts

With the tank you will have received one of three different shafts dependent on your order. Please note which has been received and refer to the relevant shaft in the grid below :

- VS20 – 235mm shaft and pedestrian lid
- VS60 – 635mm shaft and pedestrian lid - The overall height difference below is because up to 400mm can be cut off the 635mm shaft on site so as to achieve your exact invert level
- Driveable shaft & lid – Steel lid and shaft for vehicle loading

	1500 L	3000 L	5000 L	7500 L
Weight KG	80	170	250	310
Length	2400	2400	2960	3340
Width	1200	2400	2220	2310
Overall Height (VS20 – 235mm shaft)	1015	1015	1350	1415
Overall Height (VS60 – 635mm shaft)	1015 – 1415	1015 – 1415	1350 – 1750	1415 – 1815
Overall Height (Driveable shaft and lid)	1415	1415	1750	1815
Ground to Invert (VS20 – 235mm shaft)	320	320	345	310
Ground to Invert (VS60 – 635mm shaft)	320 – 720	320 – 720	345 – 745	310 – 710
Ground to Invert (Driveable shaft & lid)	720	720	745	710
Invert to Outlet	162	162	162	162

Excavation

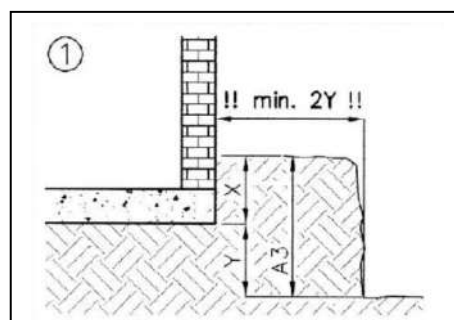
	1500 L	3000 L	5000 L	7500 L
Length	2800	2800	3360	3740
Width	1600	2800	2620	2710
*Overall Height VS20	1115	1115	1450	1515
*Overall Height VS60	1115 – 1515	1115 – 1515	1450 – 1850	1515 – 1915
*Overall Height Driveable shaft & lid	1515	1515	1850	1915

*The overall excavated height allows for a base of 100mm compacted aggregate

1. Location

1.1 Position to the building

- The excavation must not be within the minimum distance to the building. See Image 1.
- The tank may not be built over by any loads greater than vehicle loads.



Please refer to the table on Page 2. A3 relates to the 'Excavated Overall Height' dependent on shaft and tank type

1.2 Traffic Conditions

- Loading Class A15 e.g pedestrian or cyclist – The standard pedestrian lid is suitable.
- Loading Class B e.g car, minibus, max axle load of 2.2 tonnes – Vehicle loading shaft and lid required. Minimum distance from top of tank body to earth surface must be 600mm

1.3 Ground conditions

- The tanks may lie in ground water and / or surface water up to the top of the body of the tank. Please refer to the table below to see the maximum depth dependent on your tank and shaft type.

	1500 L	3000 L	5000 L	7500 L
Max water table depth (VS20 – 235mm shaft)	365	365	430	290
Max water table depth (VS60 – 635mm shaft)	365 - 765	365 – 765	430 - 830	290 - 690
Max water table depth (Driveable shaft & lid)	765	765	830	690

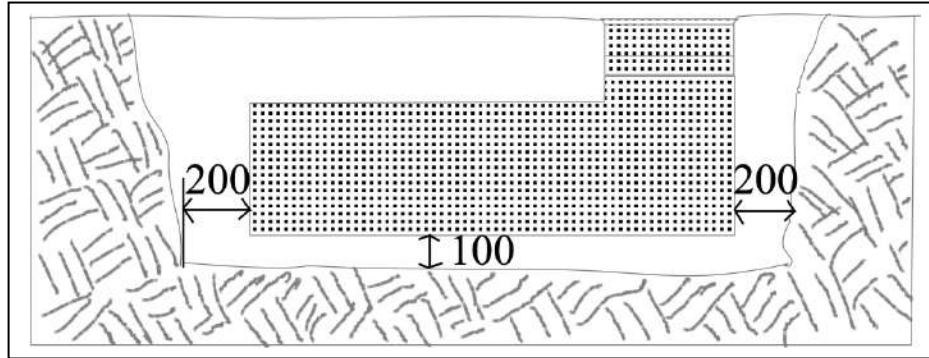
1.4 Hillside location

- The soil within the area where the tank is to be positioned must be checked for possible soil movement (DIN 1054 edition 1/2003, E DIN 4084 edition 11/2002) and if necessary will need to be secured with a supporting structure (eg retaining wall)
- Consultation with local authorities is recommended.

1.5 Installation details

1.51 In clay ground conditions:

- The excavated area should be wide enough to allow the compression of the filling material (200mm) See Image below.



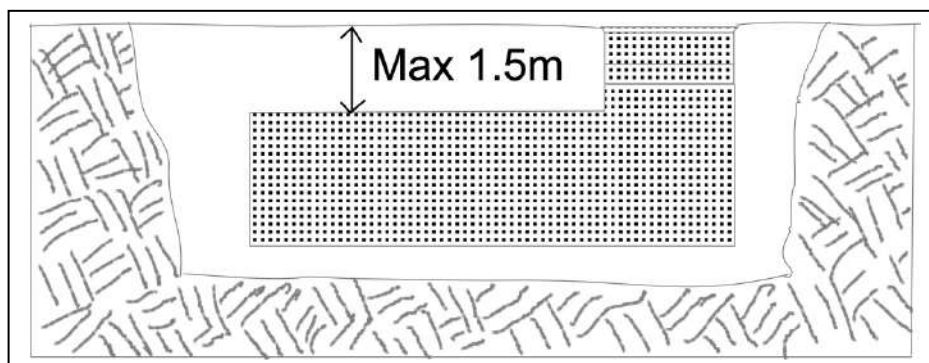
- With installations deeper than 1.75m (ground to base of tank) use 500mm width of the filling material.
- The tank should be covered with at least 300mm of filling material.

1.52 In loose ground conditions:

- Up to 1.75m depth of excavation use 200mm of filling material around the sides of the tank.
- With installations deeper than 1.75m use 500mm width of the filling material
- The tank should be covered with at least 300mm of filling material

1.6 Further criteria

- Existing pipelines, pipes, vegetation and other specifics must be considered so that damage or hazards will be avoided.
- The maximum soil coverage on top of the tank body is 1.5m
- If it is not guaranteed that the ground water level will remain below the permitted maximum level, a drainage system must be installed around the tank, which reliably drains the water. If a drainage system is not possible then contact your supplier about an alternative tank.





2. Installation

2.1 Backfill around and below the tank

- Backfill material around the tank has to be well compacted and permeable to water allowing close packing and no damage to the surface of the tank
- If the filling material contains sharp or sharp-edged components, the wall of the tank must be protected by a sandy coating.

2.1.1

- Gravel mixtures are the preferred filling material. The recommended sizes 8mm-16mm

2.1.2

- Concrete gravel with a particle size of up to 16mm is recommended for use in clay / loam soil conditions with ground water and high water table.
- When ground water and a high water table are present it is important to ensure good compaction when applying the filling material.

2.1.3

- Stone Chippings – crushed rock particles between 4mm and 16mm in size are suitable filling material. However due to the sharp edges the tank must be protected against damage, for example using a sand coating.

2.1.4

- Excavation – sand and gravel mixtures with mixed particle sizes is suitable as a filling material providing they meet the criteria listed under 2.1

2.1.5

- Top soil, clay, loam and other types of cohesive soils are not suitable as filling material.

2.2 Backfill on top of the tank

- Excavated soil or other material can be used if it is stable and permeable

2.3 Backfilling and compaction methods

- The backfilling and compaction methods to be used are described in Section 3 (Installation Instructions)

2.3.1

- Adding water to the filling material is not recommended as this will make the compacting unstable
- The base layer for driveable situations must use a grain size of 2/45

2.4 Pipes

2.4.1

- The feed pipe should be laid with a fall to the tank of greater than 1 degree
- Ensure that underground rainwater pipes come from sealed gullies (do not use open gullies)

2.4.2

- The overflow pipe / drain pipe should have a deeper fall away from the tank than the fall from the feed pipe to the tank

2.4.3

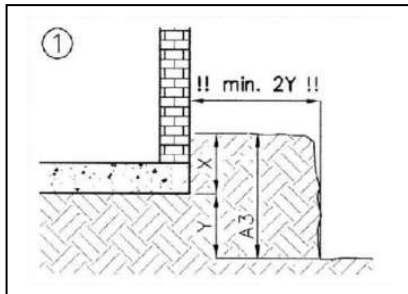
- The service pipe is to be installed using the provided seals to ensure a tight fixture to avoid contaminants entering the tank. All electrical and other cables are laid through this service pipe back to the property.

2.4.4

- The pipes must be laid in such a way to avoid frost damage.

3. Installation Instructions

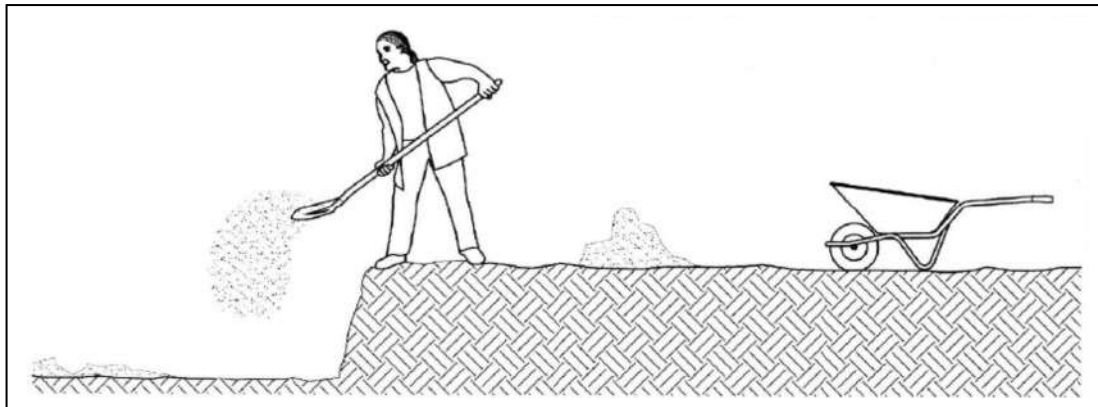
1. Establish distance from the property.



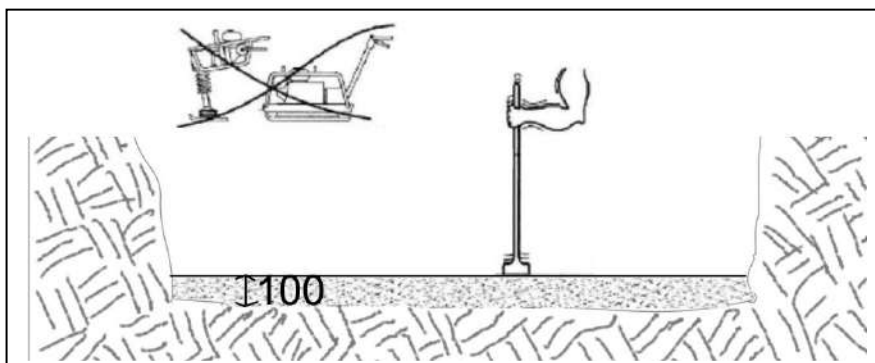
2. Dig hole



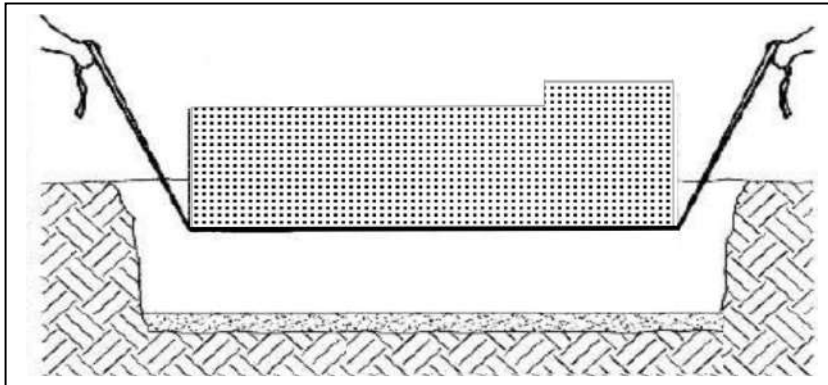
3. Lay 100mm base



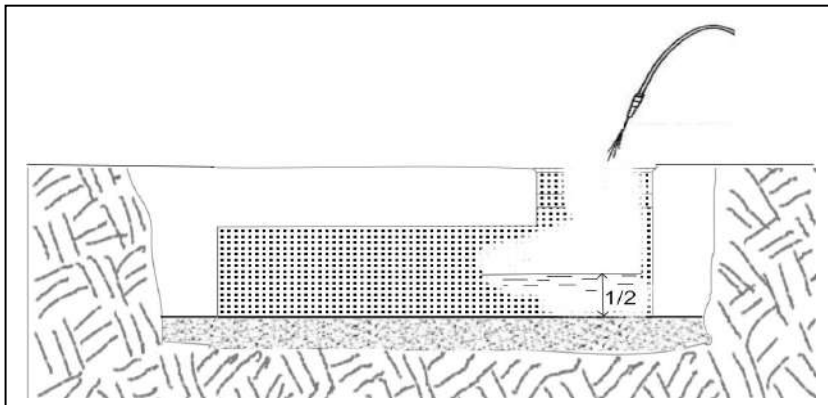
4. Compact the base by hand only. Ensure you have a level base.



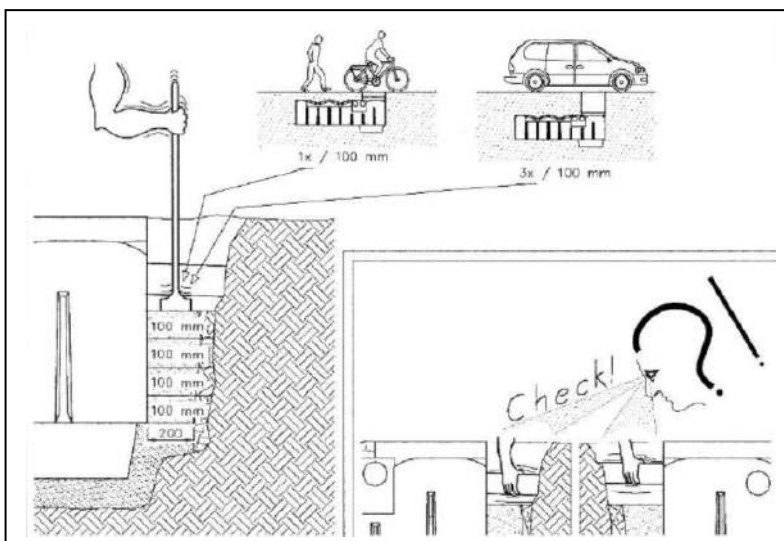
5. Lower the tank carefully into the hole ensuring that you are achieving the necessary widths around the tank for the filling material.



6. Fill the tank with water up to half way

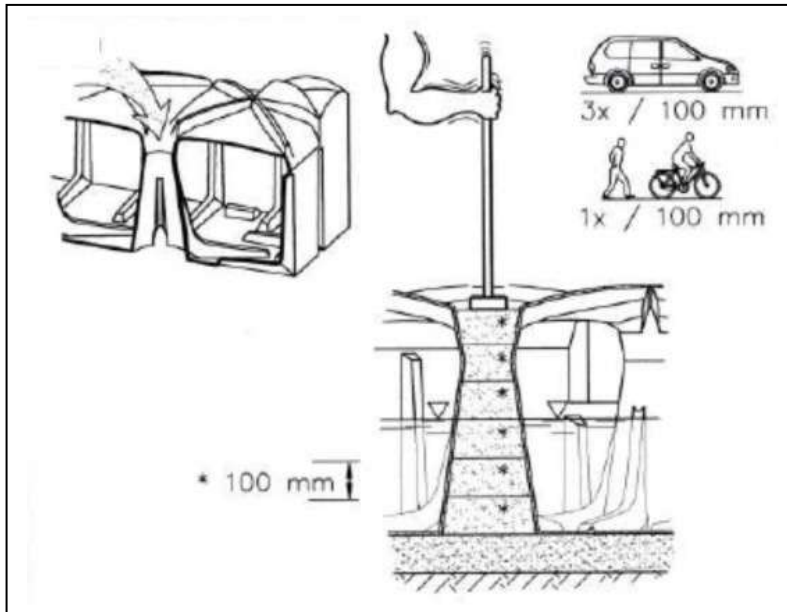


7. Apply filling material



- Do not use a mechanical whacker plate.
- Hand tap the material to compress it.
- Lay in 100mm layers for pedestrian install
- Lay in 300mm layers for driveable install
- Check to ensure the minimum width between the tank and excavation wall is correct (min 200mm)

8. Hand compress the filling material into the central columns



To link tanks together do the following:

- Drill a hole using a 127mm drill bit into a flat part of the tank at low level.
- Insert the supplied grommets (seals) into the hole.
- Feed a 4" pipe into the hole allowing at least 500mm to be inside of the tank.
- Use washing up liquid if necessary to assist with pushing the pipe through the grommet.

NOTES :

- Please refer to the individual installations documents for the shafts, extension sleeve and driveable shaft and lid.

11.6.2 Rainwater Gardens

See next page.

Stormwater Solutions for Homeowners Fact Sheet: Rain Gardens



Stormwater is rainwater and snowmelt that runs over the ground, picking up pollutants along the way—such as oil from roadways, silt and sand from exposed soil, nutrients from fertilizers, bacteria from pet waste, and pesticides from lawns. These pollutants are not treated or removed when the stormwater flows through a storm drain or directly to the nearest body of water, resulting in stormwater pollution that can contaminate shellfish beds and swimming areas, cause algae blooms and fish kills, and otherwise impact people, wildlife, and ecosystems. This runoff can also cause flooding and erosion on your property and beyond. To help address these problems, the Massachusetts Office of Coastal Zone Management (CZM) has developed Stormwater Solutions for Homeowners, a series of fact sheets on techniques to control runoff on your property and reduce stormwater contamination of local waters.

Introduction

Rain gardens are specially designed and planted depressions in the ground that collect, filter, and treat stormwater. These slightly sunken gardens allow collected water to be taken up by plants or slowly infiltrated (i.e., filtered into the ground), reducing the amount of water running off site. Rain garden soils—which are typically amended with mulch and sand to promote proper moisture levels and drainage properly—also remove pollutants (including metals, nutrients, sediments, oils/grease, and organic matter) before they reach groundwater or flow to coastlines and local waterbodies. By preventing stormwater from running into roads, storm drains, and waterways, rain gardens may also help reduce localized flooding and erosion. Rain gardens are an excellent choice for most properties and are a potential do-it-yourself project with many options for shape, plantings, and size (even small rain gardens provide great benefits). Planting a rain garden with flowering and fruiting plants, shrubs, and trees will also provide visual interest, as well as food and habitat for wildlife (see “Native Plants for Rain Gardens in Massachusetts” at the end of the fact sheet for recommendations, including options for coastal sites).



A rain garden planted along the road collects and filters stormwater before it runs off and drains to local waterbodies.

Rain gardens can be strategically located to collect and treat water flowing from roof downspouts, paved areas, or sump pumps, helping to reduce drainage problems and soggy areas in your yard—and because rain gardens more effectively capture and absorb rainwater than lawns, they make an excellent runoff-control alternative for yard areas. Rain gardens do require an appropriate soil depth to effectively treat stormwater, so they may not be suitable in areas with poorly drained or clay soils, ledge, or a high groundwater table. Be sure to follow the guidelines in this fact sheet for siting a rain garden to ensure success and avoid harmful effects.

Do You Need a Permit?

For properties near beaches, coastal banks, dunes, floodplains, rivers, salt marshes, wetlands, and other “resource areas” protected under the Massachusetts Wetlands Protection Act,* rain gardens can be particularly beneficial for helping to reduce stormwater impacts. Projects directly next to or within these resource areas, however, are likely to require a permit through the local Conservation Commission. To maximize benefits and avoid impacts to resource areas and adjacent properties, permitted projects must be properly designed, installed, and maintained. For example, rain gardens near coastal banks should be sited so there is no potential for infiltrated water to break out on the bank face and cause erosion problems. Also, a sufficient depth of soil must be maintained between the base of the rain garden and the water table to allow for proper filtration and treatment. Rain gardens must not be sited within wet resource areas, such as marshes, swamps, bogs, rivers, streams, ponds, and vegetated wetlands. During the construction of the rain garden, impacts must be minimized by providing erosion and sedimentation controls. The Massachusetts Department of Environmental Protection’s [*Structural BMP Specifications for the Massachusetts Stormwater Handbook \(Volume 2, Chapter 2\)*](#) (PDF, 6.5 MB) provides additional information and design requirements for stormwater control projects proposed in wetland resource areas and buffer zones. Homeowners are encouraged to contact their local Conservation Commission before undertaking any work to determine whether a resource area exists, what permitting requirements may apply, and how to avoid impacts.

* MGL Chapter 131, Section 40 and corresponding regulations at 310 CMR 10.00.

Impacts to Neighboring Properties

Stormwater management practices must be designed to responsibly manage runoff from your property without transferring problems to neighboring properties, roads, and municipal drainage systems. Rain gardens, vegetated swales, and other techniques that collect and hold stormwater have the potential to overflow “muddy” water in major storms. When designing these options, be sure that there is enough area on your property to effectively capture and treat any overflow onsite. Management practices that redirect or divert stormwater—such as disconnecting/redirecting downspouts or re-grading the land surface—can similarly cause flooding problems in roadways or neighboring yards, basements, or leach fields (potentially causing a septic system failure). These projects must therefore be designed to ensure that no additional stormwater is transferred offsite. Carefully following design guidelines in the Stormwater Solutions for Homeowners fact sheets will help you avoid impacts to neighboring properties. If in doubt about offsite impacts, consult a professional, such as a civil engineer or landscape architect.



Size and Location for a Rain Garden

Even small rain gardens capture and treat stormwater, so a project of any size can be beneficial on your property. The “Technical Specifications for Calculating Rain Garden Size” section on page 10 of this fact sheet provides some advanced, optional steps for calculating a specific rain garden size for treating runoff. As a general rule, rain gardens should be at least 1/8 to 1/3 the size of the drainage area (i.e., the area that drains runoff to the rain garden) and 3-8 inches deep to fully treat stormwater. (The specific size needed to fully treat stormwater will vary depending on your soil type and slope, which affects how well water infiltrates into the ground—see the last two bullets of this section or the “Technical Specifications” section for details.) When choosing the rain garden location, follow these steps:

- **Find places where rain or runoff can easily be collected** - Look for relatively flat areas in your yard that are downslope from roof downspouts and impervious surfaces (i.e., surfaces that do not allow water to filter into the ground, such as rooftops or driveways). Rain gardens should be located at least 10 feet away from home foundations and at least 50 feet away from septic systems or wells. If necessary, you can more efficiently direct water to the rain garden by adding extensions to downspouts or piping water underground. Directing water through rocky or grassy drainage swales is another option to convey water while providing additional infiltration (for more information on swales, see [Stormwater Solutions for Homeowners Fact Sheet: Vegetated Swales](#)). Be sure that any overflow from the rain garden will not run onto neighboring properties or roadways. Also, be sure that all components of the project are located on your property and not the road right-of-way.

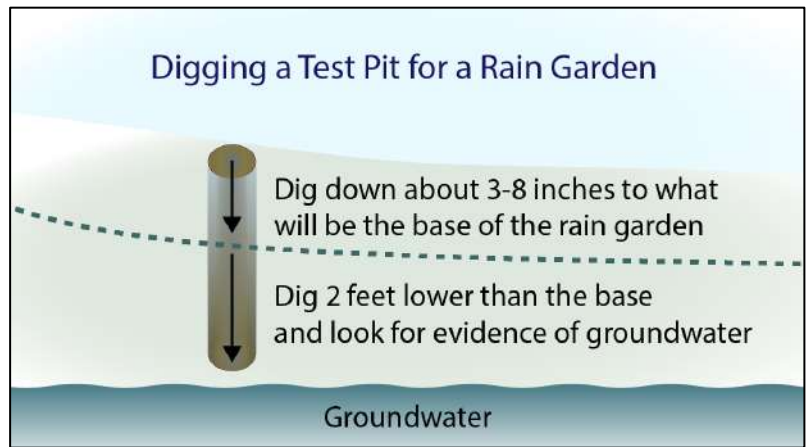


Water from a roof downspout runs through a rocky swale and into this small residential rain garden. The three photos show the sequence as native plants grew and filled in over time.

- **Check for groundwater** - Generally, at least 2 feet of soils are needed between the bottom of the rain garden and the water table to effectively filter out pollutants and protect groundwater. To check if the water table is too high, wait until the groundwater is normally at its highest (in the spring months, typically April through May), but not immediately after a heavy rain. Then, dig a hole 2 feet deeper than the planned base of your rain garden (see the “Digging a Test Pit for a Rain Garden” diagram). Leave the hole open for at least an hour, and if water seeps in or if you see soil mottling (a blotchy pattern of red, orange, or yellow that differs from the rest of the soil, indicating prolonged soil saturation from groundwater), gley (a sticky, waterlogged soil that is a green-blue-gray color), or organic muck, the location is unsuitable for a rain garden. An alternative to digging a hole is to drive

rebar or a pipe into the soil and then pull it out and check if it is damp (like using an oil dipstick). If signs of groundwater are found, you will need to try another location.

- **Ensure the water drains properly** - A rain garden will not drain properly when located too close to the groundwater level, in an area with clay or silty soils, or in a low spot that tends to collect standing water. (Please note, however, that placing a rain garden directly uphill from soggy, low spots can be ideal.) You can assess the drainage rate by digging a hole at least 1-2 feet deep (again, this is best done in the spring, and you can use the same hole you dug to check for groundwater). If water seeps into the hole within an hour, the site does not drain properly. If the hole stays dry, fill it with water and then time how long it takes the water to seep into the ground. If it drains in less than 24 hours, the location properly drains. If it takes more than 24 hours or does not fully drain, try another location or amend the soil to improve drainage (additional information on amending soils is given in the "Rain Garden Base" section).
- **Determine the soil type** - Soil type also affects how well the rain garden will drain. A "ribbon test" can be used to determine soil type—dig down below the topsoil (since organic matter can interfere with results), grab a handful of soil, roll it in a ball, and squeeze. If the soil sticks together and forms a clump (or "ribbon") more than 1.5 inches long, it is clay soil with low infiltration rates. If it forms a weak ribbon that breaks at a length of approximately 1.5 inches or less, it is a silty soil with medium infiltration rates. Sandy soil, which has high infiltration rates, will not form a ribbon at all. The type of soil and its infiltration rate will help determine whether soil amendments are necessary and can be used to help determine the ideal size for a rain garden.



Rain Garden Base

Follow these instructions to build the rain garden base:

- **Dig/excavate the base** - Mark the perimeter of the rain garden. Then remove the sod, grass, or other vegetation and dig out the rain garden area to a depth of 3-8 inches. For larger rain gardens, an excavator may be needed to remove soil or regrade the ground surface. (When using heavy equipment, be careful to avoid compacting the soil, which reduces infiltration and limits the growth of plants.) To minimize potential erosion, ensure that the rain garden base is level so the water spreads out and drains evenly. You may also grade the rain garden base so that it pitches slightly to the center to help avoid washouts and erosion along the edges.
- **Amend the soils** - Rain garden soils need to retain enough moisture for plants to grow, but also provide enough drainage so that water does not pool for extended periods. For ideal soil conditions, use 50-60% sand, 20-30% topsoil, and 20-30% shredded bark mulch—blended together as much as possible. (Triple shredded mulch should be used because it can be incorporated into the soil much faster than coarser mulch, which helps reduce compaction and improve water infiltration.) Mixing compost with rain garden soils is typically not recommended due to compost's high phosphorus content. If the ribbon test showed that your soils are high in clay and silt, dig

***Dig Safe** - At least 3 days before you plan to dig even a small hole in your yard, call [Dig Safe](#) at 811 for professional assistance in determining the location of underground utility lines!*

down an additional 6-18 inches and replace the soil with a layer of gravel or crushed stone covered with the recommended mix of sand, topsoil, and shredded mulch. (Once these materials are added, you can perform another drainage test to see if water infiltrates within 24 hours.) In some cases, you may be able to simply add amendments (such as sand) to increase the infiltration capacity of the rain garden. Soils can also be topped with a layer of bark mulch (either before or after planting) to help retain moisture and nutrients while preventing erosion and compaction. (Triple shredded mulch is also recommended for this top layer since the finer fibers interlock, helping the mulch to stay in place and providing better weed control; do not use light-weight wood chips or straw because they are easily washed away.)

- **Build a berm** - A berm (a raised barrier) built on the downhill side of the rain garden is an option to help hold water and give it time to seep into the soil. The soil removed when digging the rain garden base can be used to build the berm. If a berm is used, it should be no more than 6-8 inches high—just enough for stormwater to pond to improve infiltration into the ground.



A berm built around the downhill sides of a rain garden helps hold stormwater. The rain garden soils have been amended with sand and a planting soil mix.

- **Prevent erosion** - To help prevent runoff from washing out the mulch or soil during heavy rain, the rain garden should be relatively level or only slightly sloped and contained by a berm. In addition, the mulch used should be finely shredded and the ground surfaces should be well vegetated. During construction, you may want to install a temporary erosion-control blanket made of natural fibers over the rain garden to protect the soil until the vegetation becomes established (the natural fibers in the blanket disintegrate in 6-24 months, and the root systems of the plants take over the job of stabilizing the site; for details, see CZM's [StormSmart Fact Sheet 5: Bioengineering - Natural Fiber Blankets on Coastal Banks](#)). Optional approaches for slowing the speed of runoff flowing into the rain garden include spreading a layer of crushed stone on the uphill side of the area or creating a small stone drainage path (or drainage swale) from the source of the runoff to the rain garden (see the illustration on page 7).

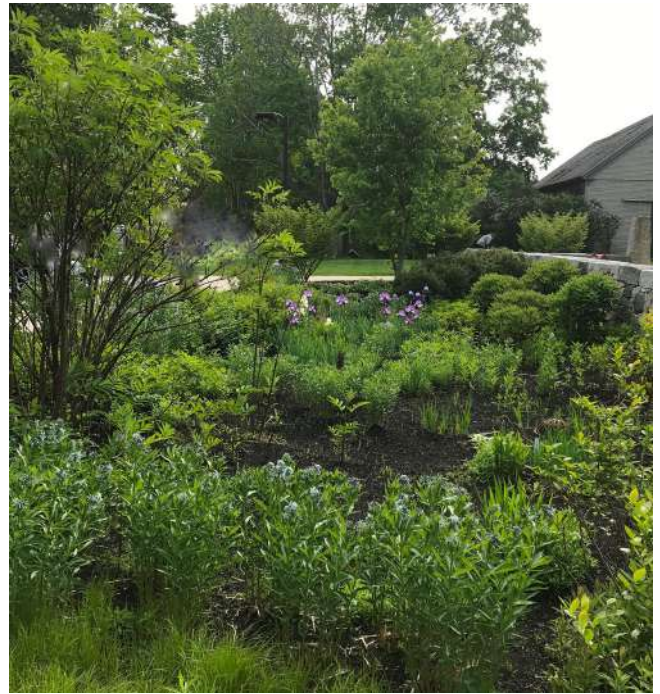
Rain Garden Plantings

Follow these guidelines to improve success of rain garden plantings.

- **Species selection and placement** - Choose hardy native species, which are well adapted to local conditions and typically do not require the use of chemical fertilizers and pesticides. Ideally, your rain garden should include a variety of plant species to ensure survival and diversity. All plants will need to tolerate some fluctuation in water levels and be able to withstand both wet and dry conditions (including droughts when soils drain completely for extended durations). Wet-tolerant plants should be placed in the wettest locations, such as in the deepest areas and where the water enters the rain garden. Plants better suited to moderate moisture or dry conditions should be placed on the edges and higher areas of the rain garden. To reduce initial planting costs, younger plants can be used—but since young plants do not necessarily thrive in standing water, for the first year you may need to dig out a small opening in your soil berm to allow water to drain. Rain gardens may also be planted with native grasses and mowed periodically. (Rain gardens should be mowed infrequently to

prevent soil compaction and to allow the growth of longer grasses and deeper root systems, which more effectively treat stormwater.) The “Native Plants for Rain Gardens in Massachusetts” box at the end of this fact sheet lists plants that are appropriate for different moisture levels. For additional plant options, see the [UMass Extension Rain Gardens fact sheet](#).

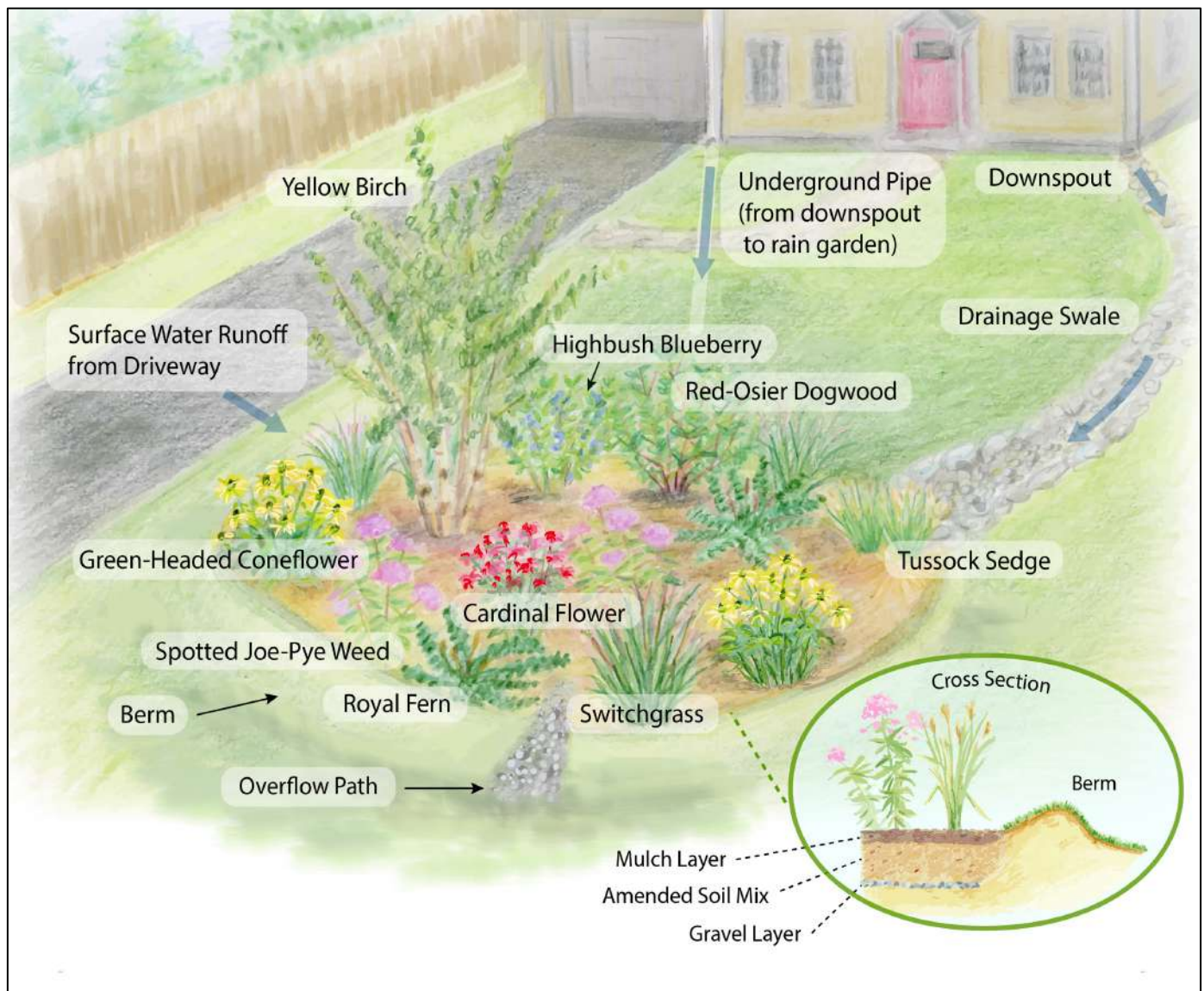
- **Aesthetics** - By planting trees, shrubs, perennials, and grasses that offer color, texture, light, and movement, rain gardens can be a source of beauty in your landscape. Planting a mix of species with different heights, forms, and flowering times can enhance appearance. Other useful design tips include placing taller flowers, shrubs, or trees behind shorter ones and arranging the plants in odd-numbered groupings. Spread plants out during the initial installation to give them room to grow—though it might look sparse at first, the plants will fill in and thrive throughout the years. Before digging, place the plants on top of the ground and move them around to find the best configuration. You can also design the shape of your rain garden to enhance the landscape, such as by creating a striking linear shape along a roadway or a more traditional round or kidney-shaped garden as landscape focal points.
- **Planting instructions** - Plant each species at the appropriate time of year (generally spring or fall when more moisture is available) and follow the specific planting and care instructions.



This rain garden was planted with a variety of native trees, shrubs, grasses, and perennials to tolerate local conditions, provide wildlife habitat, and control runoff.



Butterfly Milkweed (left), Red Columbine (middle), and White Turtlehead (right) can all be planted in the upper reaches of a rain garden where water tends to drain completely. Their long-blooming flowers are a colorful and attractive addition to a rain garden and an important nectar source for butterflies, bees, and hummingbirds.



This rain garden with native plants was sited at a low point in the yard to treat runoff from the driveway and rainwater from two roof downspouts (water is directed through a drainage swale from one downspout and an underground pipe for the other). The cross section shows the rain garden base—a layer of gravel, a 6-18" layer of soil mix, and a 2-3" layer of triple shredded mulch. The berm was built with soil removed when digging the rain garden base. An overflow path of crushed stone helps release heavy volumes of water in large rain events.

Management

These management steps can help ensure the long-term success of rain gardens.

- **Weed** - Weed newly planted rain gardens regularly to help the plants grow successfully and out-compete encroaching lawn grass and other undesirable plants. In particular, check for invasive species and remove them as soon as possible (see the Mass.Gov [Invasive Plants website](#) for more on identifying and managing these plants). Once the rain garden becomes established, less weeding will be required.
- **Prune, cut, and replace plants** - Only minimal pruning and cutting, such as removing dead or diseased limbs, is needed to keep established rain gardens in proportion and healthy. Avoid cutting or deadheading spent perennials in the fall so that they can continue to provide a seed source for birds and habitat for beneficial insects over the winter. Finally, when necessary, replace plants that have died.

- **Water** - Rain garden plants typically do not require watering once they become established. Newly planted vegetation, however, needs careful watering until the limited root system can effectively find and absorb water from the surrounding soils, particularly when planted in the hot, dry summer months. To ensure plant survival, follow the specific watering instructions on plant labels and seed packets. Adjust water levels if necessary for weather, time of year, and site conditions, such as soil type and sun and wind exposure (i.e., windblown areas, sandier soils, and dry, hot weather will warrant extra water). When watering larger perennials, shrubs, and trees, place an open hose (with a slow flow), a soaker hose, or drip tubing at the base of each plant, which will allow water to slowly seep into soils. You can water less each year, with only minimal watering needed in the third year, if at all. During long periods of drought, the rain garden will require watering. Use water that has been collected and stored in rain barrels to maximize your conservation efforts (see [Stormwater Solutions for Homeowners Fact Sheet: “Green” Lawn and Garden Practices](#) to find out how).
- **Greenscape** - Avoid using fertilizers, herbicides, and pesticides, and choose organic methods where possible (see [Greenscapes.org](#) for more information). [Stormwater Solutions for Homeowners Fact Sheet: “Green” Lawn and Garden Practices](#) has additional information on eco-friendly yard care methods that use less fertilizers and chemicals and promote the use of drought-tolerant native species that benefit the local environment.
- **Cover exposed areas with mulch or leaf litter** - If the soil dries out quickly, add 2-3 inches of organic bark mulch each spring to prevent moisture loss. (A finer mulch, such as triple shredded, is recommended.) Leaving leaf litter in place is another option for helping to retain moisture. Leaf litter also naturally fertilizes rain garden plants by releasing nutrients as the organic material decays and provides essential overwintering habitat for beneficial insects. Mulch and leaf litter can also help improve water infiltration and keep weeds down.
- **Remove sediment build-up** - Inspect rain garden areas once every 3-6 months, as well as after large storms, and remove excess sediment (such as silts) that may have accumulated from runoff. (Build-up of sediments decreases infiltration rates and smothers plants.)
- **Address any erosion impacts** - Inspect the area where water enters and exits the rain garden for signs of erosion and re-establish the vegetation or add gravel or pea-sized stone if needed to slow stormwater flow and reduce erosion impacts. Where berms show signs of washout or erosion, build them back up and replant with grass or other groundcover to stabilize the soils.
- **Minimize standing water** - To keep mosquitoes from breeding, check that water does not remain in the rain garden for longer than 24-36 hours. If water does not drain within this timeframe, create a temporary opening in the berm. If the problem persists, you may need to amend the soils to help improve infiltration. (Rain gardens with proper drainage, however, have the added advantage of serving as death traps for mosquito eggs and larvae when they regularly dry out!)
- **Expand rain garden size or create an overflow path as necessary** - If you find the rain garden is too small to hold and infiltrate the amount of water flowing into it, you can expand the size. Another option is to install a series of interconnected rain gardens or direct overflow to a drainage swale covered with crushed stone or stabilizing vegetation. To create an overflow path, dig a small channel (filled with a layer of gravel or pea-sized stone) from the rain garden to another rain garden or swale (for more on swales, see [Stormwater Solutions for Homeowners Fact Sheet: Vegetated Swales](#)). Make sure the runoff is not channeled directly to surface water, wetlands, municipal drainage systems, or your neighbor’s yard.

Additional Information

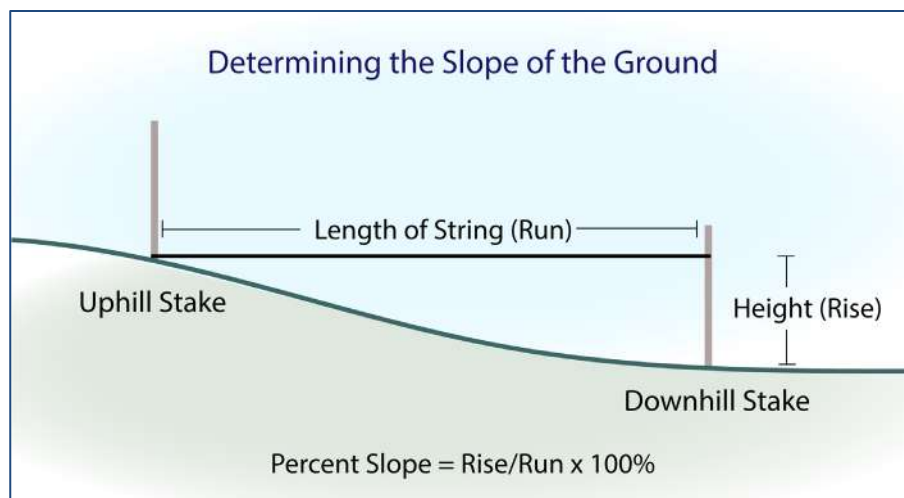
- For related fact sheets, see the CZM [Stormwater Solutions for Homeowners fact sheet website](#).
- The Massachusetts Executive Office of Energy and Environmental Affairs [Raingardens factsheet](#) (PDF, 1.2 KB), produced by GeoSyntec, describes how to design a rain garden and provides rain garden plant lists, sample plans, and photographs.
- The Massachusetts Department of Environmental Protection (MassDEP) [Structural BMP Specifications for the Massachusetts Stormwater Handbook \(Volume 2, Chapter 2\)](#) (PDF, 6.5 MB) has descriptions, design considerations, and pollutant removal efficiency information for various best management practices, including rain gardens.
- MassDEP's [Massachusetts Clean Water Toolkit](#) offers guidance on the prevention and control of nonpoint source pollution and gives links to many fact sheets, including [Bioretention Areas](#) (which use soil, plants, and microbes to treat stormwater before it is infiltrated or discharged).
- The [Think Blue Massachusetts website](#), part of a stormwater awareness campaign of MassDEP and the Statewide Stormwater Coalition, provides information to [residents](#), businesses, and developers about what they can do to reduce stormwater pollution in the environment, including methods for soaking up rainwater.
- [Massachusetts Watershed Coalition](#) has resources and information about protection and restoration of watershed ecosystems, including details, designs, and construction information on [rain gardens](#).
- New Hampshire's [Homeowner's Guide to Stormwater Management](#) (PDF, 4 MB) provides guidance to help homeowners manage stormwater on their properties and includes detailed information on rain gardens. Their [Soak Up the Rain program](#) also has useful tips and information on methods to minimize stormwater runoff.
- New Hampshire's [Native Plants for New England Rain Gardens](#) (PDF, 7 MB) identifies native plants that are adaptable, available, and have been successful for the northern New England region.
- The University of Connecticut's [Nonpoint Education for Municipal Officials \(NEMO\) program website](#) provides many useful stormwater resources, including a [Rain Gardens website](#) and a link to a mobile device app designed to help homeowners properly install a rain garden on their properties.
- The [Ecological Landscape Alliance website](#), which includes links to their newsletter, conferences, and webinars, offers design ideas and tips from professionals that install rain gardens and other ecological landscapes.
- The [Greenscapes web page](#) provides information on "green" lawn and gardening practices and includes a downloadable [Greenscapes Guide](#) that details information on how to use attractive, nature-friendly landscaping practices to reduce pollution, conserve water, support wildlife, and protect against climate change.
- Hingham's [Rain Garden Installation video](#) is an on-the-ground tutorial for building a rain garden, with details on how to dig and level the rain garden base, mix soils with compost, and select and install plants. *(Please note that compost is no longer recommended as a soil amendment for a rain garden; triple shredded mulch is recommended for its ability to stay in place, help reduce compaction, and lower nitrogen levels.)*
- The Association to Preserve Cape Cod's [Rain Garden video](#) showcases a recently installed rain garden as a natural and beautiful way to control storm water runoff and filter the groundwater.
- The U.S. Environmental Protection Agency (EPA) [Soak Up the Rain: Rain Gardens website](#) gives design details for rain gardens, including plant selection, soils, and maintenance requirements specific to Massachusetts.
- EPA's [National Stormwater Calculator](#) is a desktop application that estimates the annual amount of rainwater and frequency of runoff from a specific site. The calculator can also be used to help homeowners determine what mix of rain garden and other stormwater control options can be used to capture this runoff.
- CZM's [Coastal Landscaping website](#) provides information on landscaping coastal areas with salt-tolerant vegetation to reduce storm damage and erosion.

Technical Specifications for Calculating Rain Garden Size

While rain gardens of any size can provide benefits on your property, this section specifies how to more precisely calculate the size (depth and area) needed to fully treat stormwater from a typical storm in Massachusetts. Generally, a rain garden should be at least 1/8 to 1/3 the size of the drainage area to keep its water-level depths between 3-8 inches after a typical 1-inch rainfall. (Deeper water diminishes the ability of rain garden soils and plants to effectively treat and filter stormwater.) To specifically calculate the recommended size, follow these steps:

- 1. Drainage area** - First, identify the area that slopes toward the rain garden. Then, calculate the portion of that area with impervious surfaces, which include rooftops, driveways, patios, and other areas that do not readily absorb water (including lawns where soils tend to compact, making it difficult for water to infiltrate). For rooftops, only include the roof area that runs into the particular downspouts that flow to the rain garden. *For an example calculation, assume that **400 square feet** of driveway, walkway, and lawn are in the drainage area. In addition, a 40-foot by 30-foot roof has half of its area sloping toward and draining to the rain garden (40 feet x 30 feet x 0.5 = **600 square feet**). When added to the 400 square feet of other impervious surface, this makes for a total drainage area of **1,000 square feet**.*
- 2. Volume of runoff** - The rain garden should be built to hold runoff for a typical 1-inch rainfall. To calculate this figure in cubic feet, convert 1 inch to feet (1 inch ÷ 12 inches [per foot] = .08 feet). Then, multiply this number by the drainage area calculated in Step 1. *In this example, the volume of runoff from the drainage area is 1,000 square feet x .08 feet = **80 cubic feet**.* (This volume figure will be used in Step 7 to ensure that the size of the rain garden is sufficient.)

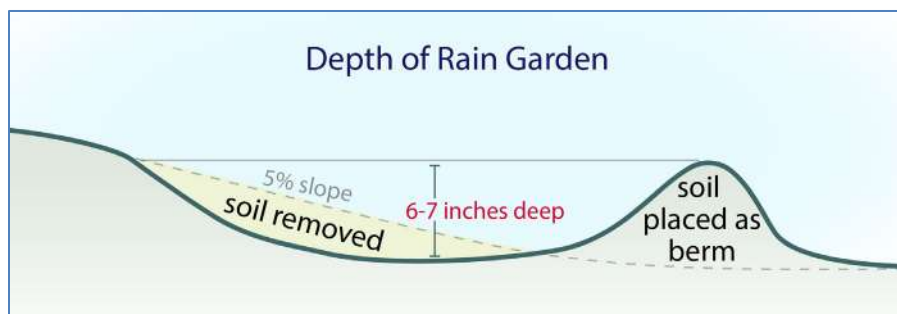
- 3. Slope** - The slope of the ground where the rain garden will be located affects how deep the rain garden needs to be. The slope is calculated using this formula: $(\text{rise} \div \text{run}) \times 100\%$. (The run is the rain garden length, and the rise is the difference in elevation along that length.) To find these measurements, place one stake on the uphill end of the proposed rain garden and another on the downhill end and tie a string between them. (Run the string from the base of the uphill stake horizontally to the downhill stake; use a line level to ensure the string is horizontal.) The run is the length of the string, and the rise is the height measured from the ground level to the string along the downhill stake. *For example, a string 6 inches high at the downhill stake and 120 inches long from stake to stake has a slope of 6 inches ÷ 120 inches x 100% = **5%**.*



This diagram illustrates the stake and string method for finding the ground slope at the location of the proposed rain garden.

4. **Depth** - Use this slope/depth chart to find the recommended rain garden depth based on the calculated slope. *In this example, a 5% slope would require a rain garden depth of 6-7 inches.*

SLOPE	DEPTH
< 4%	3-5 inches
5 - 7%	6-7 inches
8 - 12%	8+ inches



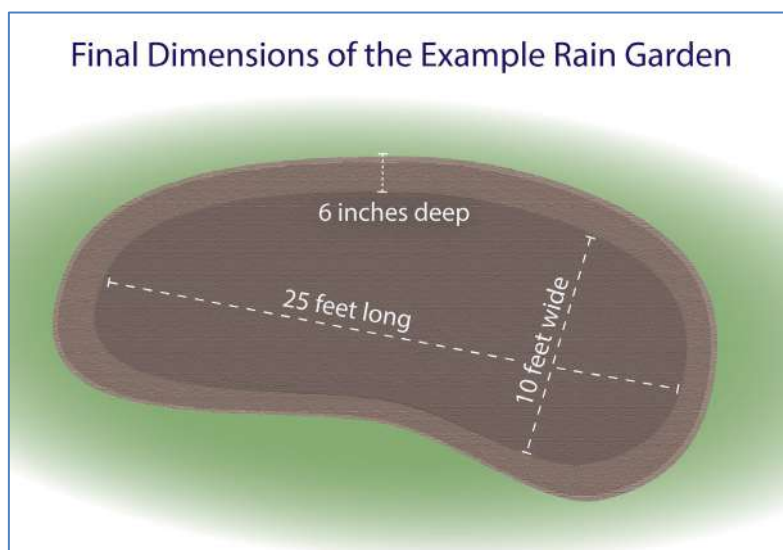
For a ground slope of 5%, a rain garden should be 6-7 inches deep. Soils can be removed from the uphill side of the slope to create the required depth and used to build a berm on the downhill side to contain the rain garden water.

5. **Size factor** - Once you know the appropriate depth, select the size factor for your soil type from this chart. *For example, if the soils were found to be silty during the ribbon test, the size factor would be 0.25 for the rain garden depth of 6-7 inches. (This 0.25 represents $\frac{1}{4}$ of the size of the drainage area and will be used in Step 6.)*

SIZE FACTOR	RAIN GARDEN DEPTH		
soil type	3-5 inches	6-7 inches	8+ inches
Sand	0.19	0.15	0.08
Silt	0.34	0.25	0.16
Clay	0.43	0.32	0.20

6. **Rain garden area** - Multiply the size factor by the drainage area calculated in Step 1 to determine the recommended square footage needed for the rain garden. *In this example, the drainage area of 1,000 square feet $\times$ 0.25 = 250 square feet.*

7. **Final dimensions** - Select an appropriate length and width to create a total rain garden area that is equal to or greater than the area calculated in Step 6, and then check that the final dimensions are sufficient. *For example, you could choose dimensions of 25 feet long by 10 feet wide to create a 250-square-foot rain garden. The final dimensions of our example rain garden would then be 25 feet long by 10 feet wide by 6 inches (or .5 feet) deep. This rain garden could hold up to 250 square feet $\times$.5 feet = 125 cubic feet of water, which can easily treat the 80 cubic feet of runoff from the drainage area (calculated in Step 2).*



The final dimensions for the example rain garden are 25 feet long, 10 feet wide, and 6 inches deep. This rain garden could hold approximately 125 cubic feet of water.

Native Plants for Rain Gardens in Massachusetts

	High-Moisture Areas	Moderate-Moisture or Dry Areas
Perennials and Grasses	Blue Flag Iris (<i>Iris versicolor</i>) Cardinal Flower (<i>Lobelia cardinalis</i>) Common Sneezeweed (<i>Helenium autumnale</i>) Golden Alexanders (<i>Zizia aurea</i>) Great Blue Lobelia (<i>Lobelia siphilitica</i>) Marsh Marigold (<i>Caltha palustris</i>) Royal Fern (<i>Osmunda regalis</i>) Sensitive Fern (<i>Onoclea sensibilis</i>) Soft Rush (<i>Juncus effuses</i>) Spotted Joe-Pye Weed (<i>Eutrochium maculatum</i>) Swamp Milkweed (<i>Asclepias incarnata</i>) Swamp Rose-Mallow (<i>Hibiscus moscheutos</i>) Sweet Flag (<i>Acorus americanus</i>) Tussock Sedge (<i>Carex stricta</i>) White Turtlehead (<i>Chelone glabra</i>)	Beebalm/Wild Bergamot (<i>Monarda fistulosa</i>) Boneset (<i>Eupatorium perfoliatum</i>) Butterfly Milkweed (<i>Asclepias tuberosa</i>) Culver's Root (<i>Veronicastrum virginicum</i>) Foamflower (<i>Tiarella cordifolia</i>) Foxglove Beardtongue (<i>Penstemon digitalis</i>) Green-Headed Coneflower (<i>Rudbeckia laciniata</i>) Indian Grass (<i>Sorghastrum nutans</i>)* Little Bluestem (<i>Schizachyrium scoparium</i>)* Meadowsweet (<i>Spiraea alba</i>) New England Aster (<i>Symphyotrichum novae-angliae</i>)* Pink Tickseed (<i>Coreopsis rosea</i>) Red Columbine (<i>Aquilegia canadensis</i>)* Seaside Goldenrod (<i>Solidago sempervirens</i>)* Switchgrass (<i>Panicum virgatum</i>)*
Shrubs and Trees	Buttonbush (<i>Cephalanthus occidentalis</i>) Red-Osier, Silky, Gray Dogwoods (<i>Swida</i> spp.) Smooth Alder (<i>Alnus serrulata</i>) Spicebush (<i>Lindera benzoin</i>) Swamp Rose (<i>Rosa palustris</i>) Sweetgale (<i>Myrica gale</i>) Sweet Pepperbush (<i>Clethra alnifolia</i>)* Winterberry (<i>Ilex verticillata</i>)*	Arrowwood Viburnum (<i>Viburnum dentatum</i>)* Black Chokeberry (<i>Aronia melanocarpa</i>)* Cranberry Bush (<i>Viburnum opulus</i>) Highbush Blueberry (<i>Vaccinium corymbosum</i>)* Inkberry (<i>Ilex glabra</i>)* Red Chokeberry (<i>Aronia arbutifolia</i>)* Serviceberry (<i>Amelanchier</i> spp.)* Yellow Birch (<i>Betula alleghaniensis</i>)

*These plants are tolerant of coastal conditions, such as salt spray and wind, and may also be appropriate in rain gardens near roadways treated with salt or other deicers during the winter.

www.mass.gov/coastal-water-quality-program

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Bethany A. Card, Secretary

Massachusetts Office of
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11.7 Appendix 7 - Drainage Modelling

11.7.1 Drainage Layout



Map Legend

	Surface Water Manhole		Geocellular Storage		Surface Water Pipe
	Surface Water Inspection Manhole		Rough Permeable Track		Perforated Pipe
	Flow Control Chamber		Hard Standing		Slot Drainage Channel
	Rainwater Down Pipe		Filter Strip		Overflow Flow Route
	Modeled Storage Structure		Soft Landscaping / Amenity Space		Drainage Gully Run
	Maintenance Access Point		Tarmac Roadway		Gravel Drainage Trench
	Permeable Paving Baffle		SuDS - Rain Garden / Bio Retention		Temporary Drainage Run
	450mm Check Dam		Shallow Swale 3m wide		

Project ID:
SWDS - 2025 - 000036
Date:November 2025

Site:
Land at Bollands Hill, Seend, Wiltshire, SN12 6NQ

Title;
Surface Water Drainage Plan

STM Environmental Consultants Ltd

Issue :No.1.0

By :M. Ashdown

11.7.2 Drainage Results

Design Settings

Rainfall Methodology	FEH-22	Time of Entry (mins)	5.00	Connection Type	Level Soffits	Enforce best practice design rules	x
Return Period (years)	1	Maximum Time of Concentration (mins)	30.00	Minimum Backdrop Height (m)	0.200		
Additional Flow (%)	0	Maximum Rainfall (mm/hr)	50.0	Preferred Cover Depth (m)	0.600		
CV	0.750	Minimum Velocity (m/s)	1.00	Include Intermediate Ground	✓		

Adoptable Manhole Type

Max Width (mm)	Diameter (mm)	Max Width (mm)	Diameter (mm)	Max Width (mm)	Diameter (mm)	Max Width (mm)	Diameter (mm)
374	1200	499	1350	749	1500	900	1800

>900 Link+900 mm

Max Depth (m)	Diameter (mm)	Max Depth (m)	Diameter (mm)
1.500	1050	99.999	1200

STM Links SW Link Type

Template	Freeform Carrier	Shape	Circular	Barrels	1	Auto Increment (mm)	75	Follow Ground	x
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Available Diameters (mm)

100 | 150

Nodes

Name	Area (ha)	T of E (mins)	Cover Level (m)	Diameter (mm)	Easting (m)	Northing (m)	Depth (m)
1	0.030	5.00	79.000	600	394003.890	161292.490	0.500
2			79.000	600	393991.062	161303.182	1.150
BR1			78.200	600	393986.207	161306.830	0.900
4			78.500	300	393979.484	161300.688	1.250
DummyOut			78.500	100	393977.666	161302.371	0.425

Links

Name	US Node	DS Node	Length (m)	ks (mm) / n	US IL (m)	DS IL (m)	Fall (m)	Slope (1:X)	Dia (mm)	T of C (mins)	Rain (mm/hr)
1.000	1	2	16.700	0.600	78.500	78.250	0.250	66.8	150	5.23	31.8
1.001	2	BR1	6.072	0.600	78.150	78.000	0.150	40.5	150	5.29	31.7
1.002	BR1	4	9.107	0.600	77.300	77.250	0.050	182.1	150	5.49	31.2
1.003	4	DummyOut	2.477	0.600	78.100	78.075	0.025	99.1	100	5.55	30.6

Name	Vel (m/s)	Cap (l/s)	Flow (l/s)	US Depth (m)	DS Depth (m)	Σ Area (ha)	Σ Add Inflow (l/s)	Pro Depth (mm)	Pro Velocity (m/s)
1.000	1.232	21.8	2.6	0.350	0.600	0.030	0.0	35	0.830
1.001	1.586	28.0	2.6	0.700	0.050	0.030	0.0	31	0.994
1.002	0.741	13.1	2.5	0.750	1.100	0.030	0.0	45	0.575
1.003	0.772	6.1	2.5	0.300	0.325	0.030	0.0	45	0.736

Pipeline Schedule

Link	Length (m)	Slope (1:X)	Dia (mm)	Link Type	US CL (m)	US IL (m)	US Depth (m)	DS CL (m)	DS IL (m)	DS Depth (m)
1.000	16.700	66.8	150	STM_Links_SW	79.000	78.500	0.350	79.000	78.250	0.600
1.001	6.072	40.5	150	STM_Links_SW	79.000	78.150	0.700	78.200	78.000	0.050
1.002	9.107	182.1	150	STM_Links_SW	78.200	77.300	0.750	78.500	77.250	1.100
1.003	2.477	99.1	100	STM_Links_SW	78.500	78.100	0.300	78.500	78.075	0.325

Link	US Node	Dia (mm)	Node Type	MH Type	DS Node	Dia (mm)	Node Type	MH Type
1.000	1	600	Manhole	Adoptable	2	600	Manhole	Adoptable
1.001	2	600	Manhole	Adoptable	BR1	600	Manhole	Adoptable
1.002	BR1	600	Manhole	Adoptable	4	300	Manhole	Adoptable
1.003	4	300	Manhole	Adoptable	DummyOut	100	Manhole	Adoptable

Manhole Schedule

Node	Easting (m)	Northing (m)	CL (m)	Depth (m)	Dia (mm)	Connections	Link	IL (m)	Dia (mm)
1	394003.890	161292.490	79.000	0.500	600				
						0	1.000	78.500	150
2	393991.062	161303.182	79.000	1.150	600		1	1.000	78.250
						0	1.001	78.150	150
BR1	393986.207	161306.830	78.200	0.900	600		1	1.001	78.000
						0	1.002	77.300	150
4	393979.484	161300.688	78.500	1.250	300		1	1.002	77.250
						0	1.003	78.100	100
DummyOut	393977.666	161302.371	78.500	0.425	100		1	1.003	78.075
								100	100

Simulation Settings

Rainfall Methodology	FEH-22	Winter CV	0.840	Drain Down Time (mins)	1440	Check Discharge Rate(s)	✓	100 year (l/s)	7.2
Rainfall Events	Singular	Analysis Speed	Normal	Additional Storage (m³/ha)	0.0	2 year (l/s)	2.2	Check Discharge Volume	✓
Summer CV	0.750	Skip Steady State	x	Starting Level (m)		30 year (l/s)	5.8	100 year 360 minute (m³)	21

Storm Durations

15 | 30 | 60 | 120 | 180 | 240 | 360 | 480 | 600 | 720 | 960 | 1440

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)	Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
2	0	0	0	100	0	0	0
30	0	0	0	100	40	0	0

Pre-development Discharge Rate

Site Makeup	Brownfield	PIMP (%)	23	Betterment (%)	0	Q 100 year (l/s)	7.2
Brownfield Method	MRM	CV	0.750	Q 2 year (l/s)	2.2		
Contributing Area (ha)	0.845	Time of Concentration (mins)	5.00	Q 30 year (l/s)	5.8		

Pre-development Discharge Volume

Site Makeup	Brownfield	PIMP (%)	23	Climate Change (%)	0	PR	0.173
Brownfield Method	MRM	CV	0.750	Storm Duration (mins)	360	Runoff Volume (m³)	96
Contributing Area (ha)	0.845	Return Period (years)	100	Betterment (%)	0		

Node BR1 Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.10000	Safety Factor	2.0	Invert Level (m)	77.200
Side Inf Coefficient (m/hr)	0.10000	Porosity	0.90	Time to half empty (mins)	184

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	25.0	25.0	0.400	25.0	32.1	0.401	0.0	32.1

Node BR1 Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	77.600
Side Inf Coefficient (m/hr)	0.00000	Porosity	0.15	Time to half empty (mins)	

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	50.0	50.0	0.500	50.0	62.5	0.501	0.0	62.5

Node BR1 Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	78.100
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	50.0	50.0	0.100	50.0	52.5	0.101	0.0	52.5

Other (defaults)

Entry Loss (manhole)	0.250	Entry Loss (junction)	0.000	Apply Recommended Losses	x
Exit Loss (manhole)	0.250	Exit Loss (junction)	0.000	Flood Risk (m)	0.300

Approval Settings

Node Size	✓	Cover Depth	✓	Proportional Velocity	✓	Time to Half Empty	✓
Node Losses	✓	Minimum Cover Depth (m)	0.600	Return Period (years)	1	Return Period (years)	30
Link Size	✓	Maximum Cover Depth (m)	3.000	Minimum Proportional Velocity (m/s)	0.750	Discharge Rates	✓
Minimum Diameter (mm)	150	Backdrops	✓	Maximum Proportional Velocity (m/s)	3.000	2 year (l/s)	0.5
Link Length	✓	Minimum Backdrop Height (m)	0.200	Surcharged Depth	✓	30 year (l/s)	1.3
Maximum Length (m)	100.000	Maximum Backdrop Height (m)	1.500	Return Period (years)	1	100 year (l/s)	1.6
Coordinates	✓	Full Bore Velocity	✓	Maximum Surcharged Depth (m)	0.100	Discharge Volume	✓
Accuracy (m)	1.000	Minimum Full Bore Velocity (m/s)	1.000	Flooding	✓	100 year 360 minute (m³)	21
Crossings	✓	Maximum Full Bore Velocity (m/s)	3.000	Return Period (years)	30		

Approval Results

The network has been designed using IDF rainfall
It contains 5 nodes (1 outfall) and 4 links
The total impermeable area is 0.030 ha
2 structures have been defined, providing 11m³ of storage below the flood risk level
Infiltration based on BRE 365 has been applied at 1 of the structures
Simulations have been completed using FEH-22 summer and winter storms from 15 to 1440 minute duration

5 manholes are smaller than that required by the library

Node	Required Dia (mm)	Actual Dia (mm)
1	1200	600
2	1200	600
BR1	1200	600
4	1200	300
DummyOut	1200	100

2 connections have combined exit and entry losses less than the recommended total

Node	US Link	DS Link	US Exit Loss	DS Entry Loss	Angle (degrees)	Recommended Node Losses
BR1	1.001	1.002	0.250	0.250	79	0.900
4	1.002	1.003	0.250	0.250	85	0.900

1 circular link has a diameter < 150mm

US Node	DS Node	Link	Dia (mm)
4	DummyOut	1.003	100

No links have lengths > 100.000m

No links have lengths that differ from their coordinated length by more than 1.000m

No links cross one or more other links

3 links have cover depth outside the range 0.600-3.000m

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US Node	DS Node	Link	Minimum Depth (m)	Maximum Depth (m)
1	2	1.000	0.350	0.600
2	BR1	1.001	0.050	0.700
4	DummyOut	1.003	0.300	0.325

1 node has backdrops outside the range 0.200-1.500m

Node	US Link	DS Link	Backdrop (m)
2	1.000	1.001	0.100

2 links have full bore velocity outside the range 1.000-3.000m/s

US Node	DS Node	Link	Velocity (m/s)
BR1	4	1.002	0.741
4	DummyOut	1.003	0.772

No links have peak proportional velocity outside the range 0.750-3.000m/s during the 1 year return period

No links have a surcharged depth greater than 0.100m during the 1 year return period

No nodes flood during the 30 year return period

No infiltrating structures failed to half empty in 1440 minutes during the 30 year return period

No outfalls have a discharge rate greater than 0.5l/s during the 2 year return period

No outfalls have a discharge rate greater than 1.3l/s during the 30 year return period

No outfalls have a discharge rate greater than 1.6l/s during the 100 year return period

No outfalls have a discharge volume greater than 21m³ during the 100 year 360 minute storm

Rainfall

Event	Peak Intensity (mm/hr)	Average Intensity (mm/hr)	Event	Peak Intensity (mm/hr)	Average Intensity (mm/hr)	Event	Peak Intensity (mm/hr)	Average Intensity (mm/hr)
1 year 15 minute summer	62.840	17.782	2 year 600 minute summer	10.221	2.796	100 year 180 minute summer	69.807	17.964
1 year 15 minute winter	44.099	17.782	2 year 600 minute winter	6.984	2.796	100 year 180 minute winter	45.376	17.964
1 year 30 minute summer	40.077	11.340	2 year 720 minute summer	9.129	2.447	100 year 240 minute summer	55.266	14.605
1 year 30 minute winter	28.124	11.340	2 year 720 minute winter	6.135	2.447	100 year 240 minute winter	36.717	14.605
1 year 60 minute summer	26.660	7.045	2 year 960 minute summer	7.498	1.974	100 year 360 minute summer	42.499	10.937
1 year 60 minute winter	17.712	7.045	2 year 960 minute winter	4.967	1.974	100 year 360 minute winter	27.626	10.937
1 year 120 minute summer	20.623	5.450	2 year 1440 minute summer	5.412	1.451	100 year 480 minute summer	33.677	8.900
1 year 120 minute winter	13.701	5.450	2 year 1440 minute winter	3.637	1.451	100 year 480 minute winter	22.374	8.900
1 year 180 minute summer	17.443	4.489	30 year 15 minute summer	270.467	76.533	100 year 600 minute summer	27.673	7.569
1 year 180 minute winter	11.338	4.489	30 year 15 minute winter	189.802	76.533	100 year 600 minute winter	18.908	7.569
1 year 240 minute summer	14.568	3.850	30 year 30 minute summer	175.190	49.573	100 year 720 minute summer	24.700	6.620
1 year 240 minute winter	9.679	3.850	30 year 30 minute winter	122.940	49.573	100 year 720 minute winter	16.600	6.620
1 year 360 minute summer	11.797	3.036	30 year 60 minute summer	116.205	30.710	100 year 960 minute summer	20.258	5.335
1 year 360 minute winter	7.668	3.036	30 year 60 minute winter	77.204	30.710	100 year 960 minute winter	13.420	5.335
1 year 480 minute summer	9.543	2.522	30 year 120 minute summer	71.178	18.810	100 year 1440 minute summer	14.474	3.879
1 year 480 minute winter	6.340	2.522	30 year 120 minute winter	47.289	18.810	100 year 1440 minute winter	9.727	3.879
1 year 600 minute summer	7.932	2.170	30 year 180 minute summer	54.673	14.069	100 year +40% CC 15 minute summer	486.666	137.710
1 year 600 minute winter	5.420	2.170	30 year 180 minute winter	35.539	14.069	100 year +40% CC 15 minute winter	341.520	137.710
1 year 720 minute summer	7.134	1.912	30 year 240 minute summer	43.236	11.426	100 year +40% CC 30 minute summer	318.398	90.096
1 year 720 minute winter	4.794	1.912	30 year 240 minute winter	28.725	11.426	100 year +40% CC 30 minute winter	223.437	90.096
1 year 960 minute summer	5.922	1.559	30 year 360 minute summer	32.988	8.489	100 year +40% CC 60 minute summer	212.181	56.073
1 year 960 minute winter	3.923	1.559	30 year 360 minute winter	21.443	8.489	100 year +40% CC 60 minute winter	140.968	56.073
1 year 1440 minute summer	4.328	1.160	30 year 480 minute summer	25.944	6.856	100 year +40% CC 120 minute summer	127.690	33.745
1 year 1440 minute winter	2.909	1.160	30 year 480 minute winter	17.237	6.856	100 year +40% CC 120 minute winter	84.834	33.745
2 year 15 minute summer	98.952	28.000	30 year 600 minute summer	21.189	5.796	100 year +40% CC 180 minute summer	97.730	25.149
2 year 15 minute winter	69.440	28.000	30 year 600 minute winter	14.478	5.796	100 year +40% CC 180 minute winter	63.527	25.149
2 year 30 minute summer	63.338	17.922	30 year 720 minute summer	18.820	5.044	100 year +40% CC 240 minute summer	77.372	20.447
2 year 30 minute winter	44.448	17.922	30 year 720 minute winter	12.648	5.044	100 year +40% CC 240 minute winter	51.404	20.447
2 year 60 minute summer	41.856	11.061	30 year 960 minute summer	15.326	4.036	100 year +40% CC 360 minute summer	59.499	15.311
2 year 60 minute winter	27.808	11.061	30 year 960 minute winter	10.152	4.036	100 year +40% CC 360 minute winter	38.676	15.311
2 year 120 minute summer	29.515	7.800	30 year 1440 minute summer	10.906	2.923	100 year +40% CC 480 minute summer	47.148	12.460
2 year 120 minute winter	19.609	7.800	30 year 1440 minute winter	7.330	2.923	100 year +40% CC 480 minute winter	31.324	12.460
2 year 180 minute summer	24.076	6.196	100 year 15 minute summer	347.618	98.364	100 year +40% CC 600 minute summer	38.742	10.597
2 year 180 minute winter	15.650	6.196	100 year 15 minute winter	243.943	98.364	100 year +40% CC 600 minute winter	26.471	10.597
2 year 240 minute summer	19.692	5.204	100 year 30 minute summer	227.427	64.354	100 year +40% CC 720 minute summer	34.579	9.268
2 year 240 minute winter	13.083	5.204	100 year 30 minute winter	159.598	64.354	100 year +40% CC 720 minute winter	23.240	9.268
2 year 360 minute summer	15.554	4.003	100 year 60 minute summer	151.558	40.052	100 year +40% CC 960 minute summer	28.362	7.468
2 year 360 minute winter	10.111	4.003	100 year 60 minute winter	100.691	40.052	100 year +40% CC 960 minute winter	18.787	7.468
2 year 480 minute summer	12.412	3.280	100 year 120 minute summer	91.207	24.103	100 year +40% CC 1440 minute summer	20.264	5.431
2 year 480 minute winter	8.246	3.280	100 year 120 minute winter	60.596	24.103	100 year +40% CC 1440 minute winter	13.618	5.431



Results for 1 year Critical Storm Duration. Lowest mass balance: 100.00%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute winter	1	10	78.534	0.034	2.4	0.0096	0.0000	OK
15 minute winter	2	10	78.181	0.031	2.4	0.0087	0.0000	OK
180 minute winter	BR1	128	77.270	-0.030	0.8	1.5802	0.0000	OK
15 minute summer	4	1	77.250	0.000	0.0	0.0000	0.0000	OK
15 minute summer	DummyOut	1	78.075	0.000	0.0	0.0000	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute winter	1	1.000	2	2.4	0.800	0.109	0.0494	
15 minute winter	2	1.001	BR1	2.4	0.938	0.084	0.0152	
180 minute winter	BR1	1.002	4	0.0	0.000	0.000	0.0000	
180 minute winter	BR1	Infiltration		0.4				
15 minute summer	4	1.003	DummyOut	0.0	0.000	0.000	0.0000	0.0



Results for 2 year Critical Storm Duration. Lowest mass balance: 100.00%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute winter	1	10	78.543	0.043	3.8	0.0122	0.0000	OK
15 minute winter	2	10	78.189	0.039	3.7	0.0111	0.0000	OK
180 minute winter	BR1	128	77.308	0.008	1.3	2.4315	0.0000	OK
180 minute winter	4	168	77.381	0.131	3.3	0.0093	0.0000	OK
15 minute summer	DummyOut	1	78.075	0.000	0.0	0.0000	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute winter	1	1.000	2	3.7	0.909	0.172	0.0687	
15 minute winter	2	1.001	BR1	3.7	1.061	0.133	0.0213	
180 minute winter	BR1	1.002	4	3.3	0.367	0.251	0.0898	
180 minute winter	BR1	Infiltration		0.4				
180 minute winter	4	1.003	DummyOut	0.0	0.000	0.000	0.0000	0.0



Results for 30 year Critical Storm Duration. Lowest mass balance: 99.75%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute winter	1	10	78.576	0.076	10.4	0.0215	0.0000	OK
15 minute winter	2	10	78.219	0.069	10.3	0.0196	0.0000	OK
180 minute winter	BR1	152	77.508	0.208	2.6	6.9867	0.0000	SURCHARGED
180 minute winter	4	156	77.508	0.258	3.5	0.0183	0.0000	OK
15 minute summer	DummyOut	1	78.075	0.000	0.0	0.0000	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute winter	1	1.000	2	10.3	1.182	0.471	0.1449	
15 minute winter	2	1.001	BR1	10.2	1.369	0.364	0.0453	
180 minute winter	BR1	1.002	4	3.5	0.387	0.264	0.1603	
180 minute winter	BR1	Infiltration		0.4				
180 minute winter	4	1.003	DummyOut	0.0	0.000	0.000	0.0000	0.0

Results for 100 year Critical Storm Duration. Lowest mass balance: 100.00%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute winter	1	10	78.589	0.089	13.4	0.0253	0.0000	OK
15 minute winter	2	10	78.231	0.081	13.2	0.0230	0.0000	OK
180 minute winter	BR1	176	77.661	0.361	3.1	9.5742	0.0000	SURCHARGED
180 minute winter	4	176	77.661	0.411	2.5	0.0292	0.0000	OK
15 minute summer	DummyOut	1	78.075	0.000	0.0	0.0000	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute winter	1	1.000	2	13.2	1.252	0.607	0.1763	
15 minute winter	2	1.001	BR1	13.1	1.450	0.469	0.0551	
180 minute winter	BR1	1.002	4	-2.6	0.393	-0.198	0.1603	
180 minute winter	BR1	Infiltration		0.4				
180 minute winter	4	1.003	DummyOut	0.0	0.000	0.000	0.0000	0.0

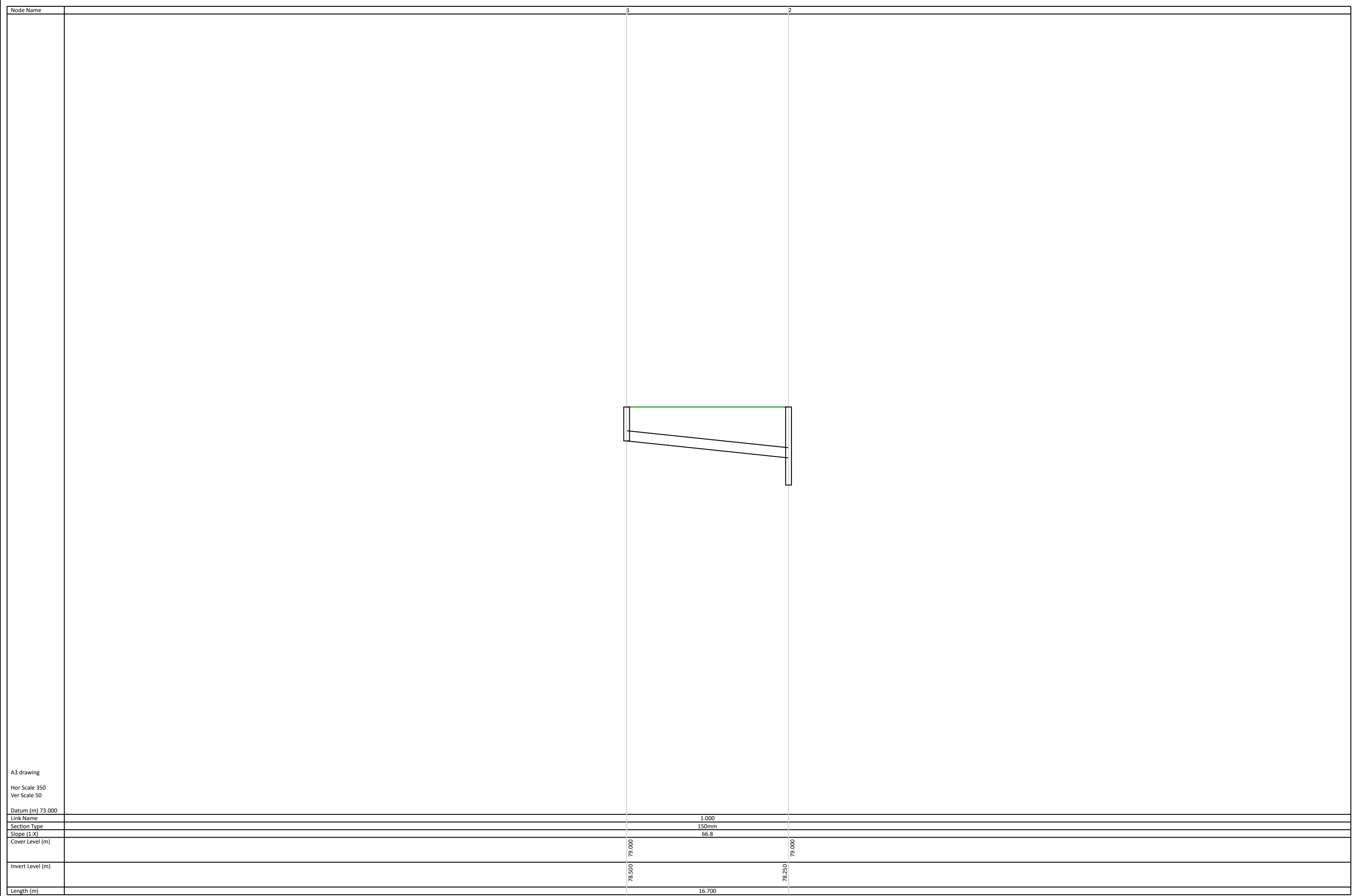


Results for 100 year +40% CC Critical Storm Duration. Lowest mass balance: 99.86%

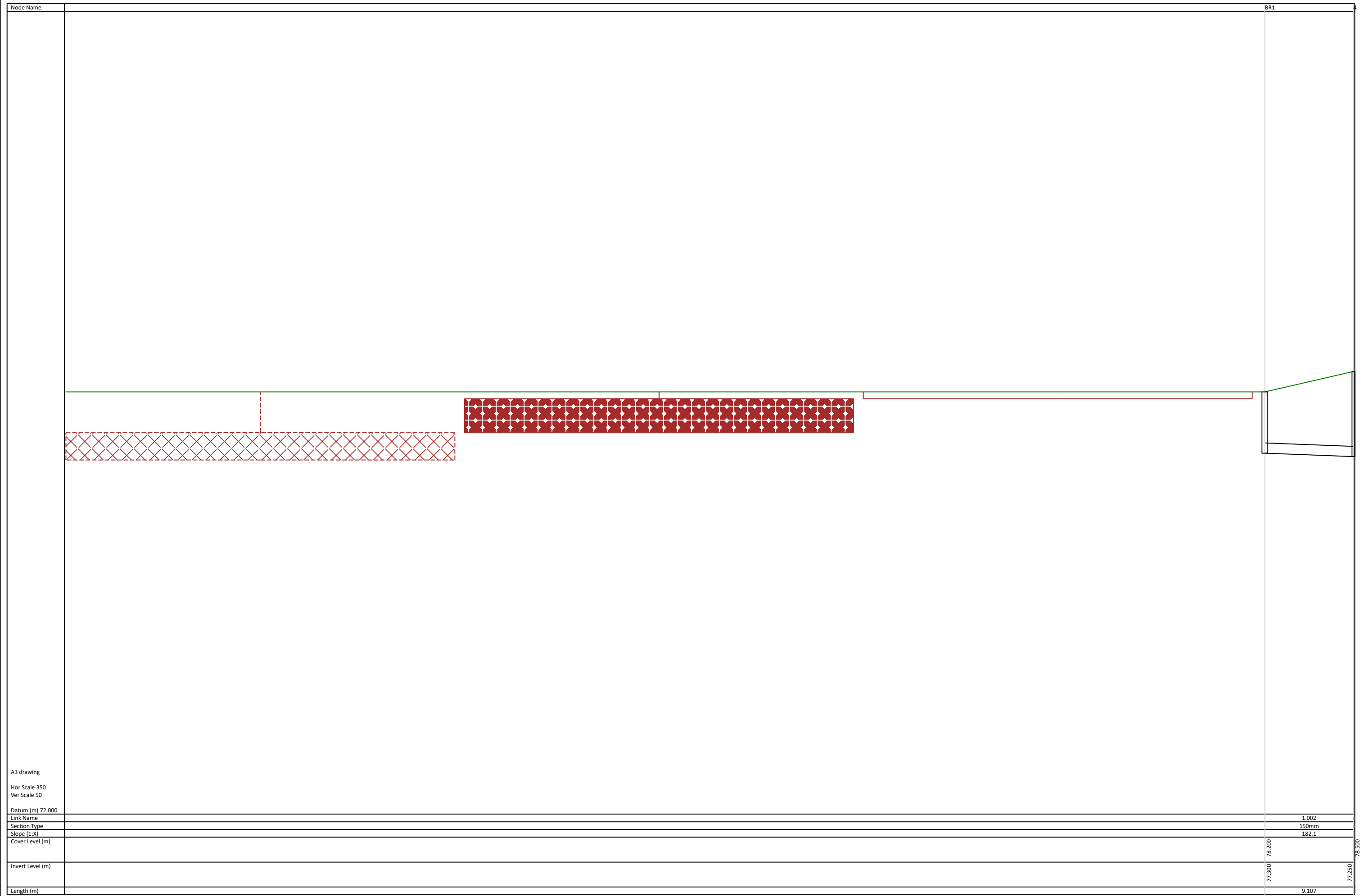
Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute winter	1	10	78.615	0.115	18.8	0.0326	0.0000	OK
15 minute winter	2	10	78.253	0.103	18.5	0.0291	0.0000	OK
360 minute winter	BR1	264	78.116	0.816	2.7	13.8289	0.0000	FLOOD RISK
360 minute winter	4	264	78.116	0.866	2.4	0.0615	0.0000	OK
360 minute winter	DummyOut	264	78.090	0.015	0.3	0.0000	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute winter	1	1.000	2	18.5	1.332	0.851	0.2323	
15 minute winter	2	1.001	BR1	18.4	1.554	0.658	0.0719	
360 minute winter	BR1	1.002	4	2.4	0.389	0.181	0.1603	
360 minute winter	BR1	Infiltration		0.4				
360 minute winter	4	1.003	DummyOut	0.3	0.396	0.051	0.0019	1.2

11.7.3 Drainage Sections



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11.8 Appendix 8 – SuDS Maintenance Manual

All maintenance activities will be the responsibility of MG Adams Plumbing & Heating Ltd. They will appoint a management company to undertake the general maintenance duties within the site and will join service agreements with the suppliers and manufactures of the SuDS/Pumps when required.

The information presented below is taken from the CIRIA SuDS Manual (Report c753) and [SuDS](#). Further details on installation and maintenance can be found detailed below and online.

11.8.1 Pervious Pavements

Maintenance Schedule	Required Action	Typical Frequency	Responsibility
Regular maintenance	Brushing and vacuuming (standard cosmetic sweep over whole surface).	Once a year, after autumn leaf fall, or reduced frequency as required, based on site-specific observations of clogging or manufacturer's recommendations - pay particular attention to areas where water runs onto pervious surface from adjacent impermeable areas as this area is most likely to collect the most sediment.	MG Adams Plumbing & Heating Ltd will be responsible for setting up the management company.
Occasional maintenance	Stabilise and mow contributing areas.	As required.	
	Removal of weeds or manage using weed killer applied directly into the weeds rather than spraying.	As required - once per year on less frequently used pavements.	
Remedial actions	Remediate any landscaping which, through vegetation maintenance or soil slip, has been raised to within 50 mm of the level of the paving.	As required.	
	Remedial work to any depressions, rutting and cracked or broken blocks considered detrimental to the structural performance or a hazard to users, and lost material.	As required.	MG Adams Plumbing & Heating Ltd will be responsible for setting up the management company.
	Rehabilitation of surface and upper substructure by remedial sweeping.	Every 10 to 15 years or as required (if infiltration performance is reduced due to significant clogging).	
Monitoring	Initial Inspection.	Monthly for three months after installation.	
	Inspect for evidence of poor operation and/or weed growth - if required, take remedial action.	Three-monthly, 48h after large storms in first six months.	
	Inspect silt accumulation rates and establish appropriate brushing frequencies.	Annually.	
	Monitor Inspection chambers.	Annually.	

Many of the specific maintenance activities for pervious pavements can be undertaken as part of a general site cleaning contract (many car parks or roads are swept to remove litter and for visual reasons to keep them tidy). Therefore, if litter management is already required at the site, this should have marginal cost implications.

11.8.2 Rain Garden / Bioretention / Filter Strip Maintenance / Swale

Maintenance Schedule	Required Action	Typical Frequency	Responsibility
Regular maintenance	Inspect for sediment and debris in inlet and outlet components	Quarterly; As required.	MG Adams Plumbing & Heating Ltd will be responsible for setting up the management company.
	Inspection & Cleaning of gutters and any filters on downpipes feeding into rain gardens as required.	Quarterly; As required.	
	Remove, replace and maintain vegetation as required; Ensuring cuttings are removed to prevent debris build up; Weeding of flower bed to maintain the desired vegetation, density and biodiversity - Vegetation management	Monthly inspections Summer; As required Quarterly during Winter month; Or as required.	
Remedial actions	Replace dead or overgrown vegetation as required.	As required.	
	Replacement of clogged geotextile (will require reconstruction of raingarden).	As required.	
Monitoring	Inspect silt traps / discharge points and note rate of sediment accumulation and ensure no erosion pathways forming.	Monthly in the first year and then annually.	
	Check raingardens are emptying as required following a storm event occurring.	After storms; When possible.	

Maintenance will be carried out manually. All monitoring and maintenance will be carried out by the appointed estate management company that undertakes the general landscaping maintenance.

11.8.3 Rain Water Harvesting Maintenance

Maintenance Schedule	Required Action	Typical Frequency	Responsibility
Regular maintenance	Inspect for sediment and debris in inlet and outlet components;	Monthly;	MG Adams Plumbing & Heating Ltd will be responsible for setting up the management company.
	Inspection & Cleaning of gutters and any filters on downpipes feeding into the Rain Water Butts.	Monthly; Increase freq. to weekly during Autumn; After storm events;	
Remedial actions	Cleaning of the rainwater Tanks. Fully drain the clear out debris and enable access; Scrub / Pressure wash out the inside of the tank if accessible, use appropriate cleaning product Rinse with clean water; Cleaning of Gutters; Clean or fit a new filter;	2 - 5 years;	
Monitoring	Check Correct pumping operations; Check volume of water being held in tank after storm events; Replace parts as required; Replace pump as required	Quartlerly	

Maintenance will be carried out manually. All monitoring and maintenance will be carried out by the appointed the MG Adams Plumbing & Heating Ltd who will instruct a management company to undertake the tasks.