CONSULTATION VERSION

HEOLDDU SOLAR FARM

OUTLINE
SOIL MANAGEMENT PLAN

September 2025

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Authorised By APK 09/25

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CONTENTS

1 INTRODUCTION

1.1 The Heolddu Solar Farm (the Proposed Development) is proposed across 81.8 ha of land near Ferryside, Carmarthenshire (the Site).

1.2 The land quality of the Site, as defined under the Agricultural Land Classification (ALC) is about half Subgrade 3b “moderate” quality (41.2 ha). The rest of the site comprises of subgrade 3a “good” (39.7 ha) quality land.

1.3 Soil is an important resource. This outline Soil Management Plan (oSMP) sets out the key principles for handling soils during the construction, operation and decommissioning phases of the Proposed Development.

1.4 The oSMP draws on the detailed soil and agricultural land classification undertaken by James Fulton of Amet Property.

Structure of the Report

1.5 The purpose of the oSMP is to set out the key principles, based on current design information, to ensure that there is no significant loss of agricultural land or soils, and no significant adverse impacts on soil resources, during the key stages of construction, operation and decommissioning.

1.6 This oSMP:

- describes the soils and land quality in section 2;
- sets out key principles in section 3;
- describes how to carry out soil suitability tests in section 4;
- sets out principles for construction compounds in section 5;
- sets out principles for the construction of the solar PV arrays and associated works in section 6;
- sets out principles for the substations in section 7;
- covers operational soil management in section 8;
- and key principles for the decommissioning phase in section 9.

1.7 Implementation of the principles will be the responsibility of the site manager.

Advice Drawn Upon

1.8 This document has drawn upon:

- Construction code of practice for the sustainable use of soils on construction sites, DEFRA (2009);
- Working with soils guidance note on benefiting from soil management in development and construction, BSSS (2022);
- Building on soil sustainability: principles for soils in planning and construction, Lancaster University and Partners (2022);
- Agricultural good practice for solar farms, BRE (2014);
- Good practice guide for handling soils in mineral workings, the Institute of Quarrying (2021).

2 SCOPE OF THE OSRMP

2.1 This oSRMP sets out:

- a description of the soil types and their resilience to being trafficked;
- how access will be managed to minimise impacts on soils;
- a description of works and how soil damage will be minimised and ameliorated;
- a methodology for monitoring soil condition, and criteria against which compliance will be assessed;
- and an outline of how soil will be protected at decommissioning.

2.2 The instillation of the solar panel framework, and the assembly of the panels, does not require the movement or disturbance of the soils. Those works should not, therefore, result in localised disturbance or effects on soils or agricultural land quality. The oSRMP however particularly covers vehicle movements and related impacts, as those could result in compaction.

2.3 Trenching works to connect the panels to the infrastructure do have the potential to cause localised effects on soils. Localised damage will be minimised by good practice. This oSRMP sets out soil resilience, good practice and monitoring criteria. It considers the effect of trenching works.

2.4 In localised areas there is a need for access tracks or bases for infrastructure and equipment. In those localised areas soil will need to be stripped and moved, for stockpiling for subsequent restoration. This oSRMP sets out:

- a description of the types of soils and their resilience to being trafficked and handled
- an outline map showing the areas proposed for being moved, soil thickness and type
- a methodology for creating and managing stockpiles of soil
- an outline methodology for testing soils prior to restoration, and a methodology for the respreading and amelioration of compaction at restoration

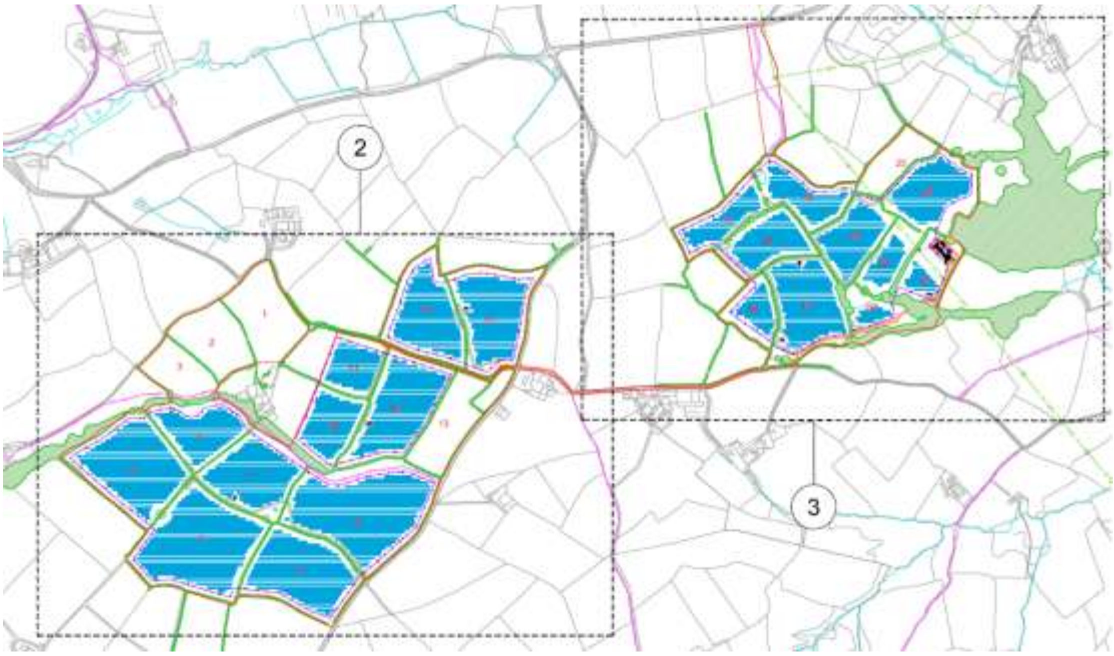
2.5 This oSRMP focuses on the construction phase and immediate aftercare, and on the decommissioning phase, especially to set principles to avoid creating compaction. There will be some long-term storage of soils for restoration uses at the decommissioning phase. Any soil removal at construction for future restoration (e.g. of the tracks) will be stored on site and labelled for subsequent restoration.

3 SOIL RESOURCES AND CHARACTERISTICS

The Site

3.1 The Proposed Development is shown on the plan below.

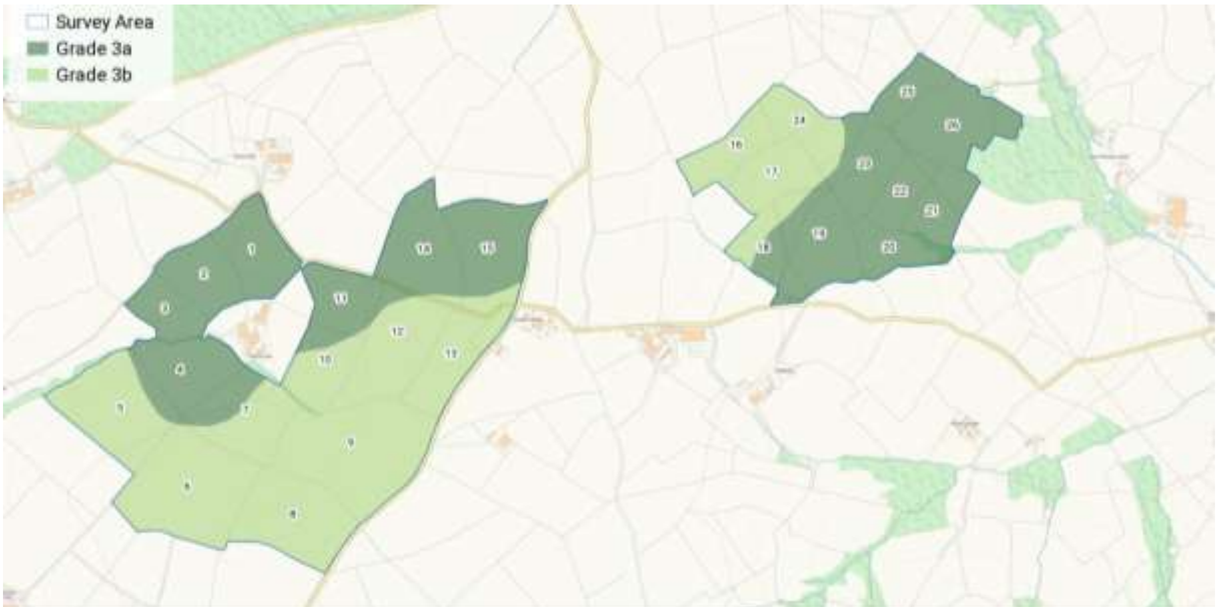
Insert 1: The Site Layout



Land Quality

3.2 The Site has been the subject of a detailed Agricultural Land Classification Survey (ALC). This is reproduced in **Appendix SMP1**. The results are shown below.

Insert 2: ALC results



Soils and Physical Limitations

3.3 The ALC describes the soils found.

3.4 For the purposes of ALC, the climate of the site includes:

- annual rainfall of 1339mm;
- Field Capacity Days (FCD) period of 260 days per annum.

3.5 There is no limitation from gradient on the site, as the site is flat to gently sloping.

3.6 The topsoils across the site are generally consistent, being a reddish-brown colour (5YR 4/4) clay loam. There were the periodic spots where the topsoil was considerably heavier and was recorded as clay. Much of the topsoils on the site were on the margin of medium clay loam and heavy clay loam, 24% - 29%, with the cut off for heavy clay loam being 27%.

3.7 The subsoils across the Site were heavier than the topsoils and as such were recorded as clay. Subsoils were found to be moderately structured with a friable coarse subangular blocky structure. The colour of subsoils was found to be generally similar to the topsoils with the occasional area of differentiation (5YR 5/4 or 2.5YR 5/3).

3.8 The difference is shown below from Appendix 4b of the ALC report.

Inserts 3 and 4: Topsoils and Subsoils

Topsoil

Subsoil

3.9 **Solar Area West**. The proposed layout for the western area is shown below. It will be noted that field parcels 1, 2, 3 and 13 are not proposed for panels.

Insert 5: Proposals for the Western Area

3.10 The soils from fields 4 and 8 are shown below. Due to the very dry conditions at the time of these being dug, they are primarily of topsoil and the distinction to subsoil is not readily apparent.

Inserts 6 and 7: Soils from Fields 4 (3a) and 8 (3b)

3.11 **Solar Area East**. The proposed layout for the eastern area is shown below. Field 25 is not proposed for panels.

Insert 8: Proposals for the Eastern Area

3.12 The Eastern Area is generally more undulating. The following soil pit, shallow over rock, is in an area of Subgrade 3a in field 22.

Inserts 9 and 10: Soil Pit in Field 22 (Subgrade 3a)

Insert 11: Field 22 Looking Southwest

4 KEY PRINCIPLES

Terminology

4.1 In this oSRMP the following terminology is used:

- Soil trafficking, which means that vehicular passage over soils, but not physical disturbance;
- Soil handling, which describes where soil is physically moved, such as by mechanical means (e.g. excavators).

Overview

4.2 For much of the installation process there is no requirement to handle (i.e. move or disturb) soils. Soils will need to be moved and disturbed to create temporary working compounds and to create the tracks and small fixed infrastructure bases. Soils will need to be handled to enable cables to be laid, but those soils will be reinserted shortly after they are lifted out (i.e. this is a swift process). More significant works will be required to create larger areas of infrastructure.

4.3 For those limited areas where soils need to be disturbed to create tracks and bases the soils will be stored in suitably managed bunds on the site. The soil needs to be looked after because it will be needed at the decommissioning stage to restore the land under the tracks and bases back to agricultural use.

4.4 It is unlikely that any subsoils will need to be removed to create shallow tracks and bases. But if any subsoil does need to be removed for any reason it will be stored separately to the topsoil and will be clearly marked.

4.5 For the majority of the Proposed Development soils do not need to be disturbed. The effects on agricultural land quality and soil structure are therefore limited to the effects of vehicle passage (i.e. trafficking). This is agricultural land, so it is already subject to regular vehicle passage. Therefore, the key consideration is to ensure that soils are passed over by vehicles (trafficked) when the soils are in a suitable condition, and that if any localised damage or compaction occurs (which is common with normal farming operations too), it is ameliorated suitably. Aside from the construction and decommissioning periods, vehicle movement is very limited.

4.6 The key principles for successfully avoiding damage to the soils are

- timing;
- retaining soil profiles;

- avoiding compaction;
- ameliorating compaction;
- retaining and storing soils for subsequent reuse.

Timing

4.7 The most important management decision/action to avoid adverse effects on soils is the timing of the works. If the construction work takes pace when soil conditions are sufficiently dry, then damage caused by vehicle trafficking and trenching will be non-existent or minimal.

4.8 Timing of soil moving activities needs to be flexible, as each season is different to the previous year. With large projects flexibility is often difficult, so the timing and soil handling measures will always have to be to the optimum so far as possible.

4.9 Generally across the site the soil depth is mostly 30 to 40 cm, as set out in the ALC. The topsoils are mostly comprising of medium clay loams <27% clay and heavy clay loams 27 - 35% clay and very sparse areas of clay >35% clay. Stones vary up to 15%.

4.10 The Institute for Quarrying “Good Practice Guide for Handling Soils in Mineral Workings” (2021) provides the following table for optimum times for stripping soils (e.g. for the tracks and infrastructure bases). This table shows an optimum time for stripping soils to be late May to early October. Both land owners farming the land (the landowners) reported that in a normal year vehicular travel without damage is possible from mid-April to mid to late October.

	Climatic Zones		
Soil Clay Content	**1**	**2**	**3**
Soil Depth <30cm			
<10%	Mid Apr - Early Oct	Late Mar – Early Nov	Late Mar – Early Dec
10 -27%	Late May - Early Oct	Early May – Early Nov	Early Apr – Early Dec
Soil Depth 30-60cm			
<10%	Late Apr - Early Oct	Mid Apr – Early Nov	Early Apr – Early Dec
10-27%	Late May - Early Oct	Early May – Early Nov	Early Apr – Early Dec
>27%	Late June – Early Oct	Early June – Early Nov	Late May – Early Dec
Soil Depth >60cm			
<10%	Late Apr - Early Oct	Mid Apr – Early Nov	Early Apr – Early Dec
10-18%	Late May - Early Oct	Early May – Early Nov	Early Apr – Early Dec
18-27%	Late June – Early Oct	Early June – Early Nov	Late May – Early Dec
>27	Mid July – Mid Sept	Early July – Mid Oct	Late June – Mid Oct

Table 4.1: Indicative on-average months when vegetated mineral soils might be in a sufficiently dry condition according to geographic location.

4.11 The installation of panels does not require land to be stripped, and so the time period is not restricted. In most years an April to October window will be perfectly acceptable and this may be extended at either end depending on the amount of rainfall and soil wetness conditions enable. There may be opportunities to travel the soils outside of this window.

4.12 The soils are generally resilient to summer trafficking.

4.13 Any damage from trafficking in the winter, which is to be avoided so far as possible, can generally be made good again by mechanical husbandry, once the soils have started to dry in the spring.

4.14 In the winter and early spring there is a higher risk of damaging the soil structure from vehicular trafficking. There are a great number of variables, such as recent rainfall, if the ground is frozen or has standing water, inevitable variations in soil conditions across single fields, and the size and type of machinery driving on the land. However, land work in this period is most likely to result in the need of restorative works post installation and so far, is practicable, will be avoided.

4.15 As a general rule any activity that requires soils to be dug up and moved, such as cable laying and cable works, should be reduced as far as possible during that period. Soils handled when wet tend to lose some of their structure, and this results in them taking longer to recover after movement, potentially needing restorative works, (e.g. ripping or subsoiling), to speed up the recovery of damaged soil structures.

4.16 In localised instances where it is not practicable to avoid undertaking construction activities when soils are wet and topsoil damage occurs then soils can be recovered by normal agricultural management, using normal agricultural cultivation equipment (subsoiler, harrows, power harrows etc.) once soils have dried adequately for this to take place. There may be wet areas in otherwise dry fields, for example, which are difficult to avoid.

Determining if soils are suitable

4.17 Soils should be friable when moved.

4.18 With clayey soils of this type, if you can roll soil into a ball or sausage easily and the soil holds its shape, it is too wet to be handled or trafficked. This is illustrated below with images of physical impressions vehicular trafficking can make in unsuitable conditions. Further guidance in the form of a Suitability Test is given in sheet A of the good practice guide to handling soils in mineral workings, the Institute of Quarrying (2021) (see **Appendix SMP2**).

4.19 Clay soils are not suitable for widespread trafficking, or being moved, when they are saturated. As set out in the Suitability Test, if the soil rolls into a ball or, more easily assessed, a thread (basically a sausage) and keeps its shape, it is too wet to be handled.

Inserts 13 and 14: Clayey soils too wet to be handled

4.20 Clay soils that are almost dry enough for being travelled across, in that they break up when pushed with a thumb, are shown below.

Inserts 15 and 16: Clayey Soils Almost Sufficiently Dry

4.21 Clay soils when dry are impossible to roll into a ball or thread. An example of a clay soil with low organic matter is shown below.

Inserts 17 and 18: Dry Clayey Soils

4.22 When soils are too wet and are trafficked indentations, ruts, are formed leading to areas of compaction, soil structure damage and areas where standing water will collect.

Insert 19: Trafficking Damage on Wet Soils

Retaining Soil Profiles

4.23 The successful installation of cabling requires a trench to be dug into the ground. Topsoils vary across the site and the coverage varies from 25 – 75cm.

4.24 As set out in the BRE Agricultural Good Practice Guidance for Solar Farms (extracts at **Appendix SMP3**) page 3:

"**When excavating cable trenches, storing and replacing topsoil and subsoil separately and in the right order is important to avoid long-term unsightly impacts**

on soil and vegetation structure. Good practice at this stage will yield longer-term benefits in terms of productivity and optimal grazing conditions".

4.25 In those areas where soil is dug up (trenching and for compounds and access roads), the soils should be returned in as close to the same order, and in similar profiles, as it was removed.

Avoiding Compaction

4.26 This oSRMP sets out when soils should generally be suitable for being trafficked. There may be periods within this window, however, when periodic prolonged rainfall events result in soils becoming liable to damage from being trafficked or worked. In these (likely rare) situations, work should only continue with care, to minimise structural effects on the soils, until soils have dried, usually within 48 hours of heavy rain stopping.

Ameliorating Compaction

4.27 If localised compaction occurs during construction, it should be ameliorated. This can normally be achieved with standard agricultural equipment, such as subsoilers, disks, power harrows, tine and chain harrows and rolls.

4.28 The amount of restorative work will vary depending on the localised impact. Consequently where the surface has become muddy, for example in the insert below, this can be recovered once the soil has dried, with the use of harrows and or disks and a roller. As far as possible this sort of damage should be avoided.

Inserts 20 and 21: Inter-row Ground Restoration: THIS IS AN EXAMPLE OF POOR PRACTICE FROM A DIFFERENT SITE

4.29 With a principal construction programme of April to October, this type of more extensive damage is unlikely to occur.

4.30 If there are any localised problems, thy type of machinery is shown below. This shows small horticultural versions.

Insert 22 and 23: Restorative Machinery (power harrows)

4.31 If there are any areas where there has been localised damage to the soils due to vehicular trafficking, for example, a low wet spot within a field which despite best efforts could not be avoided, this should be made good and reseeded at the end of the installation stage. This is not uncommon: most farmers will have times when they have to travel around the farm in a tractor when conditions are not suitable. This can happen during silaging, wet harvests, and cultivations.

Insert 24: Tractor Stuck in a Wet Spot

4.32 The ground surface should be levelled prior to any seeding or reseeding works commence.

4.33 Examples of areas that have been cultivated following the installation of panels, are shown below. These are the main vehicle trafficking routes. As can be seen, the area under and mostly between the panels is not damaged.

Insert 25: Localised Repairs (Solar Farm in Sussex)

<u>Retaining Soils</u>

4.34 At decommissioning stages the areas that will form the bases for the fixed infrastructure, can be returned to agricultural use. For this to be successful, the soils must have been retained on site, properly recorded or labelled so that they can be returned to the approximate position from where they came and stored properly for the lifetime of the scheme in an appropriately sized and managed bund.

4.35 No soil removed to construct the tracks will be removed from the site. It will all be stored on site for use at the decommissioning phase.

4.36 The storage bunds will be managed to prevent the growth of woody vegetation.

5 TEMPORARY CONSTRUCTION COMPOUNDS

Construction Methodology

5.1 A temporary construction compound will be created at the start of construction and reinstated at the end. Construction compounds are built by either matting over the top of the topsoil, or by stripping topsoil and storing that in a bund on the edge of the site. A matting is then laid down, and stone imported and levelled, as shown below.

Insert 26: Newly-laid Construction Compound (Elsham-Lincoln Pipeline)

5.2 The matting prevents the stone from mixing with the subsoil, as shown below.

Insert 27: Matting

5.3 Topsoil when removed will need to be stored in a bund, as shown below. If soils are still wet when moved, the soils should be stored in windrows not more than 1m high, but otherwise temporary bunds should be no more than 3m in height, to protect the aerated nature of the soil resource.

Insert 28: Topsoil Storage Bund

<u>Movement of Soils</u>

5.4 The soils need to be sufficiently dry to handle. Guidance on determining soils suitability to be handled is set out in the IQ Good Practice Guide for Handling Soils, **Appendix SMP2** and in section 4.

5.5 The soils across the site are not expected to be suitable for being moved between late May and early October, so the main construction compound should be planned for being built outside that period.

5.6 The topsoils will be stripped to a depth of 20-30cm, and placed in bunds on the edge of the compound, as shown above.

5.7 Short term storage of soil is shown above. If the soil is likely to be stored for in excess of six months then, depending upon timing, it should be seeded with grass. This binds the soil together and minimises erosion. Seeding should take place at a suitable time of the year, normally spring or autumn.

5.8 Therefore if the construction compounds are not to be removed before the wet weather in the following winter, the bunds should be seeded with grass, as per the example below, at a suitable time of the year. The compound can then be reinstated the following spring.

Insert 29: Grass-seeded Bund

Removal

5.9 The removal of the construction compound should be timed for dry weather.

5.10 At the end of the construction process, the aggregate will be removed. This can be seen in the insert below.

Insert 30: Start of Restoration of Construction Compound (example from Staffordshire)

5.11 The base area should be loosened when soils are dry and the topsoil then spread over the site to the original depth. This should be lightly cultivated.

5.12 Panels can then be installed over the construction compound, or the area returned to agricultural use.

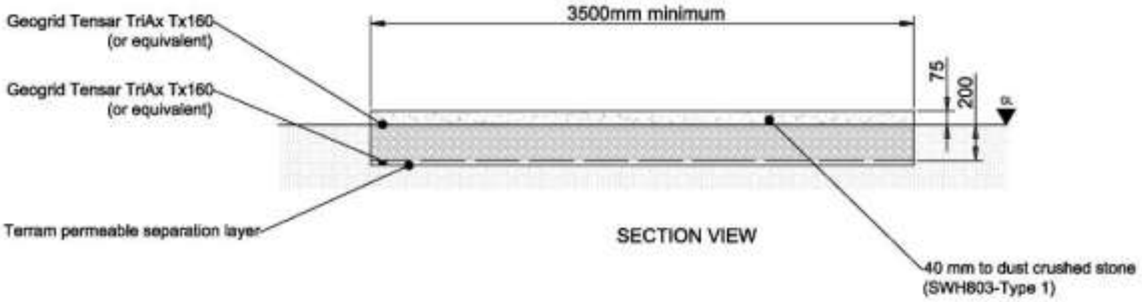
5.13 The underlying land quality will be restored and retained.

6 SOLAR SITE CONSTRUCTION WORKS

<u>Tracks and Equipment Bases</u>

6.1 The access tracks are created by stripping off some or all of the topsoil (to a depth of 200mm) and then adding an aggregate-based surface. Usually, the aggregate will be placed onto a permeable membrane, which allows water penetration, but which prevents the aggregate from mixing with the topsoils or upper subsoils. A typical cross-section is shown below.

Insert 31: Access Track Cross Section



6.2 The small areas of fixed equipment (eg inverter/transformers) will stand on concrete foundations or hardcore, requiring some removal of soil to create the hardcore foundation. Typical equipment is shown below.

Insert 32: Typical Transformer

<u>Soil Management</u>

6.3 Soil should be stripped when the soil is sufficiently dry and does not smear. This is a judgement that is easily made. Following the Suitability Test described above, if the soil can be rolled into a ball or a thread, and that holds its shape, the soil is not suitable for being worked. If the ball crumbles, or the thread breaks into small sections, or if the soil is too dry to roll into a ball or thread, it is suitably dry.

6.4 Soil stripping should be carried out in accordance with Defra "Construction Code of Practice for the Sustainable Use of Soils on Construction Sites" (Defra, 2009). The removed soil should be stored in bunds in accordance with the Construction Code of Practice.

6.5 The tracks involve the movement of soils. Therefore, the soils are more susceptible to damage from mechanical movement. The topsoil will, however, be stored for the duration of the operational period. Accordingly, if for operational reasons it is necessary to commence the construction of tracks and bases when soils are not in optimal condition, the soil to be stored should be stored initially in bunds of maximum 1 metre high.

6.7 This will allow the soils to dry. Shallow bunds can then be moved again once they are dry into larger bunds for long-term storage.

6.8 Once the soils are sufficiently dry, typically after two or three weeks, it will be possible to move the soils to long-term storage bunds.

6.9 As a general rule, soil should not be moved during or within 24 hours of heavy rain.

Bund Management

6.10 Soil bunds should be no more than 3m in height to prevent anaerobic conditions in the base of the bund. The bund should be sown with a grass mix. This should be managed at least annually to prevent the growth of woody vegetation (e.g. brambles).

Reinstatement

6.11 Reinstatement of topsoil at the decommissioning phase should involve the following:

(i) removal of the stone from the track, and the membrane;

(ii) subsoiling in dry conditions along the route of the track and base areas to loosen the subsoil;

(iii) replacement of dry topsoil from the bunds, levelled and cultivated;

(iv) a second light compaction alleviation, e.g. with a tined cultivator, if needed;

(v) sowing with a crop or grass to get rooting into the profile as soon as practicable after replacement.

Solar PV Arrays

6.12 The installation should be carried out so far as is practicable and possible when the ground conditions are suitable (i.e. the soil is not so wet that vehicles cause tyre marks deeper than about 10cm when travelling across the land). This will be possible for most of the year but is not likely to be possible between early October and mid April, and this period should be avoided if possible. If conditions are suitable, this stage of the installation should create no soil structural damage or compaction, as shown below.

Insert 33 and 34: Ground After Construction

6.13 In most years work access to the land is not restricted between May and September inclusive. Between those periods the ground conditions will normally be resilient to vehicle trafficking.

6.14 In winter periods the soils are more likely to be saturated and the propensity to being damaged, albeit in a way capable of rectification, is greatest. Generally, vehicular travel in these periods should be limited as much as possible. It is recognised that rainfall is the factor that wets the soils, so a dry spring will offer different conditions to a wet spring, and this may mean that soil structural damage will inevitably result.

6.15 Work in suboptimal conditions should be minimised. The layout includes a network of access tracks and in most cases once legs have been installed, only small numbers of vehicle movements will be needed between each string of panels.

6.16 The machinery normally used is small, lightweight and tracked, and damage to soils will generally be minimal.

Insert 35 and 36: Example or Leg Piling and Panel Moving Equipment

6.17 Any surface disturbance will be limited, will not result in deep compaction, and can be ameliorated easily in the spring, as described above.

6.18 It is very unlikely that trafficking during construction when soils are relatively dry will result in compaction sufficient to require amelioration. However, if rutting has resulted the soil should be levelled by standard agricultural cultivation equipment such as tine harrows, once the conditions suit, and prior to seeding. This can be done with standard agricultural machinery, or with small horticultural-grade machinery such as is shown below.

Insert 37 and 38: Horticultural Machinery (subsoiler and power harrow)

6.19 The objective is to get the surface to a level tilth for seeding/reseeding as necessary, as was shown earlier. Grass growth will then recover or establish rapidly.

<u>Trenching</u>

6.20 Cabling is done mostly with either a mini digger or a trenching machine. The cable routing areas are shown on the plans. Trenches will be at depths of up to 1.2m where soil depth permits, although the CCTV trenching around the periphery could be shallower. An example trench, with the topsoil, placed on one side (0-30cm) and subsoil on the other (below 30cm), is shown below, and with the soil put back after cable installation. This methodology should be followed.

Insert 39 and 40: Cable Installation

6.21 It is important that topsoils are placed separately to the subsoils, and that they are then put back in reverse order, i.e. subsoils first.

6.22 The type of machinery used for trenching is shown below, taken from the BRE National Solar Centre "Agricultural Good Practice Guidance for Solar Farms" (2013).

Insert 41: Machinery Used (extract from BRE Good Practice Guidance)

Cable trenching, showing topsoil stripped and set to one side, with subsoil placed on the other side ready for reinstatement (photo courtesv of British Solar Renewables)

<u>Fencing and Cameras</u>

6.23 Fence designs can vary, but they all involve a post being inserted into the ground. Pole mounted internal facing closed circuit television (CCTV) systems are also likely to be deployed around the perimeter of the operational areas. Access gates will be of similar construction and height as the perimeter fencing.

6.24 The site fencing is likely to be metal mesh or deer fencing. This can be erected at any time, if soil conditions allow. The following photographs show fencing installed early in the process.

Insert 42 and 43: The Fencing

6.25 Similarly CCTV poles are inserted in the same way.

Insert 44 and 45: CCTV Poles and Fencing

6.26 If the movement of vehicles is not causing significant rutting (i.e. more than 10cm), then fencing could be erected outside of the key working period.

6.27 Any rutting that results from fencing can be made good with standard agricultural equipment.

Drainage Works

6.28 There is the potential for parts of the site to have in place underfield drainage schemes. At the outset, prior to construction, all efforts will be made with landowners to identify historic maps and records of any known underfield schemes.

6.29 The extent to which there is the potential for an adverse effect will depend upon a number of factors including:

- the depth of drainage;
- the direction and spacing of any underdrainage;
- the extent to which the underdrainage is operational;
- the type of works being undertaken.

6.30 Further detailed investigation of the drainage will be needed before construction. Scanning for clay and plastic pipe field drainage is not possible, and the depth of drainage is not known.

6.31 The Agricultural and Horticultural Development Board advisory guide "Field Drainage Guide: principles, installations and maintenance" (2024) is reproduced in **Appendix SMP4**. This notes that given good maintenance a useful life of a system is at least 20 years, but some systems can last many decades longer (page 4 refers).

6.32 The key consideration in minimising the effects on under-field drainage is to identify the location and depth of the drainage. Page 11 sets out a methodology for identifying the location of field drainage.

6.33 The land classification system assumes that "**where limitations can be reduced or removed by normal management operations or improvements, for example cultivations or the installation of an appropriate underdrainage scheme, the land is graded according to the severity of the remaining limitations**". This is reproduced in **Appendix SMP5**.

6.34 Consequently any adverse effects on field drainage will not result in a downgrading or change to the ALC grading of the Site.

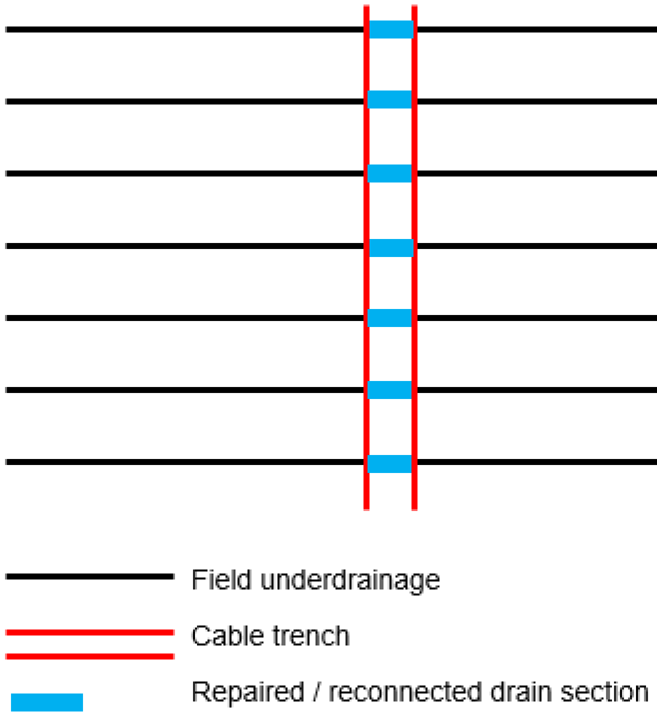
6.35 The installation of cabling will be supervised by an experienced advisor. He or she will know where to expect drainage and will be able to identify if drainage pipes are broken as either clay pipe fragments or plastic pipe will be evident in the material dug out.

6.36 Those areas affected by cable damage should be repaired in one of two ways:

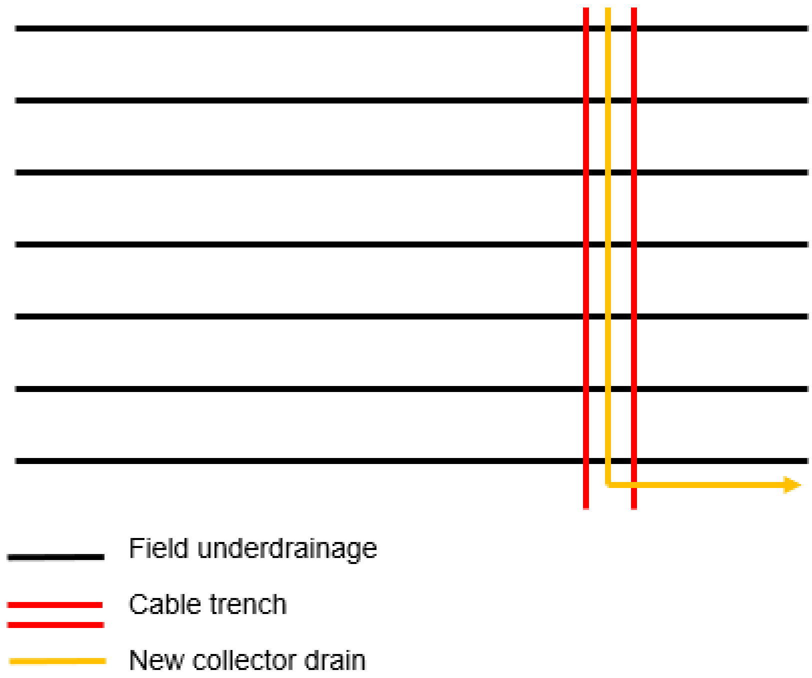
(i) the individual drains will be reconnected with new sections across the pipe, as illustrated below.

(ii) or a collector drain will be laid along the cable trench and will then connect, at a low point, to a new drainage pipe to take water away.

Insert 46: Drainage System Repair Option



Insert 47: Drainage System Repair Option



6.37 Drains affected by piling will be repaired locally, if required.

6.38 The purpose of under-field drainage is to help crop growth and to extend the time that land can be accessed. Drainage allows earlier and later access to the land, and evens out the drainage across the land to help with cultivations etc.

6.39 Allowing the land to drain less rapidly does not affect the operation of the solar farm. Vehicular access is normally only needed in the summer months, when panels are cleaned. Having under-field drainage working is not, therefore, important unless there are areas of standing water due to broken drainage.

6.40 Localised wet areas where drainage has been impeded such that surface puddling occurs, will be repaired with new sections of plastic drainage pipes dug around the blocked section to connect the old system.

7 SUBSTATION COMPOUND

7.1 The layout of the Substation and related equipment is shown below, from the application plans.

Insert 48: Extract from Substation Proposals

7.2 These works involve only part of the site area surveyed.

7.3 The soils in this area are all similar. Therefore, there is no requirement to separate topsoils, and all topsoil removed when creating operational tracks and as bases for the energy storage system and fixed equipment can be stored in one place if required.

7.4 Topsoil will need to be stripped for creating the base for the energy storage area. The topsoil depth, as recorded in the ALC, is 35cm across this area. This will be stripped and a base created, in a similar manner to the temporary construction compounds, and as in the example below.

Insert 49: Example Base Construction

7.5 The topsoil will need to be stored in aerobic conditions. An example of bund construction, taken from Work Sheet B of the Institute of Quarrying's Good Practice Guide, is shown below.

Insert 50: Bund Construction

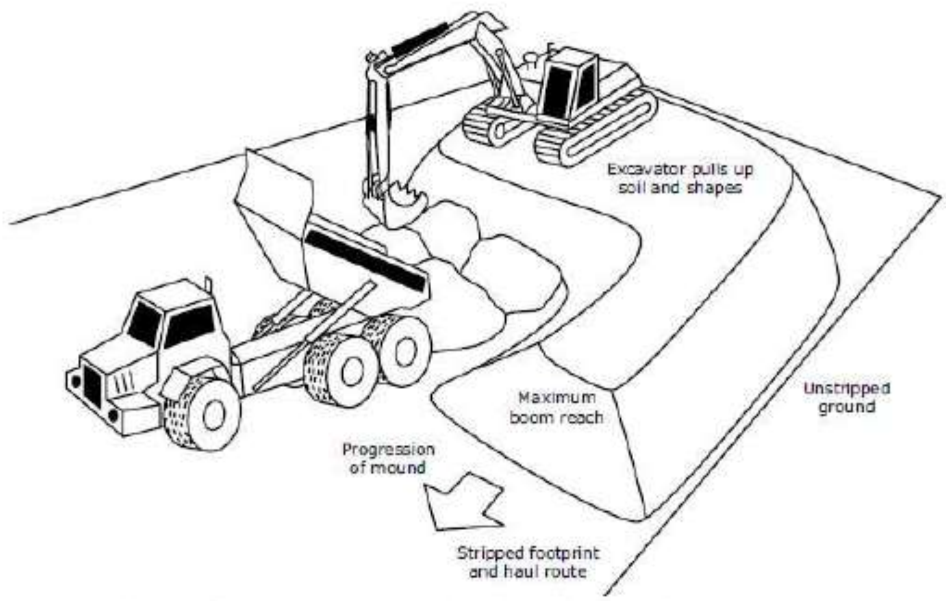


Figure B.1: Soil storage mound construction with excavators and dump trucks: Single tier mound.

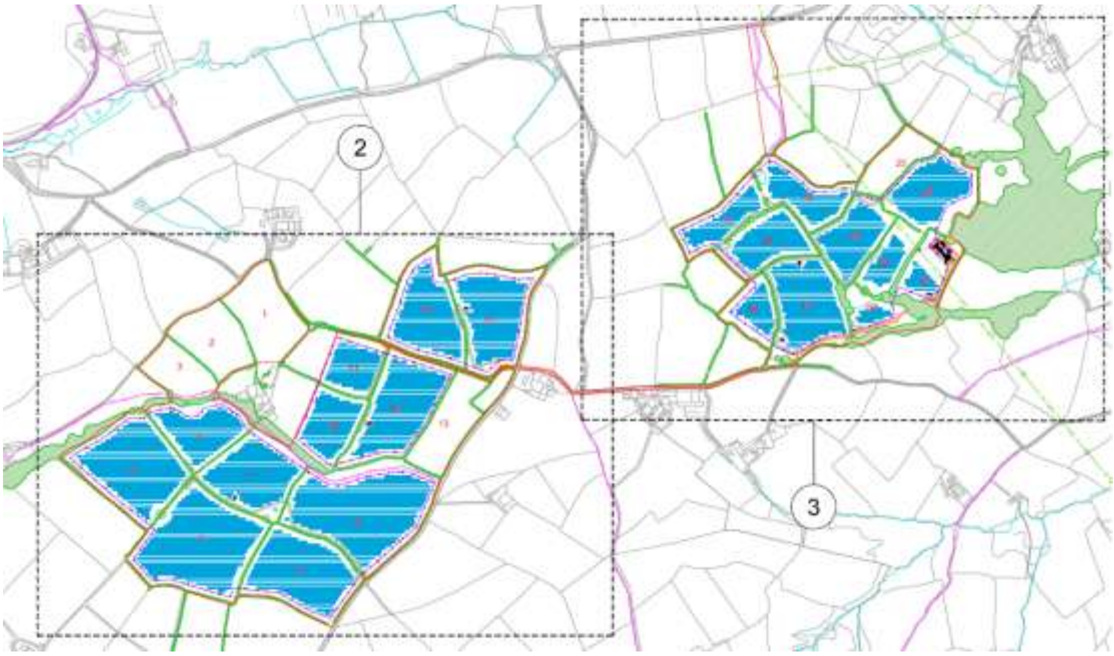
7.6 Bunds should be sown with a suitable grass seed mix at an appropriate time of the year (usually spring or autumn) and managed mechanically at least once per year to prevent woody vegetation.

8 OPERATIONAL PHASE: LAND MANAGEMENT

Solar PV Arrays

8.1 The land around the Solar PV Arrays will be managed, including potentially by the grazing of sheep.

Insert 51: Areas to be Covered by Solar PV Arrays



8.2 Panels grazed by sheep tend to be free of weeds, as shown below.

Insert 52: Sheep Grazing Under Panels

8.3 Any localised weed treatment can be carried out at the appropriate time of the year using a quad-mounted sprayer, or by hand using a strimmer or knapsack sprayer.

Ongoing Maintenance

8.4 There are many different cleaners on the market, some tractor based and some operated from smaller machines, such as below.

Insert 53: Cleaning of Solar Arrays

8.5 The normal cleaning period is early summer, so that panels are clean for the maximum light period, so damage is unlikely, but cleaning could take place at any time when ground conditions are suitable.

8.6 If vehicles, including farm vehicles, cause ruts in the soil these will naturally repair in time, especially as the land is grazed by sheep and their feet are excellent at levelling land. Alternatively, a light harrow or rolling will restore the ruts, when the soil is still soft enough to roll but hard enough to not rut more.

Insert 54: Ruts Caused by Vehicles

8.7 If vehicles have caused rutting it is probably, as per the example above, only localised. In the photograph above this is a wet spot, and on the land either side of the ruts within the row there is no evidence of wheel indentation. If these areas are not levelled they will tend to sit with water in them.

8.8 Localised, small rutting should be repaired by either treading-in the edges with feet, by light rolling or harrowing, or adding a small amount of soil simply to fill-in the depression so that water does not collect there.

8.9 Deeper rutting will require either light harrowing in the drier period, or some soil adding, or both, before reseeding.

<u>Emergency Repairs</u>

8.10 For the duration of the operational phase there should be only localised and infrequent need to disturb soils, such as for repair of a cable. Any works involving trenching should be carried out, ideally, when the soils are dry but recognising that any works will be those of emergency repair, that may not be possible.

8.11 Accordingly if new cabling is needed and must be installed in wet periods, it can be expected that the trench will look unsightly initially, such as the example below.

Insert 55: Trench During Wet Period

8.12 Any area disturbed should be harrowed or raked level once the soils have dried and be reseeded. These areas will be small, and this can probably be done by hand.

<u>Soil Storage</u>

8.13 The critical part of successful long-term storage of soils is to place the soils into storage bunds when the soils are dry.

8.14 Ongoing maintenance should ensure that the bunds remain free from woody vegetation (e.g. brambles, elder) and that the soil bunds do not erode. For this reason, the bunds should be seeded with a grassland mix, as the roots of the grasses will help bind the surface and prevent water channels forming.

8.15 At least once per year the bund should be managed, ideally by mowing or strimming.

8.16 An example of a bund that is seven years old, is shown below.

Insert 56: Soil Bund Example (Monmouthshire)

9 DECOMMISSIONING PRINCIPLES

9.1 Given the length of time before decommissioning it is likely that climate change may have altered the seasons and rainfall patterns. Therefore, this guidance is prefaced with a requirement for a suitably qualified soil scientist to revisit the Site prior to decommissioning, and to update the guidance and timing. The objective is to remove panels and restore all fixed infrastructure areas to return the land to the same ALC grade and condition as it was when the construction phase commenced.

Removal of Panels

9.2 A qualified soil scientist should advise prior to decommissioning time. The effects of climate change by the time of decommissioning may mean that these dates are no longer applicable.

9.3 Once the panels have been unbolted and removed, the framework will then be a series of legs, as shown below.

Insert 57 and 58: The Framework (example from Wiltshire and Nottinghamshire)

9.4 These will be removed by low-ground pressure machines, in a reverse operation to the installation. These machines will provide a pneumatic tug vertically upwards. This will break the seal between soil and leg, and once that surface tension is released the leg will come out easily.

9.5 The legs will be loaded onto trailers and removed.

9.6 There will be no significant damage to the soils, and no significant compaction.

Removal of Cables

9.7 Cables buried less than 1 metre deep will be removed. This is likely to need a trench to be dug. This will be done with either a mini digger or a trenching machine. Cabling will mostly be at depths of 0.8m where soil conditions permit, although the CCTV trenching around the periphery could be shallower. An example trench, with the topsoil placed to one side and subsoil on the other side, is shown below.

Insert 59: Example Trench

9.8 The type of machinery used for trenching is shown below, taken from the BRE National Solar Centre "Agricultural Good Practice Guidance for Solar Farms" (2013).

Insert 60: Machinery Used for Trenching

Cable trenching, showing topsoil stripped and set to one side, with subsoil placed on the other side ready for reinstatement (photo courtesy of British Solar Renewables)

9.9 Once the trench has been backfilled it should be left for cultivation with the rest of the field post removal of panels.

Removal of Fixed Infrastructure

9.10 Switchgear, such as that shown below, will need to be removed.

Insert 61: Switchgear

9.11 Low ground pressure vehicles, and cranes, will be needed to lift the decommissioned units onto trailers, and removed from site. An example is shown below.

Insert 62: Example of Low Ground Pressure Vehicles

Case Steiger Quadtrac used to deliver inverters and other heavy equipment to site under soft ground conditions (photo courtesy of British Solar Renewables)

9.12 Any concrete bases will need to be broken up. This will most likely involve breaking with a pneumatic drill to crack the concrete, after which it should be dug up and loaded onto trailers and removed.

9.13 The ground beneath the base may then benefit from being subsoiled, to break any compaction. This should be done by standard tractor-mounted equipment, such as the following examples.

Inserts 63 and 64: Example of Tractor Mounted Equipment

Tracks

9.14 The tracks will be the last fixed infrastructure removed. The tracks will have been used for vehicle travel during the decommissioning stage. The tracks will also be used for removal of material from the tracks themselves, which will be removed from the furthest point first.

9.15 The stone will be removed and any matting removal. The base will then be loosened by subsoiler or deep tine cultivators, depending on specific advice given by the soil expert at the time following an analysis of soil compaction and condition.

Reinstatement of Soils

9.16 Topsoil from the storage areas will then be returned and spread to the depth removed. The area will then be cultivated, probably in combination with the whole of each field.

Fences and Gates, and CCTV Cabling

9.17 The cabling be removed in the summer months, after the panels have been removed. This will involve a tractor and trailer. The CCTV cabling is shallow buried and will probably pull out without the need for trenching, but if required trenches will be dug, as described above, and replaced in order once the cables have been removed.

9.18 Fences and gates will be rocked by machinery and pulled out. The holes are generally small and will fill in easily, but the bucket could be used to loosen the surface so that soil fills the void, if there is a risk of injury from the small holes.

Cultivation

9.19 The fields will be handed back to the farmers. Whether they are handed back as grassland or sprayed off and cultivated, will be determined in discussions with each landowner.

Appendix SMP1

AMET ALC Report

AGRICULTURAL LAND CLASSIFICATION
HEOLDDU

CLIENT: QUALITAS ENERGY
PROJECT: HEOLDDU
DATE: 29TH MAY 2025 – ISSUE 2
ISSUED BY: JAMES FULTON MRICS FAAV

Contents

1. EXECUTIVE SUMMARY

1.1 This report assesses the Agricultural Land Classification (ALC) grading of 80.9Ha, of agricultural land at Llandyfaelog.

1.2 The limiting factor found to be soil wetness, a combination of the climatic regime, soil water regime and texture of the top 25cm of the soil.

1.3 The land is graded as follows:

Grade 3a:	39.7 Ha
Grade 3b:	41.2 Ha

2. INTRODUCTION

2.1 Amet Property Ltd have been instructed by Qualitas Energy to produce an Agricultural Land Classification (ALC) report on an 81-hectare site on land southwest of Llandyfaelog. The ALC report is being prepared to accompany a planning application.

2.2 The report's author is James Fulton BSc (Hons) MRICS FAAV who has worked as a chartered surveyor, agricultural valuer, and agricultural consultant since 2004, has a degree in agriculture which included modules on soils and over 10 years' experience in advising farmers on soil structure and cultivation methods and in producing agricultural land classification reports. Additional information on authors experience is found at ***appendix 1***.

2.3 The report is based on a site visit conducted by two surveyors on the 28th of November 2024 during which the conditions were overcast and mild, the soil was found to be wet.

2.4 During the inspections 2 trial pits were dug to a depth of 120cm, or as deep as possible before the soil becomes impenetrable. In addition to the trial pits an auger was used to take approximately one sample per hectare on a 100mx100m grid across the proposed development site to a depth of 120cm with smaller trial pits at some of these locations to confirm soil structure and colour where it was not clear from the auger samples. A plan of auger points and trial pit locations can be found at ***appendix 2***. The trial pit locations were selected as they were representative of the soils found on site. Where subsoils were inspected with a spade, descriptions of structure have been recorded based on the soil survey field handbook[1]; where an auger has been used the structure is described as good, moderate or poor based on figure 9,10 and 11 in the MAFF[2] guidance. Colours are described using Munsell Colours[3]. Soil texture was confirmed using soil particulate distribution by sedimentation tests conducted by an independent laboratory. Samples to send to the lab were chosen where it was considered that they were most representative of certain areas, this is not always the same as the trial pit locations.

2.5 The surveyed area extends to 80.9Ha of grassland spread cross 28 fields.

2.6 Further information has been obtained from the MAGIC website, the Soil Survey of England and Wales, the British Geological Survey, the Meteorological Office and 1:250,000 series Agricultural Land Classification maps.

2.7 The collected information has been judged against the Ministry of Agriculture Fisheries and Food Agricultural Land Classification of England and Wales revised guidelines and criteria for grading the quality of agricultural land.

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[1] Hodgson, JM (1997) Soil Survey Field Handbook

[2] MAFF (1988) - *Agricultural Land Classification of England and Wales. Revised guidelines and criteria for grading the quality of agricultural land*. MAFF Publications

[3] Munsell Color (2009) Munsell Soil Color Charts

2.8 The principal factors influencing agricultural production are climate, site and soil and the interaction between them MAFF (1988) & Natural England (2012)[4].

2.9 The report is prepared and formatted considering the latest BSSS guidance[5].

3. PUBLISHED INFORMATION

3.1 The British Geological Survey 1:50,000 scale map shows the bedrock geology to be Milford Haven Group – Argillaceous rocks and sandstone and conglomerate, interbedded.

3.2 The soils on the site are identified as being 541a MILFORD Association, well drained fine loamy reddish soils over rock.

3.3 The Welsh Government: Predictive ALC Map shows the land to be largely Grade 3a with some small areas of grade 3a.

[4] MAFF (1988) - *Agricultural Land Classification of England and Wales. Revised guidelines and criteria for grading the quality of agricultural land*. MAFF Publications

Natural England (2012) - *Technical Information Note 049 - Agricultural Land Classification: protecting the best and most versatile agricultural land*, Second Edition

[5] BSSS (2022) Working with Soil Guidance Note on Assessing Agricultural Land Classification Surveys in England and Wales

4. CLIMATE

4.1 Climate has a major, and in places overriding, influence on land quality affecting both the range of potential agricultural uses and the cost and level of production.

4.2 There is published agro-climatic data for England and Wales provided by the Meteorological Office, such data for the subject site is listed in the table below.

Agro-Climatic Data – Full details can be found at ***appendix 3***

Grid Reference	239884,210476
Altitude (ALT)	106
Average Annual Rainfall (AAR)	1339
Accumulated Temperature - Jan to June (ATO)	1440
Duration of Field Capacity (FCD)	260
Moisture Deficit Wheat	64
Moisture Deficit Potatoes	45

4.3 The main parameters used in assessing the climatic limitation are average annual rainfall (AAR), as a measure of overall wetness; and accumulated temperature (ATO), as a measure of the relative warmth of a locality.

4.4 The AAR and ATO provide climatic limitation to grade 3a.

4.5 The site is shown to be in flood zone 1 – areas with a less than 1 in 1000 annual chance of flooding. There was no evidence of flooding seen during the site visit and it is considered that will not result in a limitation to land grade.

5. STONINESS

5.1 The topsoil ranges from stoneless to up to 15% small to medium subrounded to subangular hard stones. The size and quantity of stones is not sufficient to limit the and grade.

6. GRADIENT AND MICRORELIEF

6.1 The site is flat to gently sloping with no gradient or microrelief to limit land grade.

7. SOILS

7.1 The soils found on site largely follow the expectations set by the national soils map. Full information on the sample points along with trial pit descriptions and photographs and lab test results can be found at ***appendix 4***.

7.2 The topsoil is consistently reddish brown (5YR 4/4) clay loam with odd points where the topsoil is significantly heavier and recorded as clay. The majority of survey points are on the margin of being medium clay loam or heavy clay loam as was shown by the lab tests that show a clay percentage of 24% to 29% with the cutoff between heavy and medium clay loam being 27%. There was a relatively high proportion of silt identified at all survey points, but this was not considered enough to be recorded and a silty clay loam although one of the lab tests identified enough silt for the sample point to be recorded as heavy silty clay loam.

7.3 Where a subsoil was identified it was heavier than the topsoil and recorded as clay. The subsoil was recorded as moderately structured with the soil auger and confirmed as a friable coarse subangular blocky structure at the trial pits. The subsoil was usually the same colour as the topsoil but occasionally a slightly different Munsell colour (5YR 5/4 or 2.5YR 5/3).

7.4 Almost all survey points became impenetrable to further augering or digging at between 30cm (directly below the topsoil) and 70cm due to the quantity of medium to large subrounded and subangular hard stones. This did not appear to be rock and so in terms of the droughtiness assessment it is assumed that the stone continues to 120cm and there would be some water availability to a crop.

Interactive Factors

8. Wetness

8.1 An assessment of the wetness class of each sample point was made based on the flow chart at Figure 6 in the MAFF guidance. The wetness class and topsoil texture were then assessed against Table 6 of the MAFF guidance to determine the ALC grade according to wetness. The wetness assessment can be found at ***appendix 4***.

8.2 There was no slowly permeable layer of gleying identified at any survey point and so all points were recorded as wetness class I.

8.3 Table 6, >225FCD and wetness class I result in a grade 3a limitation where the topsoil is medium clay loam and grade 3b limitation where the topsoil is heavy clay loam.

9. DROUGHTINESS

9.1 Droughtiness limits are defined in terms of moisture balance for wheat and potatoes using the formula:

MB (Wheat) = AP (Wheat) - MD (Wheat)

and

MB (Potatoes) = AP (Potatoes) - MD (Potatoes)

Where:
MB = Moisture Balance
AP = Crop Adjusted available water capacity
MD = Moisture deficit

9.2 Moisture deficit for wheat and potatoes can be found in the agro-climatic data and are as follows:

MD (Wheat) = 64
MD (Potatoes) = 45

9.3 Crop adjusted available water is calculated by reference to the total available water and easily available water which is calculated by reference to soil texture and structural condition and the stone content.

9.4 The moisture balance was calculated for each survey point and can be found at ***appendix 4***.

10. Agricultural Land Classification

10.1 The Agricultural Land Classification provides a framework for classifying land according to which its physical or chemical characteristics impose long-term limitations on agricultural use. The limitations can operate in one or more of four principle ways: they may affect the range of crops that can be grown, the level of yield, the consistency of yield and the cost of obtaining it.

10.2 The principle physical factors influencing agricultural production are climate, site and soil and the interactions between them which together form the basis for classifying land into one of 5 grades; grade 1 being of excellent quality and grade 5 being land of very poor quality. Grade 3 land, which constitutes approximately half of all agricultural land in the United Kingdom is divided into 2 subgrades – 3a and 3b. A full definition of all of the grades can be found at ***appendix 5.***

10.3 This assessment sets out that the site is limited by wetness.

10.4 Where there are single points of higher or lower grade these are classified based on the surrounding area.

10.5 The breakdown of land by classification is:

Grade 3a:	39.7 Ha
Grade 3b:	41.2 Ha

10.6 A plan of the land grading can be found at ***appendix 6***.

Appendix 1 – Details of the Authors Experience

James Fulton

Professional Education and Qualifications

BSc (Hons) Agriculture, University of Nottingham (2004)

Member of the Royal Institution of Chartered Surveyors (MRICS) (2008)

Fellow of the Central Association of Agricultural Valuers (FAAV) (2009)

Relevant Work Experience

While working for a regional firm from 2004 until 2016 as part of my work I provided advice to farmers on soils, cultivation techniques and cropping and was involved in field trials which assessed cropping and cultivation techniques and how they impacted soil structure. At the same time I worked alongside an experienced surveyor who produced Agricultural Land Classification reports and I received training in field survey techniques and the ALC process to the point where I was able to produce ALC reports.

In 2016 I left my employer and formed Amet Property Ltd providing development consultancy and other rural practice surveying services. Of all of the services that we provide Agricultural Land Classification reports is the single largest area of work accounting for approximately 70% of all of my working time.

While I am not a member of the BSSS I meet the minimum competencies set out by the BSSS in Document 1 *Foundation skills in field soil investigation, description and interpretation* and Document 2 *Agricultural Land Classification (England and Wales)*

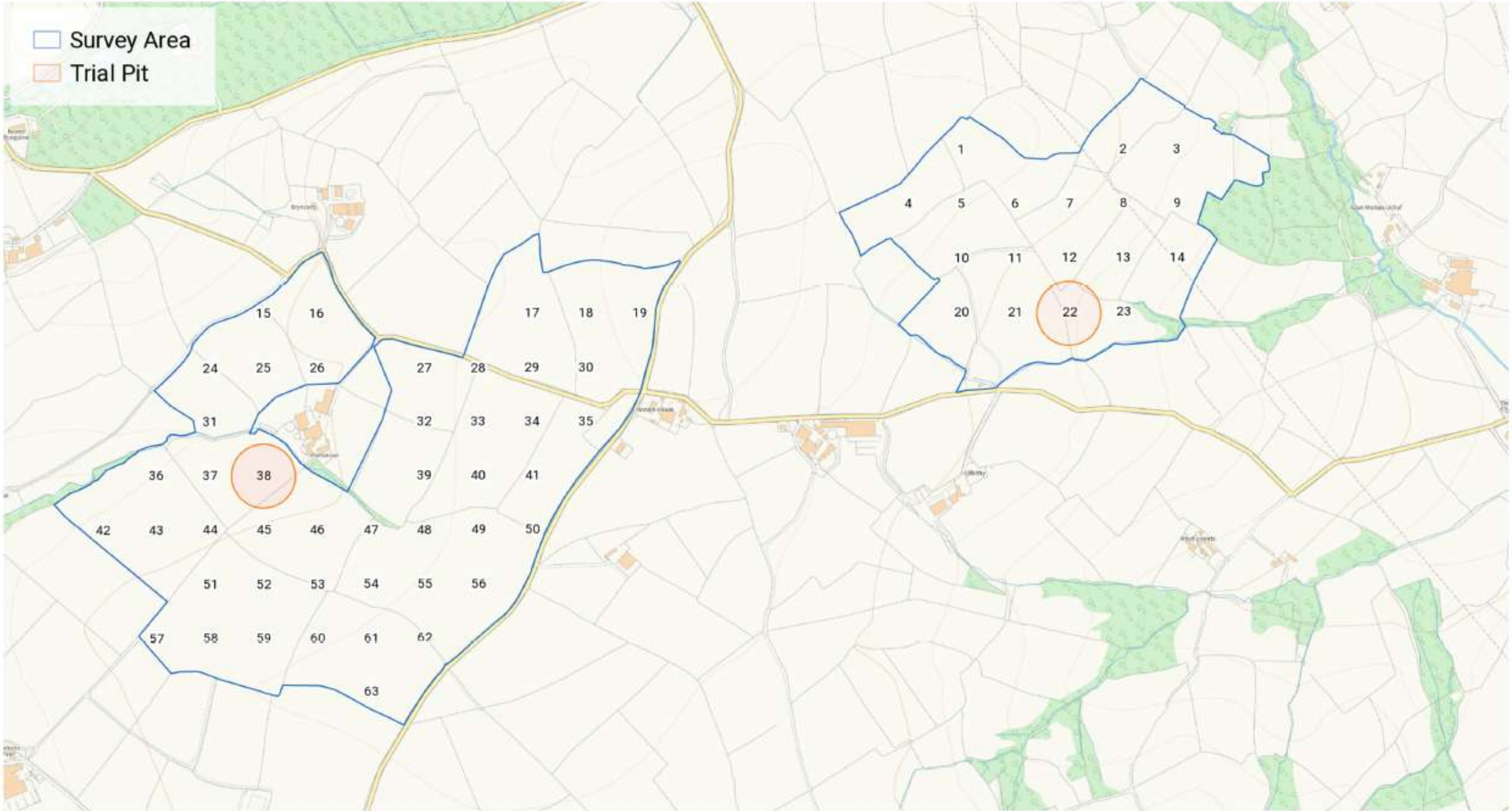
Professional Standards

As a member of the Royal Institution of Chartered Surveyors and Fellow of the Central Association of Agricultural Valuers I am bound by their professional standards and am only able to carry out work where I am suitably qualified and experienced to do so. Due to the formal and practical training that I have received I am able to competently produce Agricultural Land Classification reports.

Assistant Surveyors

All assistant surveyors have completed the BSSS working with soil course and have been trained to meet the requirements of BSSS Document 1 *Foundation skills in field soil investigation, description, and interpretation.*

Appendix 2 - Map of Survey points



Produced on Land App, Jan 10, 2025

200 m
Scale 1:9909 (at A4)
N

Appendix 3 – Climatic Data

Site Details: Heolddu

Grid reference (centre of site): 239884 210476

Altitude: Mean 105.67 AOD

Climatic data from surrounding locations:

Grid Reference	ALT	AAR	LR_AAR	ASR	ATO	ATS	MDW	MDP	FCD
23502100	38	1146	1.4	500	1518	2395	79	66	230
23502150	86	1260	0.9	565	1461	2331	66	48	248
24002100	94	1320	1.7	555	1453	2325	67	49	257
24002150	7	1256	1.5	560	1550	2432	74	60	247

Altitude Adjusted

Grid Reference	AAR	ATO	FCD	MDW	MDP	Proximity Adjustment
23502100	1240.74	1440.86	243.70	65.43	48.22	0.97%
23502150	1277.70	1438.58	250.56	62.74	43.72	0.53%
24002100	1339.84	1439.70	259.87	64.41	45.62	97.36%
24002150	1404.01	1437.52	268.40	53.52	33.18	1.14%

Appendix 4a - Sample Point Assessment

	Topsoil					Stoniness			Upper Subsoil						Lower Subsoil						Wetness Assesment			Grade	Droughtiness Assessment		Grade	Most
																					Depth to		Wetness	limit by	MB	MB	limit by	limiting
Sample No	Altitude	Depth	Texture	Colour	<2cm	2-6cm	>6cm	Mottles	Depth	Texture	Colour	Stoniness	Mottles	Structure	Depth	Texture	Colour	Stoniness	Mottles	Structure	SPL	Gley	Class	Wetness	Wheat	Potato	Droughtiness	Grade
1	111	0 - 40	HCL	5YR 4 / 4	10%			CO	40 - 120	Stone				Good	-								I	3b	5.41	22.71	2	3b
2	98	0 - 40	HCL	5YR 4 / 4	10%			CO	40 - 120	Stone				Good	-								I	3b	5.41	22.71	2	3b
3	91	0 - 40	MCL	5YR 4 / 4	10%			CO	40 - 120	Stone				Good	-								I	3a	5.41	22.71	2	3a
4	116	0 - 40	MCL	5YR 4 / 4	10%			CO	40 - 120	Stone				Good	-								I	3a	5.41	22.71	2	3a
5	116	0 - 50	HCL	5YR 4 / 4	5%			CO	50 - 120	Stone				Good	-								I	3b	24.96	42.26	2	3b
6	114	0 - 30	HCL	5YR 4 / 4	5%			CO	30 - 120	Stone				Good	-								I	3b	-7.34	9.96	3a	3b
7	109	0 - 50	MCL	5YR 4 / 4	5%			CO	50 - 120	Stone				Good	-								I	3a	24.96	42.26	2	3a
8	105	0 - 30	MCL	5YR 4 / 4	5%			CO	30 - 120	Stone				Good	-								I	3a	-7.34	9.96	3a	3a
9	100	0 - 45	HCL	5YR 4 / 4	10%			CO	45 - 120	Stone				Good	-								I	3b	13.06	30.36	2	3b
10	109	0 - 70	HCL	5YR 4 / 4	5%			CO	70 - 120	Stone				Good	-								I	3b	58.26	74.56	1	3b
11	105	0 - 55	HCL	5YR 4 / 4	5%			CO	55 - 120	Stone				Good	-								I	3b	33.28	50.33	1	3b
12	100	0 - 40	MCL	5YR 4 / 4	5%			CO	40 - 120	Stone				Good	-								I	3a	8.81	26.11	2	3a
13	98	0 - 35	MCL	5YR 4 / 4	5%			CO	35 - 120	Stone				Good	-								I	3a	0.73	18.03	3a	3a
14	98	0 - 35	MCL	5YR 4 / 4	5%			CO	35 - 120	Stone				Good	-								I	3a	0.73	18.03	3a	3a
15	98	0 - 45	MCL	5YR 4 / 4	5%			CO	45 - 70	C	5YR 4 / 4	5%	MO	Moderate	70 - 120	Stone				Good			I	3a	38.26	69.81	1	3a
16	102	0 - 40	MCL	5YR 4 / 4	5%			CO	40 - 70	C	5YR 4 / 4	5%	MO	Moderate	70 - 120	Stone				Good			I	3a	37.31	68.86	1	3a
17	111	0 - 40	MCL	10YR 5 / 2				CO	40 - 60	HCL	2.5YR 5 / 3	2%	MO	Moderate	60 - 120	Stone				Good			I	3a	36.22	58.91	1	3a
18	117	0 - 80	MCL	5YR 4 / 4	5%			FO	80 - 120	Stone				Good	-					Good			I	3a	74.91	74.56	1	3a
19	123	0 - 50	MCL	5YR 4 / 4	10%				50 - 120	Stone				Good	-								I	3a	20.71	38.01	2	3a
20	105	0 - 40	MCL	5YR 4 / 4	5%			CO	40 - 120	Stone				Good	-								I	3a	8.81	26.11	2	3a
21	105	0 - 35	MCL	5YR 4 / 4	5%			CO	35 - 120	Stone				Good	-								I	3a	0.73	18.03	3a	3a
22	103	0 - 40	MCL	5YR 4 / 4	10%			CO	40 - 50	HCL	5YR 4 / 4	20%		Moderate	50 - 120	Stone				Good			I	3a	17.41	34.71	2	3a
23	97	0 - 40	MCL	5YR 4 / 4	5%			CO	40 - 50	HCL	5YR 4 / 4	20%	COB	Moderate	50 - 120	Stone				Good			I	3a	20.81	38.11	2	3a
24	98	0 - 45	MCL	5YR 4 / 4	5%			CO	45 - 70	C	5YR 4 / 4	5%	MO	Moderate	70 - 120	Stone				Good			I	3a	38.26	69.81	1	3a
25	101	0 - 40	MCL	5YR 4 / 4	5%			CO	40 - 60	C	5YR 4 / 4	20%	MO	Moderate	60 - 120	Stone				Good			I	3a	26.81	50.11	2	3a
26	102	0 - 40	MCL	5YR 4 / 4	5%			CO	40 - 60	C	5YR 4 / 4	20%	MO	Moderate	60 - 120	Stone				Good			I	3a	26.81	50.11	2	3a
27	105	0 - 40	MCL	5YR 4 / 4	5%			CO	40 - 120	Stone				Good	-								I	3a	8.81	26.11	2	3a
28	110	0 - 30	MCL	5YR 4 / 4	5%			CO	30 - 120	Stone				Good	-								I	3a	-7.34	9.96	3a	3a
29	110	0 - 40	MCL	10YR 5 / 2				CO	40 - 60	HCL	2.5YR 5 / 4	2%	MO	Moderate	60 - 120	Stone				Good			I	3a	36.22	58.91	1	3a
30	111	0 - 40	MCL	5YR 4 / 3	15%			CO	40 - 120	HCL	2.5YR 5 / 4	2%	MO	Moderate	-								I	3a	81.88	63.41	1	3a
31	94	0 - 45	MCL	5YR 4 / 4	10%	2%		CO	45 - 120	Stone				Good	-								I	3a	11.53	28.83	2	3a
32	104	0 - 75	MCL	5YR 4 / 4	10%			CO	75 - 120	Stone				Good	-								I	3a	60.21	68.61	1	3a
33	108	0 - 70	C	5YR 4 / 4	5%			CO	70 - 120	Stone				Good	-								I	3b	51.61	67.91	1	3b
34	112	0 - 40	C	5YR 4 / 4	5%			CO	40 - 120	Stone				Good	-								I	3b	5.01	22.31	2	3b
35	114	0 - 40	C	5YR 4 / 4	5%			CO	40 - 120	Stone				Good	-								I	3b	5.01	22.31	2	3b
36	91	0 - 60	HCL	5YR 4 / 4					60 - 70	C	5YR 4 / 4	20%	MO	Moderate	70 - 120	Stone				Good			I	3b	52.71	75.51	1	3b
37	93	0 - 55	MCL	5YR 4 / 4	5%	2%	2%	CO	55 - 70	C	5YR 4 / 4	20%		Moderate	70 - 120	Stone				Good			I	3a	38.54	64.59	1	3a
38	96	0 - 55	MCL	5YR 4 / 4	5%	5%		CO	55 - 70	HCL	5YR 4 / 4	20%		Moderate	70 - 120	Stone				Good			I	3a	40.01	63.66	1	3a
39	105	0 - 40	HCL	5YR 4 / 4	2%			CO	40 - 100	C	5YR 4 / 4		COB	Moderate	100 - 120	Stone				Good			I	3b	63.35	73.15	1	3b
40	111	0 - 70	C	5YR 4 / 4	5%			CO	70 - 120	Stone	/			Good	-								I	3b	51.61	67.91	1	3b
41	115	0 - 30	C	5YR 4 / 4	5%			CO	30 - 120	Stone	/			Good	-								I	3b	-10.19	7.11	3a	3b
42	92	0 - 60	HCL	5YR 4 / 4					60 - 90	C	5YR 4 / 4	20%	CO	Moderate	90 - 120	Stone				Good			I	3b	64.71	75.51	1	3b
43	95	0 - 55	HCL	5YR 4 / 4					55 - 100	C	5YR 4 / 4	20%	MO	Moderate	100 - 120	Stone				Good			I	3b	64.96	73.01	1	3b
44	99	0 - 60	MCL	5YR 4 / 4	5%			CO	60 - 120	Stone				Good	-								I	3a	41.61	58.41	1	3a
45	103	0 - 50	MCL	5YR 4 / 4	5%			CO	50 - 120	Stone				Good	-								I	3a	24.96	42.26	2	3a
46	103	0 - 50	HCL	5YR 4 / 4	5%			CO	50 - 120	Stone				Good	-								I	3b	24.96	42.26	2	3b
47	107	0 - 55	HCL	5YR 4 / 4	5%			CO	55 - 120	Stone				Good	-								I	3b	33.28	50.33	1	3b
48	109	0 - 40	HCL	5YR 4 / 4	2%			CO	40 - 100	C	5YR 4 / 4		MO	Moderate	100 - 120	Stone				Good			I	3b	63.35	73.15	1	3b
49	113	0 - 30	HCL	5YR 4 / 4	2%			CO	30 - 40	C	5YR 4 / 4	20%	CO	Moderate	40 - 120	Stone				Good			I	3b	6.19	23.49	2	3b
50	117	0 - 50	HCL	5YR 4 / 4	7%			CO	50 - 120	Stone				Good	-								I	3b	23.26	40.56	2	3b
51	102	0 - 35	HCL	5YR 4 / 4	5%			CO	35 - 50	HCL	5YR 5 / 4		COB	Moderate	50 - 60	C	5YR 4 / 4	20%	MO	Moderate			I	3b	36.23	51.53	1	3b
52	103	0 - 40	HCL	5YR 4 / 4	2%			CO	40 - 70	C	5YR 4 / 4	20%	MO	Moderate	70 - 120	Stone				Good			I	3b	34.85	64.15	1	3b
53	105	0 - 50	HCL	5YR 4 / 4	2%			CO	50 - 80	C	5YR 4 / 4	20%	MO	Moderate	80 - 120	Stone				Good			I	3b	45.51	68.81	1	3b
54	106	0 - 55	HCL	5YR 4 / 4	5%			CO	55 - 120	Stone				Good	-								I	3b	33.28	50.33	1	3b
55	110	0 - 25	HCL	5YR 4 / 4	5%			CO	25 - 120	Stone				Good	-								I	3b	-15.42	1.88	3a	3b
56	114	0 - 40	HZCL	10YR 5 / 2				CO	40 - 120	Stone				Good	-								I	3b	16.21	33.51	2	3b
57	105	0 - 45	HCL	5YR 4 / 4	10%			CO	45 - 120	Stone				Good	-								I	3b	13.06	30.36	2	3b
58	107	0 - 45	HCL	5YR 4 / 4	10%			CO	45 - 120	Stone				Good	-								I	3b	13.06	30.36	2	3b
59	108	0 - 40	HCL	5YR 4 / 4	2%			CO	40 - 70	C	5YR 4 / 4	20%	MO	Moderate	70 - 120	Stone				Good			I	3b	34.85	64.15	1	3b
60	110	0 - 35	HCL	5YR 4 / 4	5%			CO	35 - 120	Stone				Good	-								I	3b	0.73	18.03	3a	3b
61	112	0 - 30	HCL	5YR 4 / 4	5%			CO	30 - 120	Stone				Good	-								I	3b	-7.34	9.96	3a	3b
62	113	0 - 25	HCL	5YR 4 / 4	5%			CO	25 - 120	Stone				Good	-								I	3b	-15.42	1.88	3a	3b
63	113	0 - 30	HCL	5YR 4 / 4	7%			CO	30 - 120	Stone				Good	-								I	3b	-8.36	8.94	3a	3b
	105.667																											

Appendix 4b – Trial Pit Descriptions

Sample Point No. 22		
Horizon 1	0-40cm (5YR 4/4) medium clay loam. With 10% small to large, rounded stones and common ochreous mottles.	
Horizon 2	40-50cm (5YR 4/4) heavy clay loam with a coarse subangular blocky structure, friable consistence. With 20% rounded stones and few ochreous mottles.	
Horizon 3	50cm impenetrable due to stone content.	
Pictures		
Horizon 1 	Horizon 2 	Horizon 3 
Slowly permeable layer	Not Present	
Gleying	Not Present	
Wetness Class	I	
Wetness limitation	3a	
MB Wheat	17.41	
MB potatoes	34.71	
Droughtiness Limitation	2	

Sample Point No. 38		
Horizon 1	0-55cm (5YR 4/4) medium clay loam. With 10% small to medium, rounded stones and common ochreous mottles.	
Horizon 2	55-70cm (5YR 4/4) heavy clay loam with a coarse subangular blocky structure, friable consistence. With 20% rounded stones and few ochreous mottles.	
Horizon 3	70cm impenetrable due to stone content, there was water present at the bottom of the hole.	
Pictures		
Horizon 1 	Horizon 2 	Horizon 3 
Slowly permeable layer	Not Present	
Gleying	Not Present	
Wetness Class	I	
Wetness limitation	3a	
MB Wheat	40.01	
MB potatoes	63.66	
Droughtiness Limitation	2	

Core pictures

Sample Point 3

Sample Point 32

Sample Point 43

Sample Point 48

ANALYTICAL REPORT

Report Number	**68034-24**	**W250**	**AMET PROPERTY**
Date Received	**02-DEC-2024**		**HENWICK BARN**
Date Reported	**10-JAN-2025**		**BULWICK**
Project	**SOIL**		**CORBY**
Reference	**AMET PROPERTY**		**NORTHANTS**
Order Number			**NN17 3DU**

Laboratory Reference				**SOIL727028**	**SOIL727029**	**SOIL727030**	**SOIL727031**				
Sample Reference				**58**	**56**	**28**	**3**				
Determinand	**Unit**			**SOIL**	**SOIL**	**SOIL**	**SOIL**				
Coarse Sand 2.00-0.63mm	% w/w			7	0	11	11				
Medium Sand 0.63-0.212mm	% w/w			4	2	5	7				
Fine Sand 0.212-0.063mm	% w/w			11	13	12	13				
Silt 0.063-0.002mm	% w/w			49	56	47	45				
Clay <0.002mm	% w/w			29	29	25	24				
Textural Class **				HCL	HZCL	MCL	MCL				

Notes

Analysis Notes: The sample submitted was of adequate size to complete all analysis requested.
The results as reported relate only to the item(s) submitted for testing.
The results are presented on a dry matter basis unless otherwise stipulated.

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** Please see the attached document for the definition of textural classes.

Reported by: *Myles Nicholson*

Natural Resource Management, a trading division of Cawood Scientific Ltd.
Coopers Bridge, Braziers Lane, Bracknell, Berkshire, RG42 6NS
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ADAS (UK) Textural Class Abbreviations

The texture classes are denoted by the following abbreviations:

Class	Code
Sand	S
Loamy sand	LS
Sandy loam	SL
Sandy Silt loam	SZL
Silt loam	ZL
Sandy clay loam	SCL
Clay loam	CL
Silt clay loam	ZCL
Clay	C
Silty clay	ZC
Sandy clay	SC

For the *sand, loamy sand, sandy loam* and *sandy silt loam* classes the predominant size of sand fraction may be indicated by the use of prefixes, thus:

- vf Very Fine (more than 2/3's of sand less than 0.106 mm)
- f Fine (more than 2/3's of sand less than 0.212 mm)
- c Coarse (more than 1/3 of sand greater than 0.6 mm)
- m Medium (less than 2/3's fine sand and less than 1/3 coarse sand).

The subdivisions of *clay loam* and *silty clay loam classes* according to clay content are indicated as follows:

- M medium (less than 27% clay)
- H heavy (27-35% clay)

Organic soils i.e. those with an organic matter greater than 10% will be preceded with a letter O.

Peaty soils i.e. those with an organic matter greater than 20% will be preceded with a letter P.

APPENDIX 5 - DESCRIPTION OF ALC GRADES

Grade 1 - excellent quality agricultural land Land with no or very minor limitations to agricultural use. A very wide range of agricultural and horticultural crops can be grown and commonly includes top fruit, soft fruit, salad crops and winter harvested vegetables. Yields are high and less variable than on land of lower quality.

Grade 2 - very good quality agricultural land Land with minor limitations which affect crop yield, cultivations or harvesting. A wide range of agricultural and horticultural crops can usually be grown but on some land in the grade there may be reduced flexibility due to difficulties with the production of the more demanding crops such as winter harvested vegetables and arable root crops. The level of yield is generally high but may be lower or more variable than Grade 1.

Grade 3 - good to moderate quality agricultural land Land with moderate limitations which affect the choice of crops, timing and type of cultivation, harvesting or the level of yield. Where more demanding crops are grown yields are generally lower or more variable than on land in Grades 1 and 2.

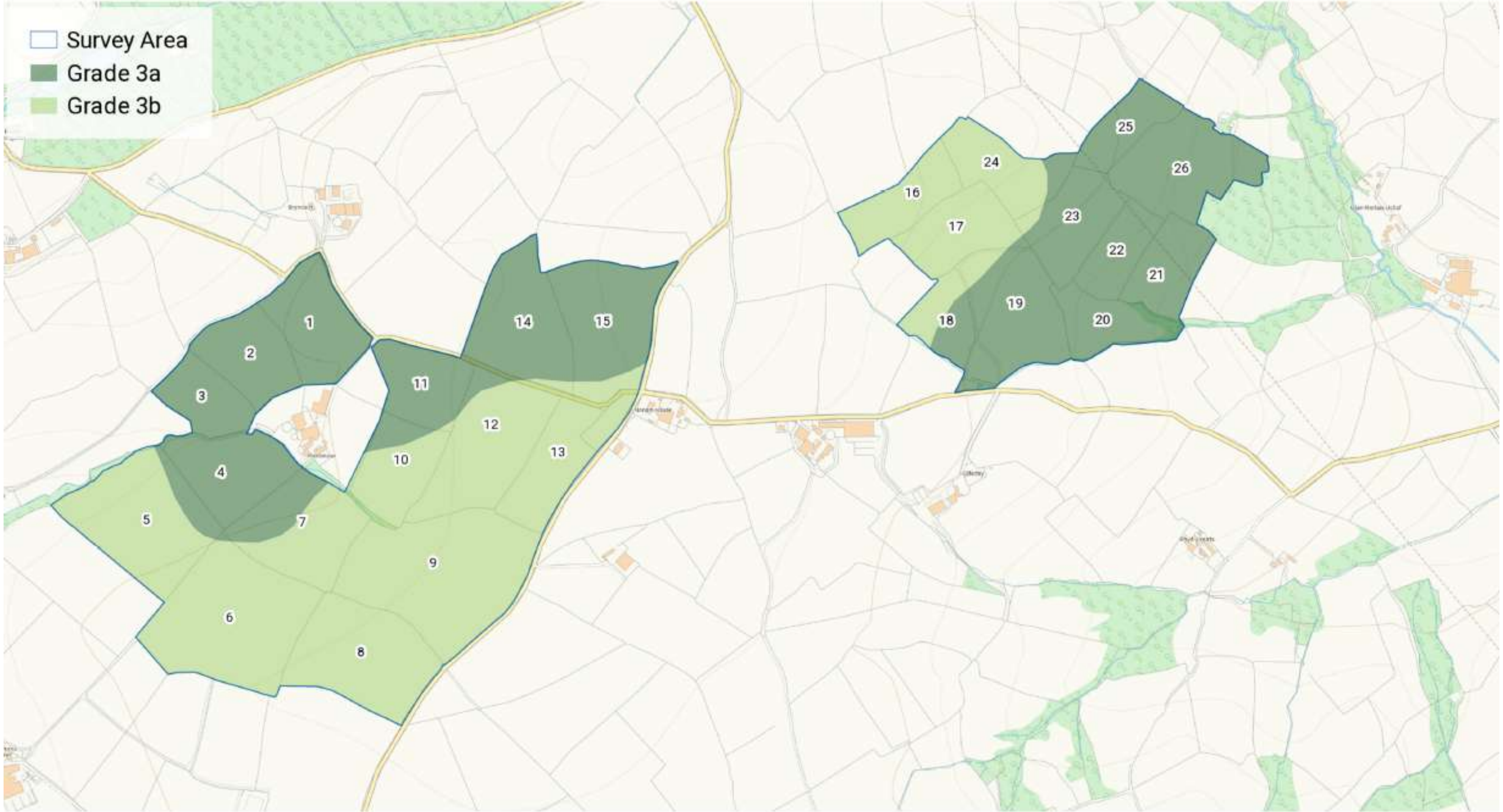
Subgrade 3a - good quality agricultural land Land capable of consistently producing moderate to high yields of a narrow range of arable crops, especially cereals, or moderate yields of a wide range of crops including cereals, grass, oilseed rape, potatoes, sugar beet and the less demanding horticultural crops.

Subgrade 3b - moderate quality agricultural land Land capable of producing moderate yields of a narrow range of crops, principally cereals and grass or lower yields of a wider range of crops or high yields of grass which can be grazed or harvested over most of the year.

Grade 4 - poor quality agricultural land Land with severe limitations which significantly restrict the range of crops and/or level of yields. It is mainly suited to grass with occasional arable crops (e.g. cereals and forage crops) the yields of which are variable. In moist climates, yields of grass may be moderate to high but there may be difficulties in utilisation. The grade also includes very droughty arable land.

Grade 5 - very poor-quality agricultural land Land with very severe limitations which restrict use to permanent pasture or rough grazing, except for occasional pioneer forage crops.

Appendix 6 - Map of ALC Grade



Produced on Land App, May 29, 2025.

Appendix SMP2

Institute of Quarrying Field Tests for Soils Suitability

IQ

The Institute of Quarrying

Good Practice Guide for Handling Soils in Mineral Workings

Supplementary Note 4
Soil Wetness

Soil wetness is a major determinant of land use, and environmental and ecosystem services in the UK. It is also a factor in the occurrence of significant compaction arising from handling soils with earth-moving machines and the practices used (Duncan & Bransden, 1986).

Relative soil wetness can range from the waterlogged to moist (mesic) or dry (xeric) depending on rainfall distribution and depth to a water-table and duration of waterlogging. In the UK, soil wetness is largely seasonal with higher evapo-transpiration rates potentially exceeding rainfall in the summer resulting in the soil profile becoming drier where there is vegetation. Whilst soil wetness is largely weather system and equinox (climate) driven, it varies with geographical and altitudinal locations, and importantly the physical characteristics of the soil profile, such as texture structure, porosity, and depth to the water-table and topography including flood risk (MAFF, 1988). The Soil Wetness Class is based on the expected average duration of waterlogging at different depths in the soil throughout the year (days per year), and can be determined by reference to soil characteristics and local climate (MAFF, 1988). The likely inherent wetness and resilience status of a soil should be indicated in the SRMP (see **Part 1, Table 2 & Supplementary Note 1**), reflecting potential risks for soil handling such as low permeability, permanently high groundwater, or a wet upland climate.

Wet soils can also be a result of other circumstances. For example, the interception of water courses, drainage ditches and field land drains. Where these occur, the provisions are to be made in the SRMP to protect the soils being handled and the operational area.

Soils, when in a wet condition generally have a lower strength and have less resistance to compression and smearing than when dry. Lower strength when soils are wet also affects the bearing capacity of soils and their ability to support the safe and efficient operation of machines than when in a dry state.

In terms of resilience and susceptibility to soil wetness, the clay content of the soil largely determines the change from a solid to a plastic state (the water content at which this occurs is called the 'plastic limit' (MAFF, 1982)). This is the point at which an increasing soil wetness has reduced the cohesion and strength of the soil and its resistance to compression and smearing.

Whilst coarse textured sandy soils are not inherently plastic when wet, they are still prone to compaction when in a wet condition. Hence, handling all soils when wet will have adverse effects on plant root growth and profile permeability, which may be of significance for the intended land use and the provision of services reliant on soil drainage and plant root growth. It may be less so in other circumstances where wet soil profiles, perched water tables and ponding are the reclamation objectives, though drainage control, for example to control flooding, may still be important in these contexts.

In cases of permanently wet soils, such as riverine sites, upland or deep organic soils where there is a persistent high water-table throughout the seasons within the depth of soil to be stripped and/or the soil profile remains too wet, a strategic decision has to be made to be able to proceed with the development of the mineral resource. This may mean alternative and less favourable soil handling practices have to be agreed with the planning authority.

Predicting & Determination of Soil Wetness
There are well established methods to predict and determine soil wetness of undisturbed and restored soil profiles (Reeve, 1994). The challenge has been the prediction of the best time for soil stripping. Models based on soil moisture deficits and field capacity dates for a range of soil textures can provide indicative regional summaries (**Table 4.1**) that can help with planning operations at broad scale but cannot be relied upon in practice for deciding operationally whether to proceed on the ground given the actual variation in weather events from year to year and within years.

	Climatic Zones		
Soil Clay Content	**1**	**2**	**3**
Soil Depth <30cm			
<10%	Mid Apr - Early Oct	Late Mar – Early Nov	Late Mar – Early Dec
10 -27%	Late May - Early Oct	Early May – Early Nov	Early Apr – Early Dec
Soil Depth 30-60cm			
<10%	Late Apr - Early Oct	Mid Apr – Early Nov	Early Apr – Early Dec
10-27%	Late May - Early Oct	Early May – Early Nov	Early Apr – Early Dec
>27%	Late June – Early Oct	Early June – Early Nov	Late May – Early Dec
Soil Depth >60cm			
<10%	Late Apr - Early Oct	Mid Apr – Early Nov	Early Apr – Early Dec
10-18%	Late May - Early Oct	Early May – Early Nov	Early Apr – Early Dec
18-27%	Late June – Early Oct	Early June – Early Nov	Late May – Early Dec
>27	Mid July – Mid Sept	Early July – Mid Oct	Late June – Mid Oct

Table 4.1: Indicative on-average months when vegetated mineral soils might be in a sufficiently dry condition according to geographic location, depth of soil and clay content

The timing of most soil handling operations takes place between April and September. Although in western (Zone 1) and central (Zone 2) areas it typically can be a later start in May with an earlier termination in August. Whilst the return to climatically 'excess rainfall' is later in the eastern counties (Zone 3) and can be as late as November/early December, there is a need to maintain transpiring vegetation to keep the soils being handled in a dry as possible condition and to establish new vegetation covers as soon as possible (on replaced soils and storage mounds). Hence, soil handling operations generally need to be completed no later than the end of September (Natural England, 2021), unless appropriate provisions can be assured.

Where data is available, more realistic local and real-time predictions can be made, however, because weather patterns and events differ between and within years, and soils can be vary locally in their condition. Experience has shown that the most practical approach for operations is to inspect the site and soils in question near to/ at the time when soil handling is to take place. Professional soil surveyors can advise on the best time for soil handling (stripping, storage & replacement) and carry out site assessments of soil wetness condition prior to the start of operations.

A Practical Method for Determining Soil Wetness Limitation

During the soil handling season (see Table 4.1 above), prior to the start or recommencement of soil handling soils should be tested to confirm they are in suitably dry condition (**Table 4.2**). The 'testing' during operations can be done by suitably trained site staff and reviewed periodically by the professional soil surveyors.

The method is simply the ability to roll intact threads (3mm diameter) of soil indicating the soils are in a plastic and wet condition (MAFF, 1982; Natural England, 2021). Representative samples are to be taken through the soil profile and across the area to be stripped. It is the best available indicator of soils being too wet to be handled and operations should be delayed until a thread cannot be formed. For coarse textured soils which do not roll into threads, a professional's view as to soil wetness and the risk of compaction may have to be taken.

Table 4.2: Field Tests for Suitably Dry Soils

Soil tests are to be undertaken in the field. Samples shall be taken from at least five locations in the soil handling area and at each soil horizon to the full depth of the profile to be recovered/replaced. The tests shall include visual examination of the soil and physical assessment of the soil consistency.

i) Examination
- If the soil is wet, films of water are visible on the surface of soil particles or aggregates (e.g. clods or peds) and/or when a clod or ped is squeezed in the hand it readily deforms into a cohesive 'ball' means **no soil handling to take place.**
- If the samples is moist (i.e. there is a sligh dampness when squeezed in the hand) but it does not significantly change colour (darken) on further wetting, and clods break up/crumble readily when squeezed in the hand rather than forming into a ball means **soil handling can take place.**
- If the sample is dry, it looks dry and changes colour (darkens) if water is added, and it is brittle means **soil handling can take place.**

ii) Consistency
First test
Attempt to mould soil sample into a ball by hand:
- Impossible because soil is too dry and hard or too loose and dry means **soil handling can take place.**
- Impossible becuase the soil is too loose and wet means no soil handling to take place.
- Possible - Go to second text.

Second test
Attempt to roll ball into a 3mm diameter thread by hand:
- Impossible because soil crumbles or collapses means soil handling can take place.
- Possible means no soil handling can take place.

N.B.: It is possible to roll most coarse loamy and sandy soils into a thread even when they are wet. For these soils, the Examination Test alone is to be used.

A Rainfall Protocol to Suspend & Restart Soil Handling Operations
Local weather forecasts of possible rainfall events during operations and the occurrence of surface lying water have been used to advise on a day-to-day basis if operations should stop (Natural England, 2021). Single events such as >5mm/day in spring and autumn months, and >10mm/day in the summer have been suggested as more precise triggers for determining soil handling operations (Reeve, 1994). However, in practice the following generic guidelines are often used:

- In light drizzle soil handling may continue for up to four hours unless the soils are already at/near to their moisture limit.
- In light rain soil handling must cease after 15 minutes.
- In heavy rain and intense showers, handling shall cease immediately.

In all of the above it is assumed that soils were in a dry condition. These are only general rules, and it is at the local level decisions to proceed or stop should be based on the actual wetness state of the soils being handled. After the above rain event has ceased, the soil tests in **Table 4.2** above should be applied to determine whether handling may re-start, provided that the ground is free from ponding and ground conditions are safe to do so.There can be extreme instances where soil horizons have become very dry and are difficult to handle resulting in dust and windblown losses. In these conditions the operation should be suspended. The artificial wetting of extremely dry soils is not usually a practice recommended but has been successful in some cases.

References

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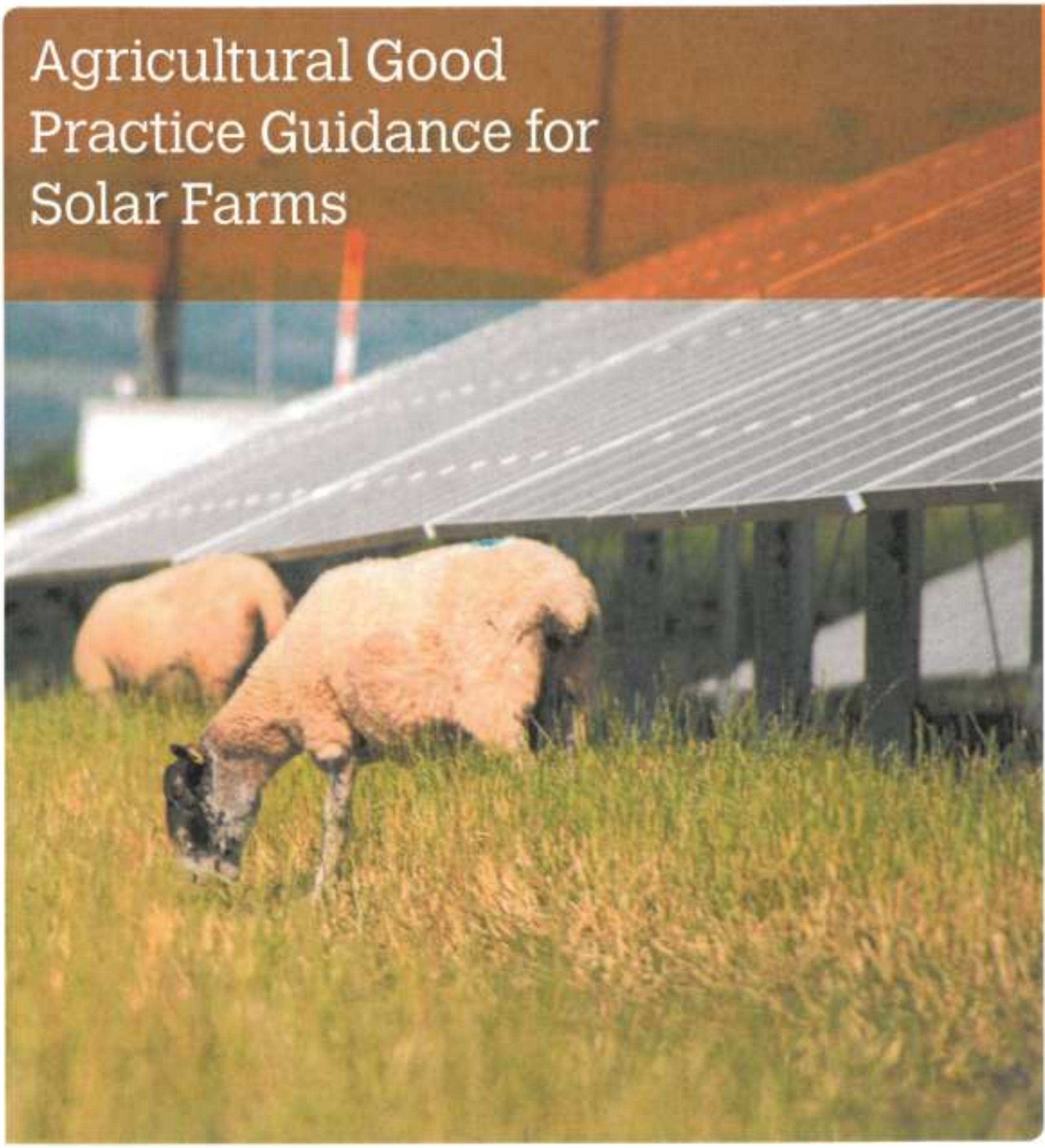
Appendix SMP3

BRE Agricultural Good Practice Guide Extract

bre

www.bre.co.uk/nsc

Agricultural Good Practice Guidance for Solar Farms



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Principal Author and Editor Dr Jonathan Scurlock, National Farmers Union

This document should be cited as: BRE (2014) Agricultural Good Practice Guidance for Solar Farms. Ed J Scurlock

BRE National Solar Centre would like to sincerely thank colleagues from the following organisations who have made significant contributions to the development of this guidance:

British Solar Renewables, Lark Energy, Lightsource, NFU, Orta Solar, Solar Trade Association, TGC renewables

With thanks to:

Marcus Dixon and Neil Macdonald of British Solar Renewables; Liza Gray of Lightsource; Julie Rankin and Amy Thorley of Lark Energy; Kate Covill of Orta Solar; Ben Cosh of TGC Renewables; Ben Thompson of Foresight Group; Simon Stonehouse of Natural England; Leonie Greene of the Solar Trade Association; and Tom Fullick, Gary Ford and Richard Wordsworth of the NFU.

With thanks to NSC Founding Partners:

beco energy solutions, BELECTRIC, British Gas Solar, British Solar Renewables, Conergy, Empower Community, Fronius, Hilti, juwi, Kingspan Insulated Panels, Lark Energy, Naked Energy, Orta Solar, Oxford Photovoltaics, Rexel Energy Solutions, Romag, Schneider Electric, SMA, solarcentury, Solar Media, Trina Solar, Yingli Solar

Context

This document describes experience and principles of good practice to date for the management of small livestock in solar farms established on agricultural land, derelict/marginal land and previously-developed land.

Proposed for publication as an appendix to existing best practice guidelines by the BRE National Solar Centre[1], it should be read in conjunction with BRE (2014) Biodiversity Guidance for Solar Developments (eds. G.E. Parker and L. Greene).

The guidance presented here has been developed with, and endorsed by, a number of leading UK solar farm developers and organisations concerned with agriculture and land management.

Introduction

Field-scale arrays of ground-mounted PV modules, or "solar farms", are a relatively recent development, seen in Britain only since 2011, although they have been deployed in Germany and other European countries since around 2005. In accordance with the "10 Commitments" of good practice established by the Solar Trade Association[2], the majority of solar farm developers actively encourage multi-purpose land use, through continued agricultural activity or agri-environmental measures that support biodiversity, yielding both economic and ecological benefits.

It is commonly proposed in planning applications for solar farms that the land between and underneath the rows of PV modules should be available for grazing of small livestock. Larger farm animals such as horses and cattle are considered unsuitable since they have the weight and strength to dislodge standard mounting systems, while pigs or goats may cause damage to cabling, but sheep and free-ranging poultry have already been successfully employed to manage grassland in solar farms while demonstrating dual-purpose land use.

Opportunities for cutting hay or silage, or strip cropping of high-value vegetables or non-food crops such as lavender, are thought to be fairly limited and would need careful layout with regard to the proposed size of machinery and its required turning space. However, other productive options such as bee-keeping have already been demonstrated. In some cases, solar farms may actually enhance the agricultural value of land, where marginal or previously-developed land (e.g. an old airfield site) has been brought back into more productive grazing management. It is desirable that the terms of a solar farm agreement should include a grazing plan that ensures the continuation of access to the land by the farmer, ideally in a form that that enables the claiming of Basic Payment Scheme agricultural support (see page 2).

[1] BRE (2013) Planning guidance for the development of large scale ground mounted solar PV systems. www.bre.co.uk/nsc

[2] STA "Solar Farms: 10 Commitments" http://www.solar-trade.org.uk/solarFarms.cfm

Conservation grazing for biodiversity

As suggested in the Biodiversity Guidance described above, low intensity grazing can provide a cost-effective way of managing grassland in solar farms while increasing its conservation value, as long as some structural diversity is maintained. A qualified ecologist could assist with the development of a conservation grazing regime that is suited to the site's characteristics and management objectives, for incorporation into the biodiversity management plan.

Avoiding grazing in either the spring or summer will favour early or late flowering species, respectively, allowing the development of nectar and seeds while benefiting invertebrates, ground nesting birds and small mammals. Hardy livestock breeds are better suited to such autumn and winter grazing, when the forage is less nutritious and the principal aim is to prevent vegetation from overshadowing the leading (lower) edges of the PV modules (typically about 800-900mm high). Other habitat enhancements may be confined to non-grazed field margins (if provision is made for electric or temporary fencing) as well as hedgerows and selected field corners.

Agricultural grazing for maximum production

The developer, landowner and/or agricultural tenant/licensee may choose to graze livestock at higher stocking densities throughout the year over much of the solar farm, especially where the previous land use suggested higher yields or pasture quality. Between 4 and 8 sheep/hectare may be achievable (or 2-3 sheep/ha on newly-established pasture), similar to stocking rates on conventional grassland, i.e. between about March and November in the southwest and May to October in North-East England.

The most common practice is likely to be the use of solar farms as part of a grazing plan for fattening/finishing of young hill-bred 'store' lambs for sale to market. Store lambs are those newly-weaned animals that have not yet put on enough weight for slaughter, often sold by hill farmers in the Autumn for finishing in the lowlands. Some hardier breeds of sheep may be able to produce and rear lambs successfully under the shelter of solar farms, but there is little experience of this yet. Pasture management interventions such as 'topping' (mowing) may be required occasionally or in certain areas, in order to avoid grass getting into unsuitable condition for the sheep (e.g. too long, or starting to set seed).

Smaller solar parks can provide a light/shade environment for free-ranging poultry (this is now recognised by the RSPCA Freedom Foods certification scheme) – experience to date suggests there is little risk of roosting birds fouling the modules. Broiler (meat) chickens, laying hens and geese will all keep the grass down, and flocks may need to be rotated to allow recovery of vegetation. Stocking density of up to 2000 birds per hectare is allowed, so a 5 megawatt solar farm on 12 hectares would provide ranging for 24,000 birds.

Solar farm design and layout

In most solar farms, the PV modules are mounted on metal frames anchored by driven or screw piles, causing minimal ground disturbance and occupying less than 1% of the land area. The rest of the infrastructure typically disturbs less than 5% of the ground, and some 25-40% of the ground surface is over-sailed by the modules or panel. Therefore 95% of a field utilised for solar farm development is still accessible for vegetation growth, and can support agricultural activity as well as wildlife, for a lifespan of typically 25 years.

As described above, the layout of rows of modules and the width of field margins should anticipate future maintenance costs, taking into account the size, reach and turning circle of machinery and equipment that might be used for 'topping' (mowing), collecting forage grass, spot-weeding (e.g. of 'injurious' weeds like ragwort and dock) and re-seeding. Again, in anticipation of reverting the field to its original use after 25 years, many agri-environmental measures may be better located around field margins and/or where specifically recommended by local ecologists. All European farmers are obliged to maintain land in "good agricultural and environmental condition" under the Common Agricultural Policy rules of 'cross compliance', so it is important to demonstrate sound stewardship of the land for the lifetime of a solar farm project, from initial design to eventual remediation.

The depth of buried cables, armouring of rising cables, and securing of loose wires on the backs of modules all need to be taken into consideration where agricultural machinery and livestock will be present. Cables need to be buried according to national regulations and local DNO requirements, deep enough to avoid the risk of being disturbed by farming practice – for example, disc harrowing and re-seeding may till the soil to a depth of typically 100-150 mm, or a maximum of 200 mm. British Standard BS 7671 ("Wiring Regulations") describes the principles of appropriate depth for buried cables, cable conduits and cable trench marking. Note also that stony land may present a risk of stone-throw where inappropriate grass management machinery is used (e.g. unguarded cylinder mowers).

Eligibility for CAP support and greening measures

From 2015, under the Common Agricultural Policy, farmers will be applying for the new Basic Payment Scheme (BPS) of area-based farm support funding. It has been proposed that the presence of sheep grazing could be accepted as proof that the land is available for agriculture, and therefore eligible to receive BPS, but final details are still awaited from Defra at the time of writing. Farmers must have the land "at their disposal" in order to claim BPS, and solar farm agreements should be carefully drafted in order to demonstrate this (BPS cannot be claimed if the land is actually rented out). Ineligible land taken up by mountings and hard standing should be deducted from BPS claims, and in the year of construction larger areas may be temporarily ineligible if they are not available for agriculture.

Defra has not yet provided full details on BPS 'greening' measures, but some types of Ecological Focus Areas may be possibly located within solar farms, probably around the margins, including grazed buffer strips and ungrazed fallow land, both sown with wildflowers. Note that where the agreed biodiversity management plan excludes all forms of grazing, the land will become ineligible for BPS, and this may have further implications for the landowner, such as for inheritance tax.

Long-term management, permanent grassland and SSSI designation

Since solar farms are likely to be in place typically for 25 years, the land could pass on to a succeeding generation of farmers or new owners, and the vegetation and habitat within the fenced area is expected to gradually change with time. According to Natural England, there is little additional risk that the flora and fauna would assume such quality and interest that the solar farm might be designated a SSSI (Site of Special Scientific Interest) compared with a similarly managed open field. However, there could be a possible conflict with planning conditions to return the land to its original use at the end of the project, e.g. if this is specified as 'cropland' rather than more generically as 'for agricultural purposes'. If the pasture within a solar farm were considered to have become a permanent grassland, it may be subject to regulations requiring an Environmental Impact Assessment to restore the original land use, although restoration clauses in the original planning consent may take precedence here. It is proposed that temporary (arable) grassland should be established on the majority of the land area that lies between the rows of modules. This would be managed in 'improved' condition by periodic harrowing and re-seeding (e.g. every 5 years), typically using a combination disc harrow and seed drill.

Other measures to maintain the productivity of grassland, without the need for mechanised cultivations or total reseeding, could include: maintaining optimum soil fertility and pH to encourage productive grass species; seasonally variable stocking rates to prevent over/under-grazing with the aim of preventing grass from seeding and becoming unpalatable. Non-tillage techniques to optimise grass sward content might include the use of a sward/grass harrow and air-seeder to revive tired pastures. When applying soil conditioners (e.g. lime), fertilisers or other products, consideration should be taken to prevent damage to or soiling of the solar modules.

Good practice in construction and neighbourliness

Consideration should also be given to best practice during construction and installation, and ensuring that the future agricultural management of the land (such as a change from arable cropping to lamb production) fits into the local rural economy. Site access should follow strictly the proposed traffic management plan, and careful attention to flood and mud management in accordance with the Flood Risk Assessment (e.g. controlling run-off by disrupting drainage along wheelings), will also ensure that the landowner remains on good terms with his/her neighbours.

Time of year should be taken into account for agricultural and biodiversity operations such as prior seeding of pasture grasses and wildflowers. Contractors should consider avoiding soil compaction and damage to land drains, e.g. by using low ground pressure tyres or tracked vehicles. Likewise, when excavating cable trenches, storing and replacing topsoil and subsoil separately and in the right order is important to avoid long-term unsightly impacts on soil and vegetation structure. Good practice at this stage will yield longer-term benefits in terms of productivity and optimal grazing conditions.

Evidence base and suggested research needs

A number of preliminary studies on the quantity and quality of forage available in solar farms have suggested that overall production is very little different from open grassland under similar conditions. A more comprehensive and independent evidence base could be established through a programme of directed research, e.g. by consultants (such as ADAS) or interested university groups (e.g. Exeter University departments of geography and biosciences), perhaps in association with seed suppliers and other stakeholders. Productivity of grasses could be compared between partial shade beneath the solar modules and unshaded areas between the rows. Alternatively daily live weight gain could be compared between two groups of fattening lambs (both under the same husbandry regime) on similar blocks of land, with and without solar modules present.

Case Steiger Quadtrac used to deliver inverters and other heavy equipment to site under soft ground conditions (photo courtesy of British Solar Renewables)

Cable trenching, showing topsoil stripped and set to one side, with subsoil placed on the other side ready for reinstatement (photo courtesy of British Solar Renewables)

Agricultural case studies

Benbole Farm, Wadebridge, Cornwall

One of the first solar farms developed in Britain in 2011, this 1.74 megawatt installation on a four-hectare site is well screened by high hedges and grazed by a flock of more than 20 geese. A community scheme implemented by the solar farm developers enabled local residents to benefit from free domestic solar panels and other green energy projects.

Higher Hill, Butleigh, Somerset

Angus Macdonald, a third-generation farmer, installed a five megawatt solar farm on his own land. Located near Glastonbury, the site has been grazed by sheep since its inception in 2011.

Eastacombe Farm, Holsworthy, Devon

This farm has been in the Petherick family for four generations, but they were struggling to survive with a small dairy herd. In 2011/12, a solar developer helped them convert eight hectares of the lower-grade part of their land into a 3.6 megawatt solar farm with sheep grazing, which has diversified the business, guaranteeing its future for the next generation of farmers.

Newlands Farm, Axminster, Devon

Devon sheep farmer Gilbert Churchill chose to supplement his agricultural enterprise by leasing 13 hectares of grazing land for a 4.2 megawatt solar PV development, which was completed in early 2013. According to Mr Churchill, the additional income stream is "a lifeline" that "will safeguard the farm's survival for the future".

Trevemper Farm, Newquay, Cornwall

In 2011, the Trewithen Estate worked with a solar developer to build a 1.7 megawatt solar farm on 6 hectares of this south-facing block of land, which had good proximity to a grid connection. During the 25-year lease, the resident tenant farmer is still able to graze the land with sheep at his normal stocking density, and is also paid an annual fee to manage the pasture.

Yeowood Solar Farm, North Somerset

Completed in 2012, this 1.3 megawatt installation on 4 hectares of land surrounds a poultry farm of 24,000 laying hens, which are free to roam the land between and underneath the rows of solar modules, as well as other fields. The Ford family, farm owners, also grow the energy crop miscanthus to heat their eco-friendly public swimming pool and office units.

Wyld Meadow Farm, Bridport, Dorset

Farmers Clive and Jo Sage continue to graze their own-brand Poll Dorset sheep on this 4.8 megawatt solar farm, established on 11 hectares in 2012. The solar farm was designed to have very low visual impact locally, with an agreement to ensure livestock grazing throughout the project's lifetime.

Wymeswold Solar Farm, Leicestershire

The author pictured in July 2014 at Britain's largest connected solar farm. At 33 megawatts, this development provides enough energy to power 8,500 homes. Built on a disused airfield in 2013, this extensive installation over 61 hectares (150 acres) received no objections during planning and is grazed by the landowner's sheep – just visible in the background.

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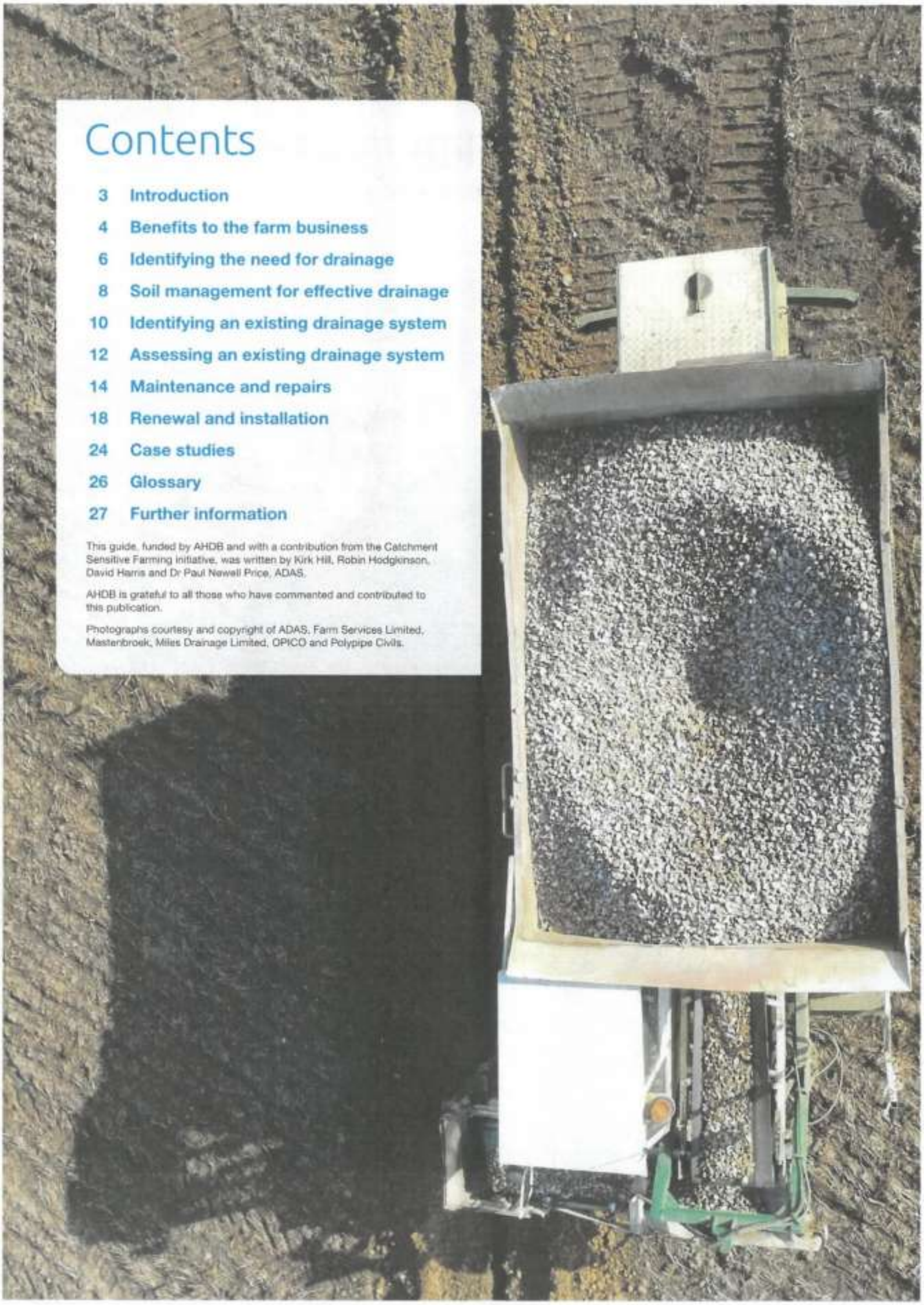
Appendix SMP4

AHDB Field Drainage Guide

AHDB

Field drainage guide

Principles, installations and maintenance



Contents

This guide, funded by AHDB and with a contribution from the Catchment Sensitive Farming initiative, was written by Kirk Hill, Robin Hodgkinson, David Harris and Dr Paul Newell Price, ADAS.

AHDB is grateful to all those who have commented and contributed to this publication.

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Introduction

What is field drainage?

Field drainage is installed to rapidly remove excess soil water to reduce or eliminate waterlogging and return soils to their natural field capacity. Drains can be used to control a water table or to facilitate the removal of excess water held in the upper horizons of the soil.

A good drainage system will reduce the risk of detrimental waterlogging to acceptable levels.

Where soils are coarsely textured and well structured, the soil may be freely draining enough to support field operations and crop growth without the need for artificial drainage systems. Field drains should be considered in the following situations:

- **Heavy clay soils:** These are slowly permeable and, without drainage, can be waterlogged for long periods, particularly in areas of high rainfall
- **Medium-textured soils in high-rainfall areas:** Drainage may be needed to reduce vulnerability to compression, slaking and compaction
- **Light-textured soils:** These soils are highly permeable, but drainage may be required to provide water table control in low-lying areas
- **Springs:** Drains are used to intercept springs before they reach the surface; this helps prevent erosion, localised waterlogging and poaching, and the intercepted water, if clean, may be used as drinking water for stock

There has been a general reduction in organic matter levels in arable soils over the past 70 years. This makes them more susceptible to waterlogging and more in need of drainage.

History of field drainage in the uk

Around 6.4 million hectares of agricultural land in England and Wales have been drained with piped systems.

The rate at which land was drained increased rapidly during World War II, as part of the drive to increase food production, and peaked during the 1960s to 1980s, when grant aid was available.

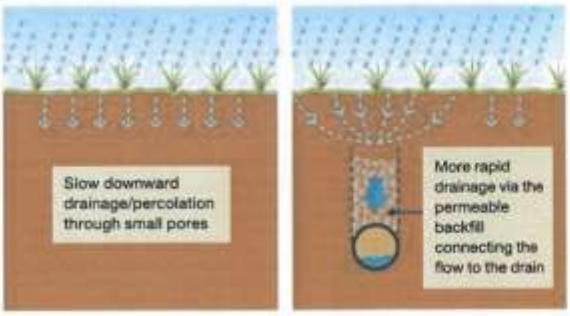


Figure 1. Drainage of heavy soil

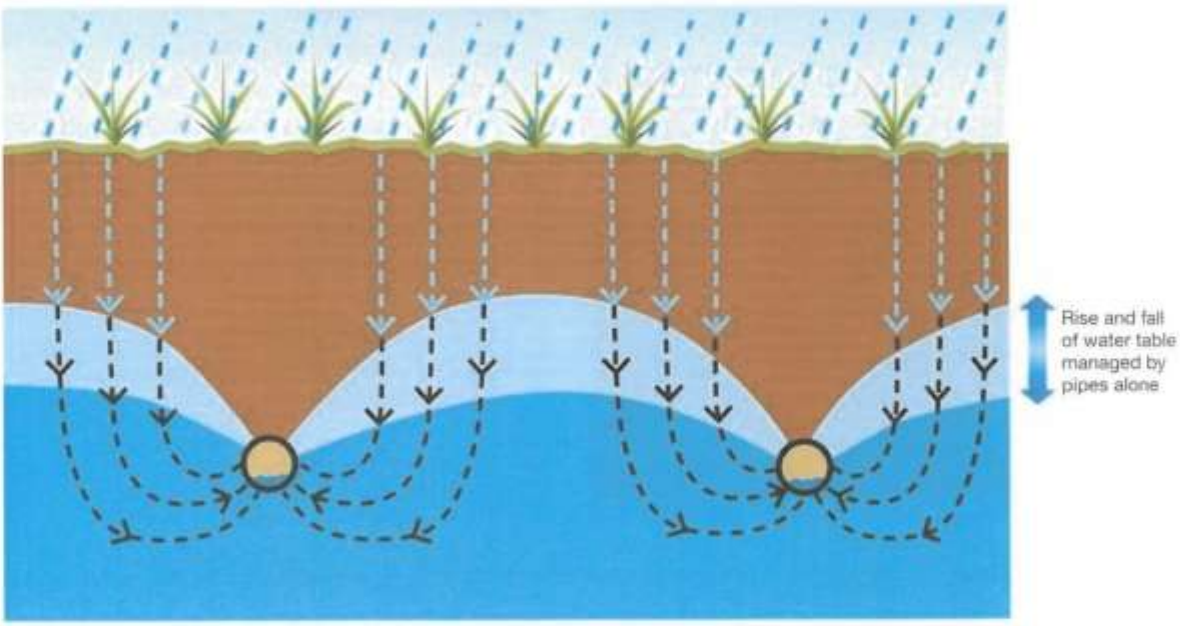


Figure 2. Water table control on permeable soils

Benefits to the farm business

In some years, drainage can make the difference between having a crop to harvest and complete crop loss; or whether or not the land can be accessed to harvest the crop.

The benefits of field drainage to the farm business are substantial, but installation can be expensive. The magnitude of the benefit varies considerably with climate, soil type and land use, so it is important to carry out both environmental and cost-benefit assessments before installing or managing field drainage systems.

Drainage is a long-term investment. Given good maintenance, a useful life of at least 20 years can be expected and some systems can last many decades longer.

Good field drainage reduces the peak surface water run-off rates by increasing the availability of storm-water storage within the soil. Rainfall then percolates down through the soil into the drains, producing a more balanced flow after storms. This reduces the risk of flooding and soil erosion, not only within the field but also further downstream in the catchment.

The cost of installation

The cost of installing a new comprehensive field drainage system varies greatly according to the scale and intensity of the system.

Based on 2024 prices, typical costs per hectare are around:

- £2,500–£3,500 with permeable backfill
- £1,400–£2,000 without permeable backfill

Improved plant performance

- Improved crop yield and quality
- More rapid warming of soils in spring, improving germination
- Improved environment for soil organisms
- Better access to water and oxygen for plant roots
- Better crop uptake of soil mineral nitrogen

Better access to land

- Reduced duration/risk of autumn waterlogging
- Quicker accessibility of fields following any period of wet weather
- Crop inputs more likely to be applied at optimum time
- An extended growing and grazing season

Improved speed of work and fuel use

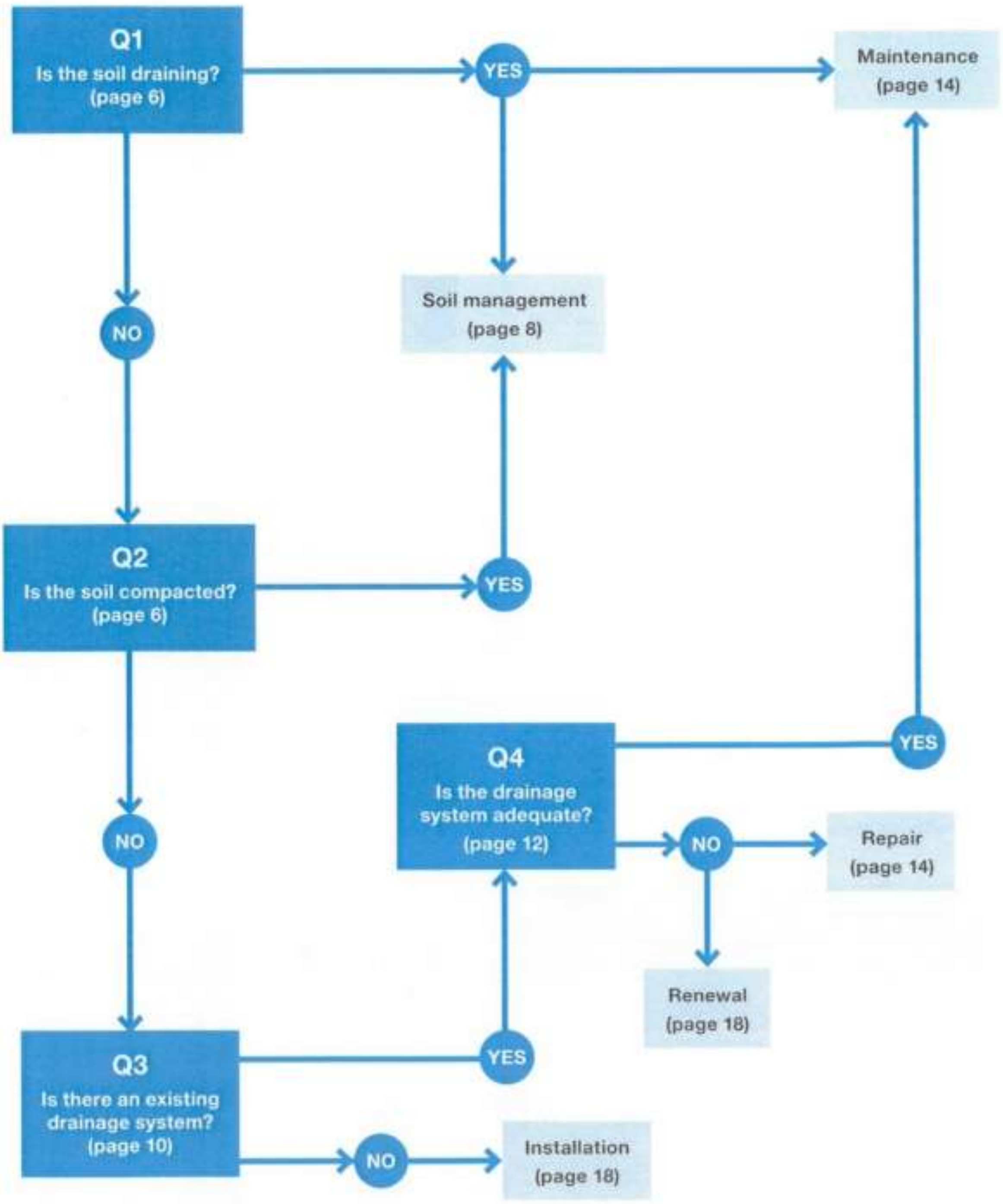
- Better traction
- Fewer cultivation passes
- Reduced draught forces
- Reduced wear and tear
- Fewer wet areas to avoid

Benefits to soil structure and the environment

- Less structural damage to soils
- Reduced frequency and extent of livestock poaching
- Better water infiltration
- Reduced surface run-off and erosion
- Reduced phosphorus and pesticide losses to water
- Decreased potential for slug activity and reproduction

Reduced risks to livestock health

- Reduced survival of parasitic larvae
- Snails carrying liver fluke do not thrive
- Footrot and foul of the foot are less common
- Udder hygiene for grazing stock is improved
- Reduced risk of soil contamination during silaging operations


Q1
Is the soil draining?
(page 6)
YES
Maintenance
(page 14)
NO
Soil management
(page 8)
Q2
Is the soil compacted?
(page 6)
YES
NO
Q4
Is the drainage system adequate?
(page 12)
YES
NO
Repair
(page 14)
Renewal
(page 18)
Q3
Is there an existing drainage system?
(page 10)
YES
NO
Installation
(page 18)

Identifying the need for drainage

Evidence of poor drainage

The evidence of poor drainage may be obvious in the form of surface ponding or saturated topsoils.

Prolonged waterlogging under the surface may not be so obvious. Poor drainage conditions may be identified by:

- Poor crop health or yields: overlaying a yield map onto a field drainage map can identify problem areas
- High surface run-off rates and soil erosion
- Limited field access without rutting or poaching (animal hoof damage) compared with other fields in the area
- The presence of wet-loving plant species, such as common rush and redshank
- Susceptibility to drought due to poor root development and limited rainfall percolation into the soil

If drainage problems are widespread across the field, it may be that:

- Soil management is not adequate
- No drains have been installed
- Mole drains need to be renewed
- In flatter fields, the outfall may simply be blocked
- The drainage system requires maintenance or has reached the end of its useful life

Environment

Surface run-off may occur, which can result in transport of faecal material, sediment, soilborne diseases (e.g. clubroot), nutrients or agrochemicals to watercourses.

Figure 3. Surface ponding

Figure 4. Areas of grassland may become heavily poached at times when soil conditions in other fields on similar soils do not lead to poaching

Figure 5. Saturated topsoils

Figure 6. Areas within arable fields may be waterlogged, resulting in crop loss or soil damage due to wheel ruts

Is the soil draining?

Examining the soils to determine if they are naturally freely or slowly draining or have damaged structure should be the first action when drainage problems are suspected.

Without good soil structure, soil drainage will be poor, whether it be by natural drainage or pipes.

Compacted layers can restrict surface water from reaching underlying drainage systems. If compacted layers are identified, remedial action should be undertaken to remove them before considering field drainage maintenance or reinstallation.

It is essential to routinely assess soil structure. This can easily be incorporated into the farm soil sampling programme and should be completed in spring or autumn. Examine the soil at several points in the field to a depth of:

- Arable land: at least 600 mm
- Grassland: at least 500 mm

Soil structure

✔ Well-developed structure is evident from the ease of digging and if the soil readily breaks down into small structural units with many vertical fissures

✗ Soils with poor structure are hard to dig and break down into larger dense blocks, with poor penetration by water, air and roots

Soil colour

Greyish-coloured soils and soils with rusty or grey-coloured mottles are signs of poorer drainage.

Soil texture

The higher the clay content, the more likely the soil is to be naturally poorly drained.

Root development

✔ Deep rooting indicates good structure

✗ Shallow rooting with many fine horizontal roots and tap roots that are diverted horizontally indicate the presence of compacted layers

Perched water table

Soil compaction occurs when soil particles are compressed, reducing the space (pores) between them. This restricts the movement of vital air and water through the soil.

When soil water is present, dig a pit (to a depth where the soil becomes drier) to aid diagnosis. Saturated soils overlying a layer of dry soil after a period of heavy rain may indicate the presence of a compacted layer preventing drainage.

It is not uncommon to find both naturally and artificially compacted layers (pans) in susceptible soils. Plough pans can develop if a field is repeatedly ploughed to the same depth.

If the pan, whether artificial or natural, is limiting water infiltration and/or root growth, it should be removed by subsoiling or topsoil loosening.

Figure 7. Natural pans – often very hard bands of soil particles cemented together by iron and manganese

Figure 8. Compaction pans – dense layers caused by farm machinery operation; often 50–100 mm thick, they generally have a platy structure and frequently contain crop residues

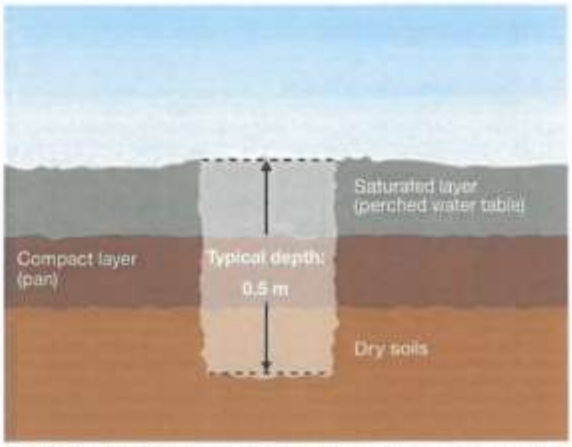


Figure 9. Soil inspection pit extending below the compacted layer

Soil management for effective drainage

Effective drainage relies on good soil management

If soil examination identifies compacted layers that act as a barrier to water movement, remedial action should be undertaken to remove them before considering new drainage.

> Maintaining a good soil structure may avoid the need for capital investment.

Minimise soil damage by reducing:

- Field trafficking
- Weight of machinery
- Tyre pressures
- Poaching of livestock
- Overworking of the seedbed

Other potential solutions include the use of low-pressure tyres, minimum tillage, controlled traffic farming and fixed wheelings, avoiding turnout in poor soil conditions, and considering the placement of livestock feeders and drinkers and livestock tracks.

Subsoil and topsoil loosening

When soils are wet, they are easily damaged by cultivation, machinery traffic and livestock trampling. If the soil structure has been damaged, subsoil or topsoil loosening (normally referred to as 'subsoiling' and 'sward lifting', respectively) in suitable conditions can be used to help restore the structure of a damaged soil. It can also be used to improve subsoil permeability.

Slit aerators can also be used in grassland fields but should only target the top 10 cm. Research has shown that they can increase infiltration rates, but good conditions are needed below the target area or they can just move water more quickly towards a drainage problem.

Operating notes

1. Suitable conditions

Topsoil loosening and subsoiling should only be carried out when the soil at working and loosening depth is in a 'dry' and friable condition, so that it will shatter rather than smear. Examine soils early in the operation to ensure effective shattering is occurring.

For arable subsoiling, both the soil surface and the compacted layer should be 'dry' to avoid soil structural damage.

For topsoil loosening in grassland using a 'sward lifter'-type machine, the ideal conditions are when the soil surface is slightly moist, to allow disc and tine leg entry while avoiding excessive sward tear, and the lower topsoil is moist to dry, to enable 'lift' and loosening.

2. Choice of soil-loosening equipment

Winged subsoilers (as seen in Figure 10), developed in the 1980s, shatter the soil much more effectively than conventional subsoilers. They require higher draught force but can disturb a volume of soil two to three times greater than a conventional subsoiler, resulting in more effective disturbance.

The use of leading tines can result in an increased volume of soil disturbed without increasing the draught, but they are not suitable for grassland as they cause considerable surface disturbance.

Topsoil looseners (as seen in Figure 11) or 'sward lifters' for grassland incorporate a leading disc, a vertical or forward-inclined leg and a tine leg and a packer roller behind to minimise sward tear and surface disturbance.

Figure 10. Winged subsoiler

Figure 11. Topsoil loosener for grassland

3. Depth

It is best practice to use a depth wheel or rear packer roller to maintain a constant tine depth.

Aim for tines to be about 25–50 mm below the base of the compacted layer, up to a maximum depth of approximately 450 mm below ground level.

Maximum depth may be limited by shallow field drains, rock or the critical depth of the tine (related to tine width and soil conditions). Normal drain depth is around 700 mm below the soil surface.

For subsoiling to result in improved drainage, the depth to which the soil is loosened must be just greater than the depth down to the top of the permeable backfill.

This will connect the fissures and allow water to move to the permeable fill over the drains.

4. Spacing between tines

- Conventional subsoiler: up to 1.5 times the tine depth
- Winged subsoiler: up to 2 times the tine depth
- With leading shallow tines: up to 2.5 times the tine depth

After a trial run, dig down and examine the effect. Spacing can be adjusted, where possible, to achieve the desired degree of soil disturbance.

Avoiding re-compaction

Recently loosened soils are very sensitive to re-compaction.

Avoid running over land that has already been subsoiled. In grassland, avoid grazing after autumn loosening and cut rather than graze in the first spring after treatment.

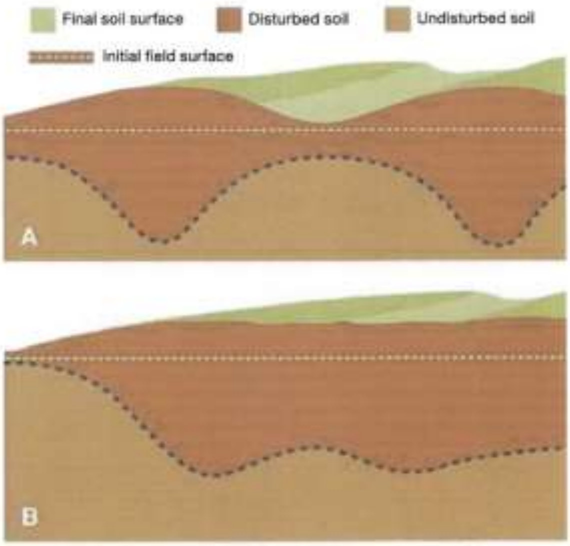


Figure 12. A is an example of tines set too wide and B shows tines correctly set

Further information

- A guide to better soil structure (Cranfield University) **landis.org.uk/downloads**
- Soil management **ahdb.org.uk/greatsoils**
- Think soils (Environment Agency) **gov.uk/managing-soil-types**
- Principles of subsoiling videos on the Practical Pig app (**practicalpig.ahdb.org.uk**)

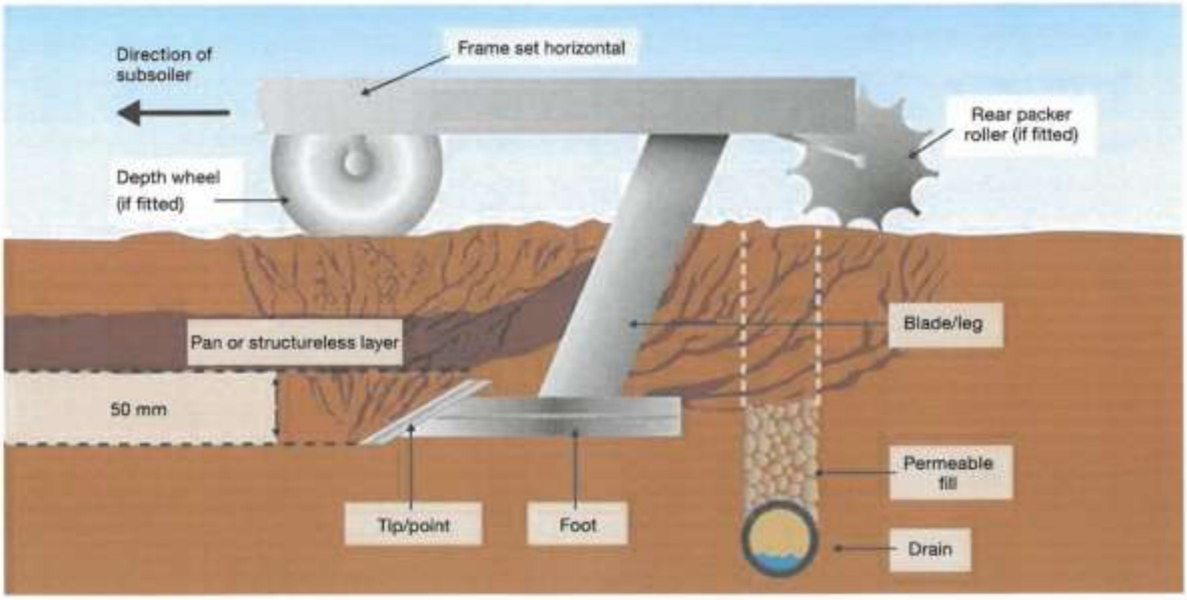


Figure 13. Subsoiler operation

Identifying an existing drainage system

Existing drainage

Fields are likely to already have some form of field drainage if they have heavy soils or medium soils in heavy rainfall areas or a naturally high water table. The system may, however, not be functioning properly or may be inadequate for the current farming needs.

Typical drainage layouts

A field can contain a combination of different layouts or be drained irregularly, depending on the surface slopes across the field. If smaller fields have been merged into one, the outfalls may be found at the low points of each original field and not the current field.

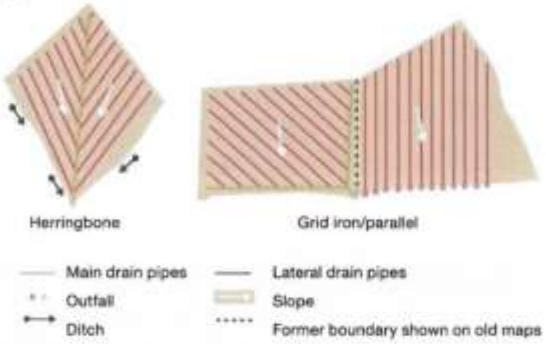


Figure 14. Typical drainage layouts

Understanding drainage plans

On many farms, final drainage plans are available that detail exactly what type of drainage was installed and where it is within each field. Final plans are normally accurate and, provided the key above-ground features shown are visible, should enable the drains to be found.

Ensure it is a final drainage plan, not a proposal. A final plan may include the words 'completion' or 'as built' and should always be signed.

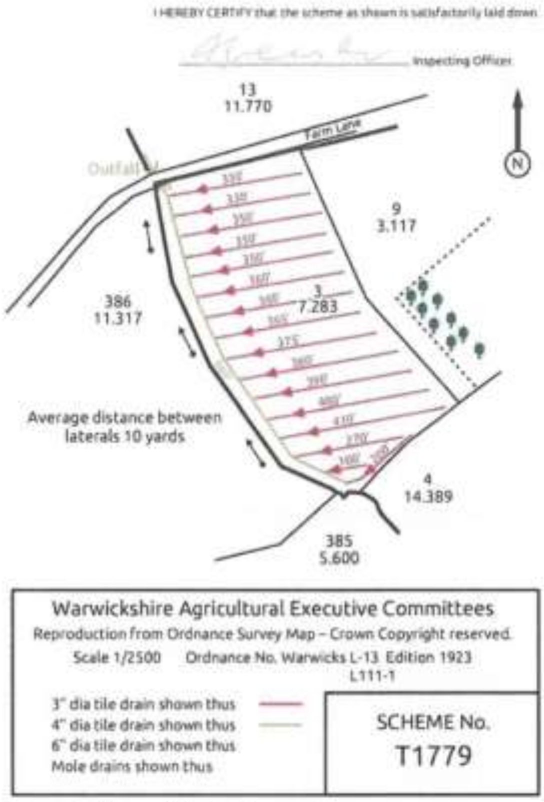


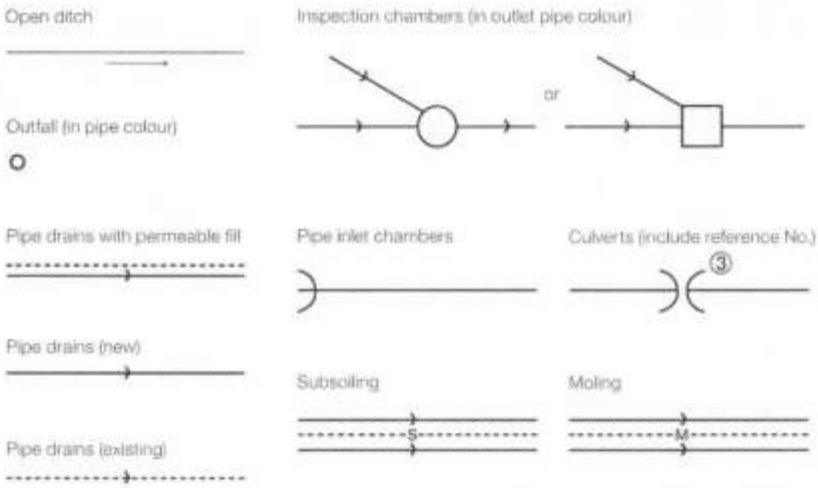
Figure 15. Example final drainage plan

Standard symbols and colours

Plastic pipes

Diameter mm	Colour
60 mmØ	Red
80 mmØ	Purple
100, 110, 125 mmØ	Green*
160 mm, 170 mmØ	Blue*
200, 225 mmØ	Yellow*
Over 225 mmØ	Black

*Indicate diameter



In the absence of a final drainage plan

Local drainage contractors may hold copies of any final record plans. If the land has been recently acquired, the previous owners may hold the plans.

Creating your own drainage plan

1. **Produce a sketch map** showing the ditches and the direction in which they flow, along with the dominant direction of slope in each field. It may also be helpful to mark any removed field boundaries or ditches, as one large field may contain several small drainage schemes.
2. **Locate any visible outfalls.** These are generally found at the lowest points within a field. There may be more than one outfall, depending on the layout of the drainage scheme.

- Walk the ditches after rainfall: you may hear an outfall running that you cannot see
- The best time to look for outfalls is in winter when drains are running and vegetation growth is reduced
- Even if an actual pipe is not visible, seepage from the bank or an area where the bank has receded can indicate the location of a drain outfall
- If the ditch is badly overgrown, it may be necessary to clear vegetation
- If the ditch has become silted up or the pipe blocked, the ditch may first need to be cleared – typically, to at least 1 m below the adjacent field level

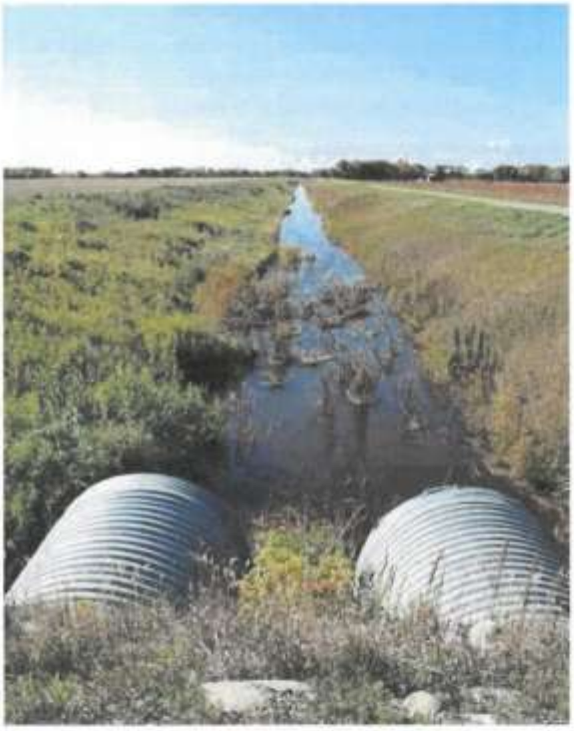


Figure 16. Drainage ditch

3. **Look for field surface signs.** Some features may only be apparent in a certain light during the day or during particular ground moisture conditions.

- Aerial photographs available online may reveal the lines of the drains, although they may be confused with other features, such as underground pipelines
- Slight linear depressions may be visible on the field surface
- The crop may vary in quality or colour over the line of a drain
- The soil may be drier directly over the drain than between drains
- Localised wet areas or small depressions ('blow holes') may be found upslope of a blocked drain

Figure 17. A 'blow hole'

4. If the outfall cannot be found by visual inspection alone, or surface signs need to be confirmed, it may be necessary to **dig trenches across the most likely locations** for drains.

Health and safety

Before excavating any trenches, ensure that:

- There are no underground cables or pipelines present that may be hazardous or damaged
- Personnel do not enter a trench unless adequate precautions have been taken to prevent trench collapse

Some helpful information can be found at **hse.gov.uk**

Figure 18. Signs indicating potential underground hazards

Assessing an existing drainage system

Risk management

An effectively designed field drainage system should afford a level of protection against waterlogging that is appropriate to the value of the crop, land access and other benefits. It should be designed to drain the field effectively up to an appropriate return period, usually based on crop value.

Thinking of drainage as insurance, a higher-value crop may justify a more intensive field drainage system than, for example, grassland, which may be able to better tolerate a small amount of waterlogging. Equally, improved drainage may attract high-value horticulture crops into the rotation, increasing the rental value.

The degree to which drainage systems provide protection against waterlogging should be matched with the value of the crops to be grown. A typical high-value crop would need to be protected against all rainfall, except very infrequent rainfall events, whereas grassland warrants a lower level of protection.

The following waterlogging risk frequencies are typically used for design:

- Very high-value specialist crops: 1 in 25 years
- Horticultural crops: 1 in 10 years
- Root crops: 1 in 5 years
- Intensive grass and cereals: 1 in 2 years
- Grassland: 1 in 1 year

Is the existing system adequate?

There are a number of reasons why an existing field drainage system may be inadequate for current needs:

- The scheme may have been designed to work with mole drains that have since collapsed and need renewal
- The drainage system may have reached the end of its useful life (e.g. blocked or collapsed)
- The land use may have changed since the system was installed
- The drains may have been installed without permeable backfill

On soils where permeable backfill is required for optimum performance, the scheme may work well initially due to the soil disturbance during trenching. With the passage of time, however, the soil will return to a more consolidated, less permeable condition that may limit water movement.

It can be difficult to recognise the signs of crop stress on fields where old drains are gradually becoming less effective and where only some crops in the rotation may be affected by stress. When deciding whether the existing field drainage system is adequate, take into account the history of the field and whether it has been deteriorating. Consider:

- Year-on-year variation in yield
- Instances of delayed cultivation or harvest due to field conditions
- Past damage due to poor drainage
- Frequent blow holes may be a sign that pipes are too small or are blocked downstream
- Increases in the presence of moisture-loving plants

Figure 19. Crop loss due to drainage problems

Assessing the costs and benefits of field drainage

While field drainage can have economic, practical and environmental benefits, installation can be expensive.

Drainage can also exacerbate water pollution and impact negatively on some habitats. It is, therefore, important to carry out an environmental and cost-benefit assessment before installing or carrying out maintenance on field drainage systems.

Production benefits resulting from drainage are most likely to be obtained in areas of high rainfall or on:

- Heavy clay soils, especially where arable or intensive livestock production is practised
- Medium soils where potatoes, other root crops or high-value crops are grown
- Low-lying permeable soils where the groundwater level comes close to the land surface in winter or after rainfall

In many cases, it is better for both agricultural production and the environment to remove excess water by field drainage, but there are cases when the production benefits are outweighed by the costs and there are opportunities to mitigate climate change, flooding, protect water quality or create wildlife habitats by allowing field drainage to deteriorate.

Waterlogged land may be low value agriculturally but it may have biodiversity benefits or help to reduce flooding risk.

Sacrificing an area of waterlogged land may reduce costs by acting as a sediment trap and reducing the need for costly activities, such as watercourse dredging. Suitable areas where drainage might be allowed to deteriorate could include land adjacent to watercourses, natural wetlands and ribbon areas at the base of steep slopes, particularly on intensive grassland on heavy soils in the centre and west of the UK.

For more information for farmers in priority areas at risk of water pollution, contact Catchment Sensitive Farming: **gov.uk/catchment-sensitive-farming**

Environment

In the Mires on the Moors project (a partnership between South West Water, two National Park Authorities and other organisations, such as the Environment Agency), drainage ditches on Dartmoor and Exmoor were blocked to restore peatland. This increases the carbon and water storage on the moor and slows the flow of water off the moor so that storm and flood damage is reduced, sediment settles out and drinking water quality is improved. Read more on **www.exmoormires.org.uk**

The impact of field drainage on pollution risk

The relationship between field drains and pollution can be contradictory.

Positive points

Maintaining good field drainage and good soil structure reduces waterlogging

↓

This reduces the likelihood of causing soil compaction through untimely field operations

↓

This decreases surface run-off, soil erosion and the loss of sediment and associated pollutants, such as phosphorus, to water

Negative points

When soils are wet or dry with deep cracks and rain falls within a few days of agrochemical application…

↓

…field drains can provide a rapid route for water enriched with ammonium, phosphorus, pesticides, fine sediment or other associated pollutants

↓

Drains are most effective at providing a conduit for agricultural pollutants when newly installed or in fields with deep cracking clays

Remember

- Best practice should always be followed when applying manures, fertilisers and agrochemicals to avoid losses via surface run-off or field drains
- Organic manures should not be applied to land within 12 months of pipe or mole drainage installation
- Organic manures should not be applied to drained land when soils are wet and drains are running
- Organic manures should not be stored within 10 m of a field drain

Maintenance and repairs

Ditches and outfalls

If ditches become infilled and outfalls are not kept clear, the field drainage system will cease to function effectively, leading to the need for more expensive maintenance or premature renewal.

In flat areas, in particular, blocked culverts and ditches can lead to waterlogging over large areas of land, restricting drainage upstream. This can cause flooding and soil erosion as the water backs up and tries to find an overland route to escape.

Given the significant cost of installing a new field drainage system, cleaning ditches and clearing outfalls is a simple, cheap and effective method of improving the effectiveness of existing systems.

Ditches are best cleared in autumn to minimise soil and crop damage.

Ditch maintenance

Fencing off ditches and watercourses from livestock can reduce maintenance needs by preventing bank damage and erosion.

It can also protect water from sediment and microorganisms in livestock manures, which impact water quality and ecology.

Blocked outfalls

The most common cause of drainage system deterioration is the failure to keep outfalls clear. This can cause the whole drainage system to fail, resulting in poor drainage, pipe siltation and possibly even blow holes across the field over time.

Environment

Ditches can be an important habitat for aquatic plants, invertebrates, amphibians, birds and small mammals. Timing of clearance operations or ditch maintenance may have implications for wildlife. Avoid disturbing breeding or nesting animals.

Localised over-digging of ditch beds can form small shallow pools that benefit invertebrates. The ditch will function as long as it has stable banks, the overall gradient is consistent such that it does not reduce drainage efficiency and it is deep enough to allow drainage outfalls to discharge.

Figure 20. Cleaning ditches is a simple way of improving the effectiveness of drainage systems

Figure 21. A blocked outfall can often be cleared in a matter of minutes with a spade

Pipes

Blockage by tree or hedge roots

When designing the drainage system, trees and hedges should be avoided wherever possible. When this is not possible, a sealed pipe should be used for any pipes within a tree rooting zone or within 1.5 m of a hedge.

If a blockage occurs, it may be possible to dig up the pipe on one or both sides of the blockage and use rods to clear the roots, but the section of pipe will often need to be replaced with a sealed pipe.

Environment

Take care to avoid unnecessary damage to tree roots or disturbing archaeological remains.

Pipe siltation

If drain outfalls are left submerged or blocked for a long period of time, siltation of the pipes may occur. This can be difficult or impossible to remedy.

Other than as a result of damaged or blocked pipes, siltation most commonly occurs on fine sandy and fine silty soils.

If pipe siltation is not too severe, it may be possible to rod the drains clear or to employ a contractor with specialist drain jetting equipment.

Figure 22. Silted clay drain

Where pipe siltation is a naturally recurring problem, a drainage system with separate outfall pipes for each drain is best. This allows easier access for cleaning operations.

Figure 23. Drain jetting

Ochre

Ochre is a generic term used to describe deposits that form in drains when soluble iron leaching out of the soil in drainage water comes into contact with air and is oxidised, at which point it becomes insoluble. It can also be caused by bacterial growths that secrete iron.

In some cases, a drainage scheme may fail completely due to ochre accumulation. In these cases, redrainage is only worthwhile if future ochre development is unlikely.

Preventing ochre formation

- Soils rich in iron may be prone to ochre and there is little that can be done to prevent ochre formation
- There are methods that attempt to prevent the build-up of ochre, but these can be specialist, intensive and often not very successful

Removing ochre

- Regular rodding or jetting may remove the ochre
- If the pipe slots or permeable fill is blocked, the benefits may be limited or nil

Design

- Where ochre is a problem, systems with separate outfall pipes for each drain are best, as they allow easier access for clearance operations

Figure 24. Drainage outfall blocked by ochre

Replacing field drains

When replacing a field drain, the same diameter (or metric equivalent) drain should be used as the drain being replaced. If the drain is a carrier drain or culvert, increasing the pipe diameter would reduce the risk of blockage or excess flows collapsing the pipe in the future. However, care may be needed to avoid increasing flood risk downstream. Expert advice should be sought if in doubt.

Mole drains

Mole drains are unlined channels formed in a clay subsoil. They are used when natural drainage needs improving in particularly heavy or calcareous clay subsoils that would require uneconomically closely spaced pipes for effective drainage.

Mole drains act as closely spaced pipe drains and conduct water to the permanent pipe drains or direct to open ditches.

Mole drains are not suitable for controlling rising groundwater or areas prone to flooding.

Soils should have a minimum of 30% clay for best results. Clay gives the soil the ability to hold together and reduces the chances of the channel collapsing after the mole is pulled.

Sand content should be less than 30%. The soil should be free of stones at the mole drain depth.

Mole drains are formed by dragging a 'bullet' (effectively, a round-nosed cylindrical foot shaped like a bullet, with slight tapering towards the tail) followed by an expander (a cylindrical plug of slightly larger diameter than the bullet) through the soil to form a circular semi-permanent channel – i.e. a natural pipe with fissuring in the soil above the channel.

Figure 25. Soil texture classification
Source: Controlling soil erosion (Defra, 2005)

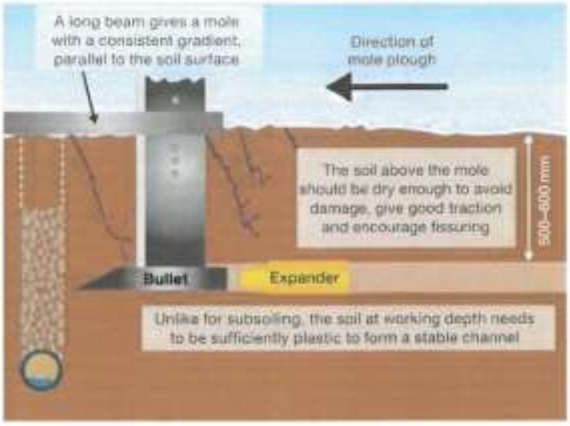


Figure 26. Appropriate conditions for forming mole drains

How long do mole drains last?

The longevity of mole drains depends on a number of factors, including:

- Soil texture (high clay content is better)
- Soil calcium content (high levels of calcium will increase longevity)
- Climate (wetter conditions will reduce longevity)
- Slope (too shallow or too steep will reduce longevity)
- The moisture conditions in which the moles were formed

Mole channels in very stable, clay soils (clay content ~45%) can last over 10 years, but the method can still be effective in soils with at least 30% clay, particularly calcareous soils.

Typical lifespan in suitable soils ranges from five to ten years, but it can be reduced where patches of sandier soil occur, leading to premature collapse. Bad soil management can seal off the routes by which water reaches the mole drains.

If the pipe drainage system was designed to be supplemented by mole drains, it is good practice to renew mole drains on a cycle of around once in every five years.

Figure 27. Appropriate conditions for forming mole drains
Source: Controlling soil erosion (Defra, 2005)

Installing mole drains

1. Suitable conditions

To achieve satisfactory results, the soil in the vicinity of the mole channel needs to be moist enough to form a channel but not dry enough to crack and break up and not soft enough to slough off and form a slurry.

Moling should be undertaken when:

- The soil at working depth is plastic, i.e. it forms a 'worm' without cracks when rolled on the hand
- The soil surface is dry enough to ensure good traction and avoid compaction

The drier the soil above moling depth, the greater the fissuring produced and the more efficient the water removal.

These conditions are most likely to arise during May to September/October, depending on the season and location.

2. Depth

Optimum mole depth depends on the soil type and the conditions when the moles are installed.

Generally, moles are pulled at 500–600 mm depth. Often, when first mole draining, the shallower depth is used, due to tractor limitations in tight, compacted soils. As the soil structure improves over time, they can often be pulled deeper, although care must be taken not to damage piped drains.

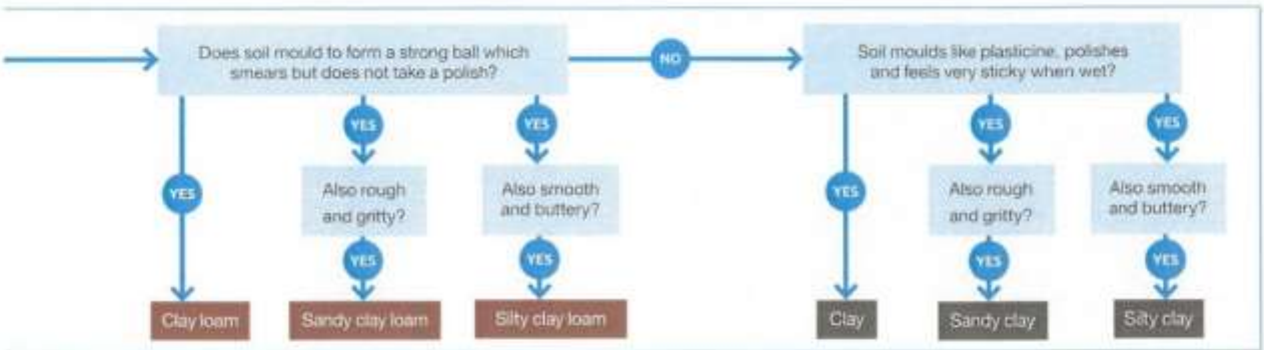
Moles less than 400 mm deep are liable to be damaged by tractors and animals during, or immediately after, rain and tend to be short-lived.

A rule of thumb is that the expander to mole-draining depth ratio is 1:7 (for example, a 70 mm diameter should have a mole depth of 490 mm).

3. Points to note

- It is essential that the 'bullet' is drawn through the permeable backfill over the pipe drains
- The mole plough should be in good condition, with minimal wear to the 'bullet' and tip
- Set up the mole plough so the 'bullet' is parallel to the ground surface when at working depth; a poorly set up mole plough will produce a poor channel and increase the draught requirement
- If the soil is liable to smearing, removal of the expander will reduce channel smearing, increasing the potential for water to enter the mole drain and reducing draught requirements
- When moling, dig a pit to expose the channel formed; it should be round and there should be fissuring above it
- Install moles at 2–3 m spacing, or closer on unstable soils
- Moles should be drawn up and down the slope across the lateral drains, making sure that they cross and connect with the permeable backfill over the drains
- Pull the plough out as soon as the mole plough has crossed the last drain: blind ends accumulate water
- If large stones are encountered, pull all the moles uphill and pull out after the channel has been disrupted

To aid decision-making, keep a record of where at least one of the most recent mole drains was pulled to allow examination of the mole drains by excavating a profile pit. This should be done just downslope of a lateral drain and, if still functioning, the mole drain should be reinstated afterwards with a short length of pipe.



Renewal and installation

Figure 28. Installing land drains and stone backfill

Factors to consider when designing a new drainage system

Drain depth

In slowly permeable soils, research has shown that (unless there is a specific crop need) lateral drain depths greater than 0.75 m give no additional benefit. Drains simply need to be deep enough to avoid damage from soil implements.

In permeable soils, where the drains control the depth of the water table, deeper drains allow the spacing between drains to be increased. Drain depths in such soil types are typically 1.2–1.5 m.

Maximum drain depth is often limited by the depth of the ditches or watercourses into which the drains discharge. These can be deepened, but only to the level of the downstream channel.

Figure 29. Recently installed drains

Drain spacing

Drain spacing has always varied according to local custom, but it has become more standardised in recent years. The correct spacing can be calculated using theoretical equations, but this is not often done in practice.

In heavy clay soils, the theoretical correct drain spacing will almost always be so small as not to be economically viable. Where soil conditions are appropriate, wide-spaced drains with permeable backfill supplemented with mole drains are the best choice. Pipe drain spacing for a mole drainage system can be as wide as 80 m, although 40 m is more typical. The main limiting factors are soil stability and landform.

On land with soils not suitable for moling, a modern system would have a spacing of 20–25 m with permeable backfill over the drains. The effectiveness of this type of system will rely greatly on maintaining good soil structure, sometimes aided by subsoiling.

Figure 30. Installing mole drains

If permeable backfill is not used, drain spacing in the region of 10 m will be needed, but this is unlikely to be as effective as a scheme using permeable backfill.

In permeable soils with a rising groundwater, the drain spacing will be determined by the depth of the drains and the level at which the groundwater is to be controlled. Permeable backfill is not usually needed.

Outfall availability and gradient

Outfall availability and gradient have an impact on the efficiency of the drainage system. As a comparison, a bath/shower is designed to slope and has a strategically positioned plughole (outfall) to drain the water. Lack of available outfall and/or gradient to enable water to drain away materially affects the efficiency of the field drainage system.

Drain diameter

In the UK, drain diameters are calculated using the procedures set out in MAFF/ADAS Reference Book 345 (The design of field drainage systems). This method takes account of:

- Soil type and slope: speed of water movement
- Land use: the degree of risk that is acceptable depending on the crop value
- Climate: rainfall intensity
- Type of drainage system: for example, mole drains must not be left submerged for more than 24 hours and, therefore, excess water must be evacuated rapidly

The rainfall figures used in the method set out in MAFF/ADAS Reference Book 345 are now outdated and in some areas may not match current rainfall patterns. They also take no account of potential future increases in storm intensities due to climate change. However, these remain the current guidelines.

Figure 31. Installing land drains with laser gradient control

Figure 32. Install drains at an appropriate depth and constant gradient (fall)

Renewal and installation

Use of permeable backfill

Permeable backfill refers to the gravel/stone chippings applied to the trench above the drain, typically to the base of the topsoil.

The use of permeable backfill has been a long-debated subject, primarily due to the significant associated cost. There are many examples of very old drainage systems without permeable backfill that still have some function; however, research indicates that on drained clay soils without permeable backfill, while the drains may initially function well, the permeability of the soil in the drain trench decreases with time.

Best practice is to install sufficient permeable backfill so that a connection exists between the drain trench and the cultivated layer. As a minimum, the permeable backfill layer should connect with the mole drains or any fissures caused by subsoiling.

If mole drains are to be installed over the pipes, the use of permeable backfill is essential to provide a hydraulic connection between the mole channels and the drain.

The performance of drains installed without permeable backfill cannot be rejuvenated by subsoiling.

The one circumstance where permeable backfill is never required is where the function of the drainage is to control a rising water table in a coarsely textured soil.

Figure 33. Mole plough

Figure 34. Permeable backfill in trench over drain

Site

Field drainage should be planned carefully to avoid negative impacts on water bodies used for drinking-water abstraction, fisheries or Sites of Special Scientific Interest (SSSIs) sensitive to raised nitrate levels. Field drains and outfalls could be designed to discharge into a wetland buffer area before flows enter a watercourse or be directed away from sensitive water bodies. Field drains should not be installed within at least 10 m of a slurry or silage store.

Sustainable drainage systems (SuDS) or novel approaches, such as bioreactors, can be used with field drainage systems to trap sediment and slow water/soil run-off and to filter pollutants in drainage water.

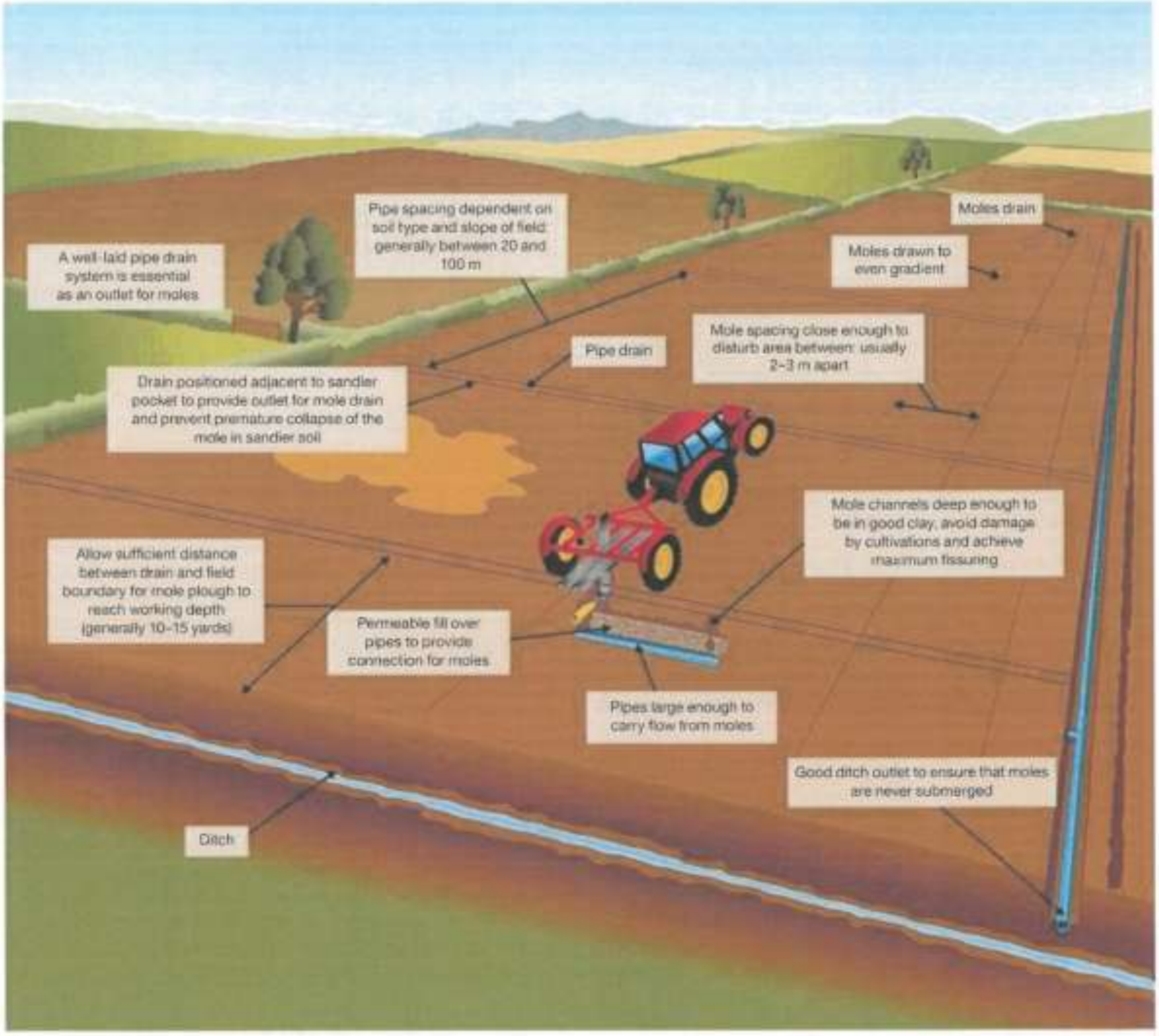


Figure 35. Layout of piped drainage and mole drains

Environment

Outfalls

New outfalls should be positioned sensitively at ditches and ponds to avoid damaging habitat. Land drains should not divert water away from areas that may depend on this water for drinking, washing or habitat. Diverting flows can also increase the risk of flooding and infrastructure failure.

Conservation

A new drainage scheme can provide an opportunity to create new conservation features. Old farm ponds that have silted up could be reopened to provide a habitat and catch pit for eroding soils, and ditches could be over-dug into localised ponds.

Government-funded schemes may be available for a range of land management options and capital items that can be used to reduce the negative impacts of field drainage on water quality or to create/improve wetlands and ditch habitats. These include the creation of wet grassland, ditch management and buffering of water bodies. For more information, see **gov.uk/guidance/countryside-stewardship-manual**

Selecting a designer

Before engaging an independent field drainage consultant, it is important to determine if they have adequate experience and qualifications. A specialist designer will have a thorough understanding of the needs and management of the soils, as well as of field drainage.

To enable them to determine if a new drainage system is required or whether maintenance of the existing system and/or improved soil management may be adequate to resolve the problem, a designer should always:

- Discuss any problems you have with the site and how you intend to manage the site in the future
- Survey the soil types, soil conditions, existing drainage systems, field topography, proximity to utility services and other features that may affect the final design
- Consider potential environmental impacts, drainage law and economic feasibility

Given the scale of the investment that a new drainage system represents, it is recommended that independent advice is sought with regard to the design.

Using an experienced consultant designer will ensure that the scheme is the best and most economically appropriate to meet the requirements.

Environment

Archaeological features can be damaged by field drain installation and drains may conflict with the conservation of a wetland or water habitat or species. Where relevant, contact Natural England, the drainage authority or a county archaeologist before commencing work.

Selecting a contractor

To install a new comprehensive field drainage system, it is essential to employ a specialist land drainage contractor with access to specialist machinery that can install and backfill drains rapidly. A drainage machine shapes the trench bed and can set a consistent gradient, even in the flattest of fields. A specialist contractor should fully understand field drainage requirements and employ the approved standards and materials.

The National Association of Agricultural Contractors (NAAC) is a trade association and has a list of members on its website (**naac.co.uk/findacontractor**) which can be a useful starting point for selecting a land drainage contractor. Not all drainage contractors are members of the NAAC, however.

Recommendations from others in the local farming community can be another helpful source of information.

Contractors may have different approaches to dealing with the scale, access and physical aspects of the location, so quotes may vary.

Health and safety

It is advisable to request:

From the contractor:

- A risk assessment and method statement (RAMS)
- Verification that they have sufficient public liability insurance cover

From the designer:

- Verification that they have sufficient professional indemnity insurance cover

Land drainage law

A landowner has an obligation to accept the natural flows of water from adjoining land and must not cause any impedance to these flows that would cause injury to adjoining land. 'Natural water flows' refers to water that has not been diverted from its natural path, artificially increased or had the run-off flow rate changed (e.g. by the construction of unauthorised paved areas within the catchment).

This means that if a landowner neglects or fills in their ditch, such that water may not freely discharge from higher neighbouring land, the landowner is guilty of causing a nuisance. In this situation, the landowner or occupier of the higher land may ask the Agricultural Land Tribunal to make an order requiring the landowner guilty of nuisance to carry out the necessary remedial works. It must be emphasised, however, that it is usually far better to attempt to resolve such situations by amicable discussions with the offending party first, as they may be unaware of the nuisance.

If the neglected ditch in question runs directly along the boundary between respective ownerships, the assumption that would be made is that the owner of the original hedge is also the owner of the ditch. On watercourses, the ownership boundary is assumed to be down the middle of the bed. Only clear evidence to the contrary, such as the deeds to the land, will rebut this assumption.

No ditch or watercourse should be piped, filled in, restricted or diverted without the approval of the regulatory authority, for example, the local authority or the EA, NRW, SEPA, NIEA or the local internal drainage board. Consent may be needed for works within 8–10 m of the bank top of a watercourse. Uncultivated or semi-natural land is protected under the Environmental Impact Assessment Regulations (Agriculture) and should not be drained without prior approval from the relevant national body.

Standards, materials and quality

There are two fundamental standards to which any designer will be working:

- Reference Book 345: The design of field drainage pipe systems (MAFF/ADAS, 1982)
- Technical Note on Workmanship and Materials for Land Drainage Schemes (ADAS, 1995)

Within these primary standards, there will be a number of decisions to be made about the design specification.

Pipe type

Currently, all new drainage schemes are installed using plastic pipes, although many older schemes were installed with clay pipes and may be replaced with the same.

It is essential that a material designed for use in field drainage is used.

Consideration should be given to the use of twin-wall or ductile iron pipes or gravel pipe surround where there is a risk of pipe crushing.

Figure 36. Modern perforated plastic drainage pipe

Permeable backfill type

- The material used must be hard and durable when wet and when dry
- The bulk of the material should be in the range 5–50 mm
- The material should not contain more than 10% fines

Figure 37. Washed gravel permeable fill over drain

Outfall type

Most modern outfalls are installed with glass-reinforced concrete headwalls; however, the actual outfall type may vary according to its location.

Figure 38. Precast concrete headwall (type K)

Filter wrap

Filter wrap is a geotextile barrier around the outside of the pipe to prevent soil particles entering the drain. It is not commonly used in the UK, as research has shown that pipe sedimentation is not usually a problem if the pipes have been laid and maintained properly. There are, however, some cases with fine, sandy soils when filter wrap can be beneficial.

Filter wrap should never be used where there is a risk of ochre.

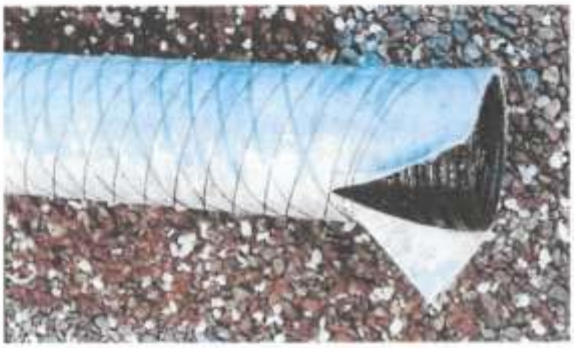


Figure 39. Single-wall pipe wrapped in geotextile

Case studies

Molescroft Farm, Beverley, East Yorkshire

The farm

- 485 ha farm with deep loam and alluvial clay soils
- Land is at or below 5 m above sea level and suffers from waterlogging
- Arable cropping: wheat, barley, oilseed rape, field beans and vining peas
- 10% of the farm is in Higher Level Stewardship and grazed by cattle and sheep appropriate to meet the requirements

The problem

The problem field had a full tile drainage system installed in the 1980s, but:

- Wet patches had started to appear
- Crops had to be drilled early to avoid soil damage and poor establishment
- The cost of weed control had increased due to the lack of opportunity for stale seedbeds
- Recent wet seasons had resulted in patchy crops with increased weed problems and soil damage

The main drain was found to be completely blocked by willow roots and some tiles were misaligned.

The solution

The solution was to drain a 6 ha area of the field, with new plastic pipes installed between the existing tiles and gravel backfill used to improve effectiveness.

The outcome

- New drainage has made the field far easier to work and manage
- It was the highest-yielding field in the following harvest year
- Lower inputs of herbicides were required

The cost

The total cost of the upgrade was £14,500 (£2,417/ha).

Maintenance costs estimated at approximately 1% of capital cost (£25/ha/year).

Benefits estimated at a total of £229/ha/year:

- Typical yield increased from 7 t/ha to 8.75 t/ha, a total of £175/ha/year
- Herbicide costs were reduced by £30/ha/year
- Better soil structure reduced subsoiling costs by 25%, saving £3/ha/year, and cultivation costs by £21/ha/year

Simple payback period

$$\frac{\text{Cost}}{\text{Benefits}} = \frac{£2{,}417}{£229 - £25} = 12 \text{ years}$$

Comment

Once the investment has been paid off, the benefits may continue to be received for many years (provided maintenance is sustained).

These calculations assume average changes to costs and returns; however, extreme weather will have a far greater effect. It is difficult to factor in random occurrences, such as the avoidance of significant crop loss due to waterlogging, and the decision to invest in drainage should be made on a field-by-field basis. The costings do not take into account the cost of finance or increased land value.

Evershot Farms Ltd, Melbury Osmond, Dorset

The farm

- 1,500 ha farm, largely on heavy, poorly drained soils
- Rainfall is over 1,000 mm/year
- Stocking: 900 cows and 2,500 mule ewes; heifers are contract reared off the farm
- Cropping: mainly grassland with about one-third cut for silage; maize is no longer grown
- The farm has a 750 kW biogas plant

The problem

The aim is for cows to be turned out in late March and housed from mid-September, but the grazing season can be very variable from year to year.

Maize was causing significant soil damage.

The solution

The solution was to replace maize with Italian rye-grass, introduce whole-crop wheat to balance the ration (and save on purchased straw) and drain a 10.2 ha field, including:

- A main drain with laterals and headwalls at outlets
- Digging out the ditches downstream to obtain sufficient fall
- Moling to increase connectivity every five years at reseeding

The outcome

- Soil problems are now avoided and increased rainfall infiltration minimises run-off
- The field is accessible two weeks earlier and for two weeks longer
- The Italian rye-grass has increased yield (from 37 t/ha to 45 t/ha) and forage value
- Reduced risk to operations and increased forage quality and dry matter yield

The cost

The total cost of the drainage was £5,245/ha (£48,500 for the drainage, plus £5,000 on ditching), plus maintenance at £52/ha and additional annual silage-making costs of £132/ha.

Benefits estimated at a total of £595/ha/year:

- The change from maize to grass silage has produced a higher dry matter yield and greater forage value from four cuts
- The change to Italian rye-grass resulted in an increase in forage value
- Cultivation savings:
  - Moving to grass, the cultivation savings were £105/ha/year
  - The average annual cost of moling was the same as subsoiling
- Forage savings (total of £490/ha) from:
  - Increased value of silage (at previous yield level): 37 t/ha at £4/t gives £148/ha
  - Increased yield of silage: 8 t/ha at £34/t gives £272/ha
  - Value of additional grazed forage: £70/ha

$$\frac{\text{Cost}}{\text{Benefits}} = \frac{£5{,}245}{£595 - £52 - £132} = 13 \text{ years}$$

Comment

Once the investment has been paid off, the benefits may continue to be received for many years (provided maintenance is sustained).

These calculations ignore the potential for extreme weather, without drainage, to result in significantly lower forage yields, soil damage and increased housing and forage requirements. Wet conditions during silage making can result in contamination from soil, leading to poor fermentation, poor milk yield and potential health problems. The costings do not take into account the cost of finance or increased land value.

Glossary

Compaction	The process by which the soil density increases due to trafficking or soil working when conditions are unsuitable, i.e. too wet
Culvert	A short length of pipe installed to allow access over the ditch or watercourse
Drain jetting	Removal of deposited sediment from a drain using a high-pressure water jet
Field capacity	The moisture content of the soil after excess water has drained away
Filter wrap	A geotextile barrier wrapped around the pipe to prevent particles entering the pipe
Friable	Soil where the aggregates crumble easily into smaller pieces
Infiltration	Water entering the soil e.g. through rainfall
Laterals	The drains installed, usually parallel to each other, to intercept soil water and transport flows to the main drain
Mains	Drains installed to collect the water from several laterals and transport it to a ditch
Mole drains	Unlined channels formed in a clay subsoil
Natural water flows	Water that has not been diverted from its natural path, artificially increased, or had the run-off flow rate changed, such as by the construction of unauthorised paved areas within the catchment
Ochre	Insoluble deposits that form in drains when soluble iron leaches out of the soil, into drainage water, and becomes oxidised. It can also be caused by bacterial growths that secrete iron
Outfall	Point at which the main drains or individual laterals discharge into a ditch
Percolation	The process of water moving down through the soil to depth
Perched water table	Saturated layer above compacted soils
Perforated drainage pipe	A slotted drainage pipe, which is used to collect water from the soil
Poaching	Damage to the soil surface caused by animal hooves
Slaking	The collapse of the soil aggregates as the soil wets up rapidly
Water table	The saturated zone of the soil

Further information

Other sources of information

Catchment Sensitive Farming:
gov.uk/catchment-sensitive-farming

Catchment Sensitive Farming officers provide free advice and support to farmers in priority catchments to reduce water pollution. This includes information on soil and water management and a review of field drainage.

National Association of Agricultural Contractors (NAAC):
naac.co.uk

Think soils (Environment Agency):
ahdb.org.uk/thinksoils

A guide to better soil structure (Cranfield University):
www.landis.org.uk/downloads

Geographic information for Great Britain:
magic.gov.uk

Countryside stewardship manual (Natural England):
gov.uk/guidance/countryside-stewardship-manual

Environmental permits for flood defence:
gov.uk/permission-work-on-river-flood-sea-defence

Guidance on owning a watercourse:
gov.uk/guidance/owning-a-watercourse

Flood and coastal erosion risk management R&D (Environment Agency):
gov.uk/government/publications/national-flood-and-coastal-erosion-risk-management-strategy-for-england--2

Pinpoint best practice information sheets (The Rivers Trust):
theriverstrust.org/our-work/farm-advice/best-practice-advice-sheets-for-farmers

Constructed farm wetlands: A guide for farmers and farm advisers in England (Wildfowl and Wetlands Trust):
wwt.org.uk/farmwetlands

Sustainable drainage systems: Maximising the potential for people and wildlife (RSPB and Wildfowl and Wetlands Trust):
www.wwt.org.uk/uploads/documents/2019-07-22/1563785657-wwt-rspb-sustainable-drainage-systems-guide.pdf

Godwin, R. J. and Spoor, G. (2015). Choosing and evaluating soil improvements by subsoiling and compaction control. In Ball, B. C. and Munkholm,L. J. (eds). *Visual Soil Evaluation: Realising Potential Crop Production with Minimum Environmental Impact.* CABI, Wallingford, UK.

Video demonstrating the principles of subsoiling

AHDB Pork has produced a series of videos demonstrating the general principles of subsoiling. The videos look at cultivation depth, choice of machine and the effects of tines and wings.

The videos are available to watch online at **youtube.com/AHDBPork** and on the Practical Pig app (**practicalpig.ahdb.org.uk**).

Further information

AHDB GREATsoils

AHDB provides a range of practical information on improving soil management for farmers, growers and advisers. Whether you need an introduction to soil biology or a detailed guide to soil structure, AHDB has the information and guidance to support you.

Information for grassland, pig producers, arable and horticultural crops is available at **ahdb.org.uk/greatsoils**

Visit ahdb.org.uk to:

- Find resources on our **knowledge library**
- Listen to our **podcasts**
- Visit **farm events and agricultural shows**
- Contact your local **knowledge exchange manager**

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AHDB is a statutory levy board funded by farmers and others in the supply chain. Our purpose is to be a critical enabler, to positively influence outcomes, allowing farmers and others in the supply chain to be competitive, successful and share good practice. We equip levy payers with easy-to-use products, tools and services to help them make informed decisions and improve business performance. Established in 2008 and classified as a Non-Departmental Public Body, AHDB supports the following industries: meat and livestock (Beef, Lamb and Pork) in England; Dairy in Great Britain; and Cereals and Oilseeds in the UK. For further information visit **ahdb.org.uk**

APPENDIX SMP5

Extracts from MAFF’s ALC Guidelines

Ministry of Agriculture, Fisheries and Food

Agricultural Land Classification

of

England and Wales

Revised guidelines and criteria for grading the quality of agricultural land

OCTOBER 1988

SECTION 1

INTRODUCTION

The Agricultural Land Classification provides a framework for classifying land according to the extent to which its physical or chemical characteristics impose long-term limitations on agricultural use. The limitations can operate in one or more of four principal ways: they may affect the range of crops which can be grown, the level of yield, the consistency of yield and the cost of obtaining it. The classification system gives considerable weight to flexibility of cropping, whether actual or potential, but the ability of some land to produce consistently high yields of a somewhat narrower range of crops is also taken into account.

The principal physical factors influencing agricultural production are climate, site and soil. These factors together with interactions between them form the basis for classifying land into one of five grades; Grade 1 land being of excellent quality and Grade 5 land of very poor quality. Grade 3, which constitutes about half of the agricultural land in England and Wales, is now divided into two subgrades designated 3a and 3b. General descriptions of the grades and subgrades are given in Section 2.

Guidelines for the assessment of the physical factors which determine the grade of land are given in Section 3. The main climatic factors are temperature and rainfall although account is taken of exposure, aspect and frost risk. The site factors used in the classification system are gradient, microrelief and flood risk. Soil characteristics of particular importance are texture, structure, depth and stoniness. In some situations, chemical properties can also influence the long-term potential of land and are taken into account. These climatic, site and soil factors result in varying degrees of constraint on agricultural production. They can act either separately or in combination, the most important interactive limitations being soil wetness and droughtiness.

The grade or subgrade of land is determined by the most limiting factor present. When classifying land the overall climate and site limitations should be considered first as these can have an overriding influence on the grade. Land is graded and mapped without regard to present field boundaries, except where they coincide with permanent physical features.

A degree of variability in physical characteristics within a discrete area is to be expected. If the area includes a small proportion of land of different quality, the variability can be considered as a function of the mapping scale. Thus, small, discrete areas of a different ALC grade may be identified on large scale maps, whereas on smaller scale maps it may only be feasible to show the predominant grade. However, where soil and site conditions vary significantly and repeatedly over short distances and impose a practical constraint on cropping and land management a 'pattern' limitation is said to exist. This variability becomes a significant limitation if, for example, soils of the same grade but of contrasting texture occur as an extensive patchwork thus complicating soil management and cropping decisions or resulting in uneven crop growth, maturation or quality. Similarly, a form of pattern limitation may arise where soil depth is highly variable or microrelief restricts the use of machinery. Because many different combinations of characteristics can occur no specific guidelines are given for pattern limitations. The effect on grading is judged according to the severity of the limitations imposed by the pattern on cropping and management, and is mapped where permitted by the scale of the survey.

The guidelines provide a consistent basis for land classification but, given the complex and variable nature of the factors assessed and the wide range of circumstances in which they can occur, it is not possible to prescribe for every possible situation. It may sometimes be necessary to take account of special or local circumstances when classifying land. For this reason, the physical criteria of eligibility in this report are regarded as guidelines rather than rules although departures from the guidance should be exceptional and based on expert knowledge. Physical conditions on restored land may take several years to stabilise; therefore, the land is not normally graded until the end of the statutory aftercare period, or otherwise not until 5 years after soil replacement.

To ensure a consistent approach when classifying land the following assumptions are made:

1. Land is graded according to the degree to which physical or chemical properties impose long-term limitations on agricultural use. It is assessed on its capability at a good[1] but not outstanding standard of management.

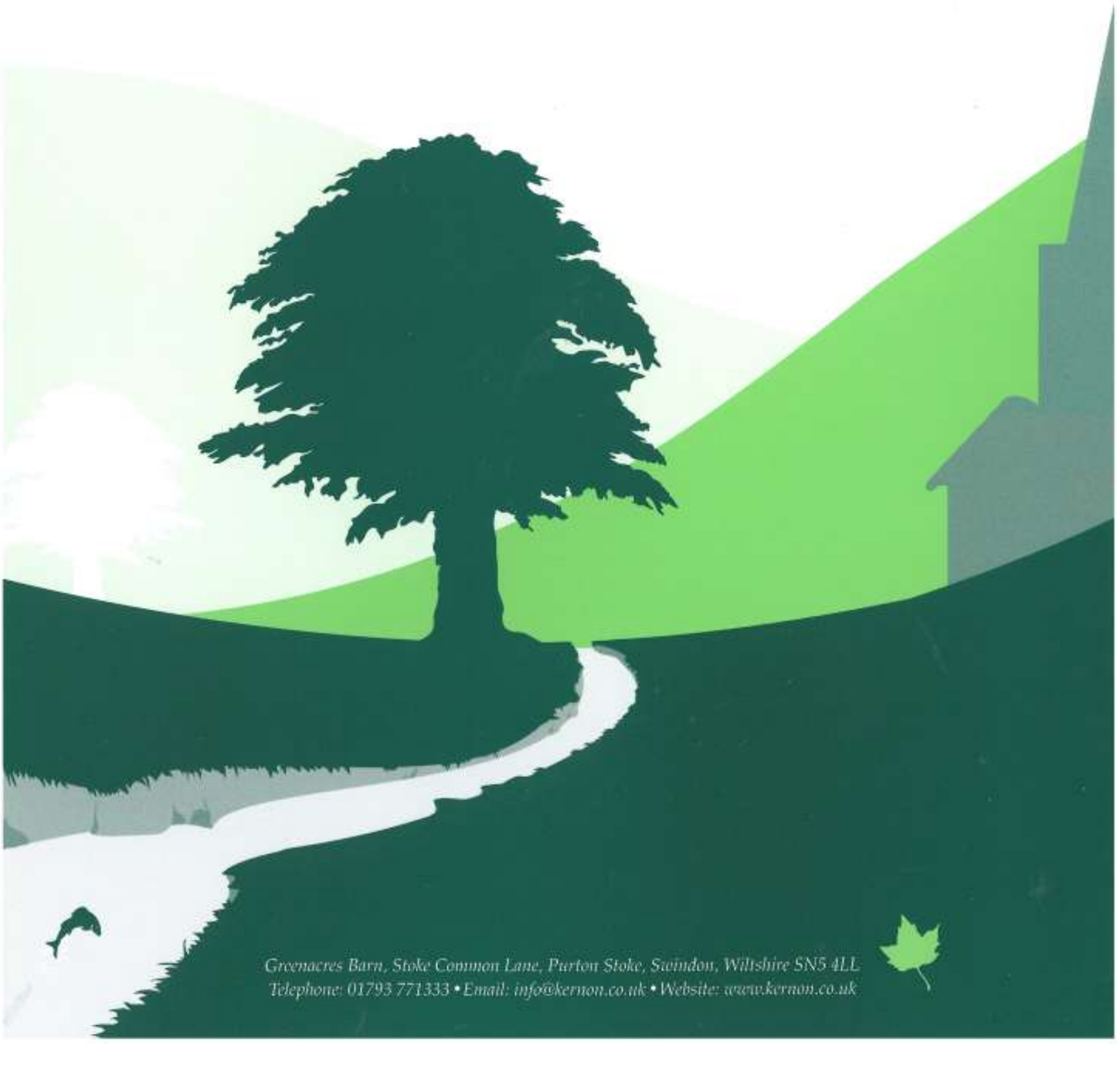
2. Where limitations can be reduced or removed by normal management operations or improvements, for example cultivations or the installation of an appropriate underdrainage system, the land is graded according to the severity of the remaining limitations. Where an adequate supply of irrigation water is available this may be taken into account when grading the land (Section 3.4). Chemical problems which cannot be rectified, such as high levels of toxic elements or extreme subsoil acidity, are also taken into account.

3. Where long-term limitations outside the control of the farmer or grower will be removed or reduced in the near future through the implementation of a major improvement scheme, such as new arterial drainage or sea defence improvements, the land is classified as if the improvements have already been carried out. Where no such scheme is proposed, or there is uncertainty about implementation, the limitations will be taken into account. Where limitations of uncertain but potentially long-term duration occur, such as subsoil compaction or gas-induced anaerobism, the grading will take account of the severity at the time of survey.

4. The grading does not necessarily reflect the current economic value of land, land use, range of crops, suitability for specific crops or level of yield. For reasons given in the preface, the grade cut-offs are not specified on the basis of crop yields as these can be misleading, although in some cases crop growth may give an indication of the relative severity of a limitation.

5. The size, structure and location of farms, the standard of fixed equipment and the accessibility of land do not affect grading, although they may influence land use decisions.

[1] Previously described as 'satisfactory'; no change in the assumed standard of management is intended.



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