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The Environmental Protection Agency

Landspreading of Organic Waste

Guidance on Groundwater Vulnerability Assessment of Land

Environmental Protection Agency
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Purpose

The 'Good Farming Practice' code was published by the Department of Agriculture, Food & Rural Development (DoAFRD) in 2001. The IFA and others have embraced this Code. In the section of the Code titled 'Protection of Watercourses & Wells' (pages 6 & 7) the code states that organic waste should not be spread in '*situations where there is a significant risk of causing water pollution*'. In cases where the soil/subsoil cover is too thin (i.e. shallow), or of such a permeability (e.g. sandy or gravely), that loss of nutrients and/or pathogens to the groundwater system cannot be ruled out; then this must be considered a situation where there is a potential significant risk of causing water pollution. This guidance document, in association with the Groundwater Protection Response for landspreading, provides a mechanism or process, by which persons involved in landspreading can identify and assess those areas, or lands, where there is a likely significant risk of causing water pollution. Subsequent landspreading operations can then be managed appropriately so as to ensure compliance with the objectives of the DoAFRD Code.

This document is intended to support the interpretation of the vulnerability verification sampling requirements specified in the Groundwater Protection Response for landspreading of organic wastes for intensive agricultural activities (DoELG/EPA/GSI, 1999).

In accordance with the principals of BAT this document will be subject to periodic review. To that end comments, difficulties encountered, suggested improvements, etc., arising from application of these guidelines should be forwarded to the Agency.

Glossary

Aquifer	Any stratum or combination of strata that stores and transmits groundwater.
Confined aquifer:	A formation in which the groundwater is isolated from the atmosphere at the point of discharge by impermeable geological formations; confined groundwater is generally subject to pressure greater than atmosphere.
Unconfined aquifer:	An aquifer where the watertable is exposed to the atmosphere through openings in the overlying material.
Attenuation	The process of diminishing contaminant concentrations in groundwater, due to filtration, biodegradation, dilution, sorption, volatilisation and other processes. Breakdown or dilution of a contaminant in water.
Baseflow	That part of a stream discharge not attributable to direct runoff from precipitation or snowmelt, usually sustained by groundwater discharge. That part of a stream discharge derived from groundwater seeping into the stream.
Downgradient	The direction toward which groundwater or surface water flows. Opposite of upgradient.
FIPS	Forest Inventory and Planning Section – Irish Forest Soils now known as ‘ and Subsoil Classification for the River Basin District Management Systems’.
Fissure	A surface of a fracture or crack in a rock along which there is a distinct separation.
Geophysics	Techniques for determining variations in a physical property of the ground that can be conducted from the ground surface or within boreholes. Techniques include electrical conductivity, density, magnetic and seismic.
Granular Aquifers	Sand/gravel aquifers that have a primary permeability and intergranular flow.
Groundwater	That part of the subsurface water that is in the saturated zone. The water contained below the earth's surface, either stored in aquifers, in "perched" conditions above layers of impermeable soils, or in the unsaturated (vadose) zone above the aquifer.
Groundwater Protection Scheme	A scheme comprising two main components: a land surface zoning map that encompasses the hydrogeological elements of risk and a groundwater protection response for different activities.

Groundwater Protection Zones	This is the integration of the aquifer categories or source areas and the associated vulnerability rating. The result is a map with each zone delineated by a code e.g. SO/H (outer source area with a high vulnerability) or Rk/E (regionally important aquifer with an extreme vulnerability). Groundwater protection responses are then assigned to these codes for different potentially polluting activities.
Groundwater Sources	This term is usually used to describe a public water supply, a group scheme or a private water supply.
GSI	Geological Survey of Ireland.
Hazard	In this case it is described as being a potentially polluting activity or source.
Hydrogeology	The interrelationship of geologic materials and processes with water.
Karst	A type of topography that is characterised by closed depressions or sink holes, and is dependent upon underground solution and diversion of surface waters to underground routes. It is formed over limestone, dolomite, gypsum and other soluble rocks as a result of differential solution of these materials and associated processes of subsurface drainage, cave formation and collapse.
Karst Features	Topographical features as a result of karstification (solution of limestone) such as turlough, swallow holes, caves etc.
Locally Important Aquifer	This can be divided into three sub groups; Sand/gravel aquifers; Bedrock that is generally moderately productive (Lm); and Bedrock that is moderately productive only in local zones (Ll).
Permeability	The ability of a porous medium to transmit fluids under a potential gradient (units = m^3/s).
Poor Aquifer	This can be sub divided into two groups; Bedrock that is generally unproductive except for local zones (Pl) and Bedrock that is generally unproductive (Pu).
Point Source	Any discernible, confined, or discrete conveyance from which pollutants are or may be discharged, including (but not limited to) pipes, ditches, channels, tunnels, conduits, wells, containers, slatted sheds and animal rearing sheds.
Quaternary Geology	This is the study of the geology of the most recent geological period. It spans the last 1.6 million years and includes the present. In Ireland it includes the loose sediments that were deposited largely during the periods of Pleistocene glaciation.
Recharge	The addition of water to the zone of saturation. The amount of water added.
Regionally Important Aquifer	This can be subdivided into three groups; karstified aquifers; fissured bedrock aquifers; and extensive sand/gravel aquifers.

Saturated zone	The zone below the watertable in which all pores and fissures are full of water.
Source Protection Areas	This is an area around a groundwater source that is divided into two sub areas; the Inner Protection Area (SI) and the Outer Protection Area (SO). The SI is designed to protect the source against the effects of human activities that may have an immediate effect on the source in particular in relation to microbiological pollution. It is defined by a 100-day time of travel (TOT) from any point below the watertable to the source. The SO covers the complete catchment area or the zone of contribution (ZOC) of the groundwater source. It is defined as the area required to support an abstraction from long-term groundwater recharge.
Subsoil	The material between the topsoil and the bedrock.
Suitably Qualified Person	Professional geologist/hydrogeologist or other appropriately qualified and trained professional.
Swallow Hole	A small steep depression caused in karst topography by the dissolution and collapse of subterranean caverns in carbonate formations.
Time of Travel	The time required for a contaminant to move in the saturated zone from a specific point to a well. It is the average linear velocity of flowing groundwater using Darcy's Law. $V=k/n_e \cdot dh/dx$ where n_e = effective porosity .
Unsaturated zone	The zone between the land surface and the watertable, in which pores and fissures are only partially filled with water. Also known as the vadose zone.
Vulnerability	A term used to represent the intrinsic geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities.
Watertable	The uppermost level of saturation in an aquifer at which the pressure is atmospheric.
Zone Of Contribution	The area surrounding a pumped well that encompasses all areas or features that supply groundwater recharge to the well.

1 INTRODUCTION

This booklet has been produced to assist farmers, farm managers, advisors, etc., develop a scope of work for the assessment of risk to groundwater under lands where it is intended to recover organic wastes, through controlled landspreading procedures. It also explains the reasons why a groundwater risk assessment is required. Certain soils/subsoils as a result of natural earth-forming processes may be shallow or highly permeable. Such soils render underlying groundwaters vulnerable to pollution from surface activities. These areas of groundwater vulnerability must be identified and documented so that appropriate landspreading strategies can be devised/implemented.

Animal wastes contain large numbers of microbial pathogens (faecal bacteria, Cryptosporidium and viruses). These microbial pathogens pose a significant risk to human health and if they enter groundwater, render it unsuitable for drinking. Soils and subsoils provide protection to groundwater by filtering out and slowing down the movement of microbes, which have a limited survival time in this type of environment. The longer the microbes are retained in the soils/subsoils, the more groundwater is protected as the microbes have more time to die off. The degree of protection depends on the type and thickness of the soils/subsoils with greater protection being afforded by thick soils/subsoils with a high clay content.

Microbes are known to survive in soils and groundwater for up to 100 days. Microbes can move considerable distances in the subsurface under the right conditions. Movement of microbes can range from negligible distances in compact clay soils/subsoils to 20 m/day in sand and gravel and up to kilometres in karstic areas. So when determining the suitability of land for the acceptance of slurry from off-farm sources, the type and thickness of the soil/subsoil needs to be determined.

It is acknowledged that organic fertilisers and wastes, such as animal slurries/manure from intensive farm enterprise, sewage sludges, poultry litter and industrial waste water treatment plant sludges are, and will continue to be spread on agricultural land and provide beneficial nutrients to crops. However, many of these materials are also potentially polluting if not properly managed and can pose a risk to groundwater and surface water quality.

Plate 1: Landspreading in operation (Courtesy of Landfeeds Environmental)

The risks to groundwater and surface water quality are influenced by:

- The chemical and microbiological content of the waste
- The method, timing and rate of application
- The groundwater vulnerability
- The proximity of a groundwater source (water supply, i.e. Local Authority Supply, Group Water Scheme, Private borehole or spring)
- The groundwater resource (the aquifer underlying the proposed spreadlands)
- The type and state of vegetation
- The weather

Tables 2 and 3 and Figure 3 of this document outline some of the key guidance elements for groundwater protection in relation to landspreading activities. In summary there should be no landspreading over Regionally Important Aquifers where the soil cover is less than 2m, and no spreading over other aquifer classes where the soil cover is less than 1m. The Best Practice Guidance in this document will help you identify and document areas where groundwater is at risk from – vulnerable to – pollution from landspreading activities.

2 THE KEY ELEMENTS OF GROUNDWATER PROTECTION

In the context of landspreading the key elements of groundwater protection are the:

- Groundwater Vulnerability
- Groundwater Resource underlying the proposed spreadlands
- Response to the perceived risk

2.1 Groundwater Vulnerability

Groundwater Vulnerability is a term used to represent the intrinsic geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities. It is usually dependent on the nature (sandy, gravely, clay, etc.,) and depth of soil/subsoil overlying an aquifer (i.e. its shallowness). The travel time, attenuation capacity of the subsoils (i.e. ability to filter contaminants) and the nature of the contaminants are also important elements in determining the vulnerability of groundwater.

Plate 2: Permeable Subsoil Profile showing cobbles and boulders. (Photo: M. Lee, GSI)

In the context of groundwater protection, **Groundwater Vulnerability** is the most important factor in determining control measures on an area where landspreading of organic wastes is proposed. This is because the type, permeability and thickness of the soil and subsoil plays a critical role in preventing groundwater contamination by acting as a protecting filtering layer over the groundwater.

The different hydrogeological requirements needed to classify groundwater vulnerability are summarised in Table 1 below (from DoELG/EPA/GSI, 1999).

Subsoil Thickness	**Hydrogeological Requirements**				
	Diffuse Recharge			**Point Recharge**	**Unsaturated Zone**
	Subsoil permeability and type				
	high permeability *(sand/gravel)*	moderate permeability *(sandy subsoil)*	low permeability *(clayey subsoil, clay, peat)*	***(swallow holes, losing streams)***	***(sand & gravel aquifers only)***
0-3 m	**Extreme**	**Extreme**	**Extreme**	**Extreme (30m radius)**	**Extreme**
3-5 m	**High**	**High**	**High**	**N/A**	**High**
5-10 m	**High**	**High**	**Moderate**	**N/A**	**High**
>10 m	**High**	**Moderate**	**Low**	**N/A**	**High**
Notes: (i) N/A = not applicable (ii) Permeability classifications relate to the engineering behaviour as described by BS5930					

Table 1: Geological and Hydrogeological conditions determining vulnerability mapping categories (from DoE/EPA/GSI, 1999)

Groundwater is most at risk where the subsoils are absent or thin and, in areas of karstic limestone, where surface streams sink underground at swallow holes.

Vulnerability classifications can be applied to two relevant scenarios:

- Regional Scale vulnerability mapping, which relies on non-site specific available data.

- Site vulnerability assessments, where relevant site investigation data is needed.

2.2 Groundwater Resource and Groundwater Sources

The resource potential of the bedrock (or gravel deposit, if appropriate) should be established. The Geological Survey of Ireland (GSI) have classified the bedrock and gravel deposits of the country into three different **Aquifer Categories**.

These categories, in order of decreasing resource importance, are:

Regionally Important Aquifers (karst/fissured/gravel)

Locally Important Aquifers (moderately productive/moderately productive only in local zones/gravel)

Poor Aquifers (unproductive in local zones/generally unproductive)

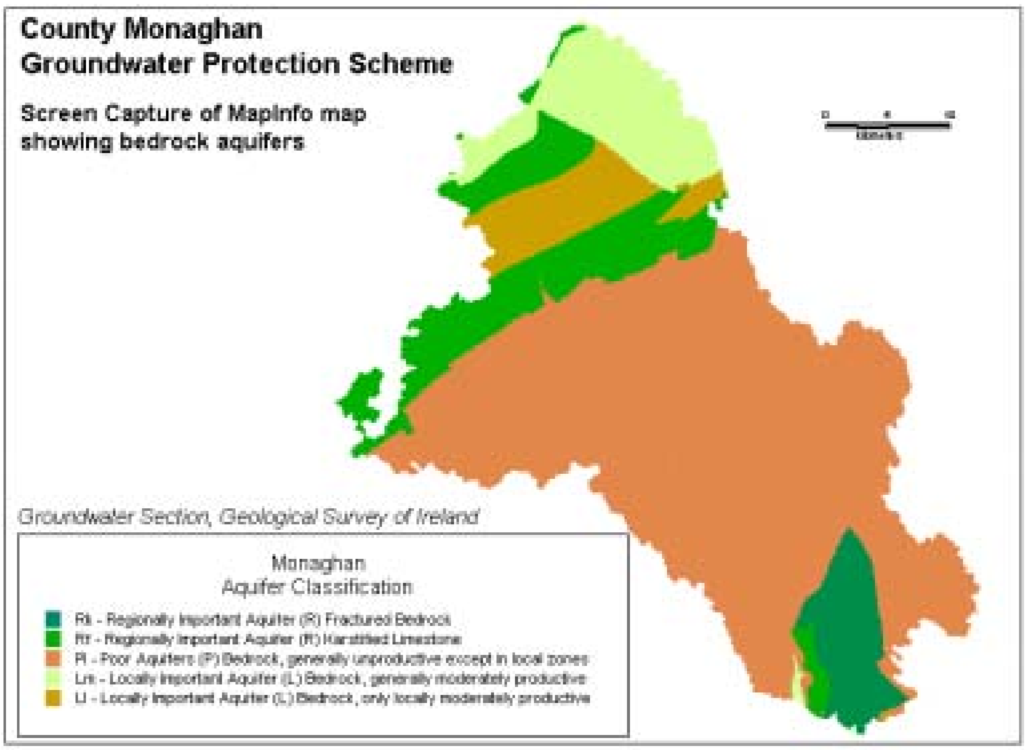


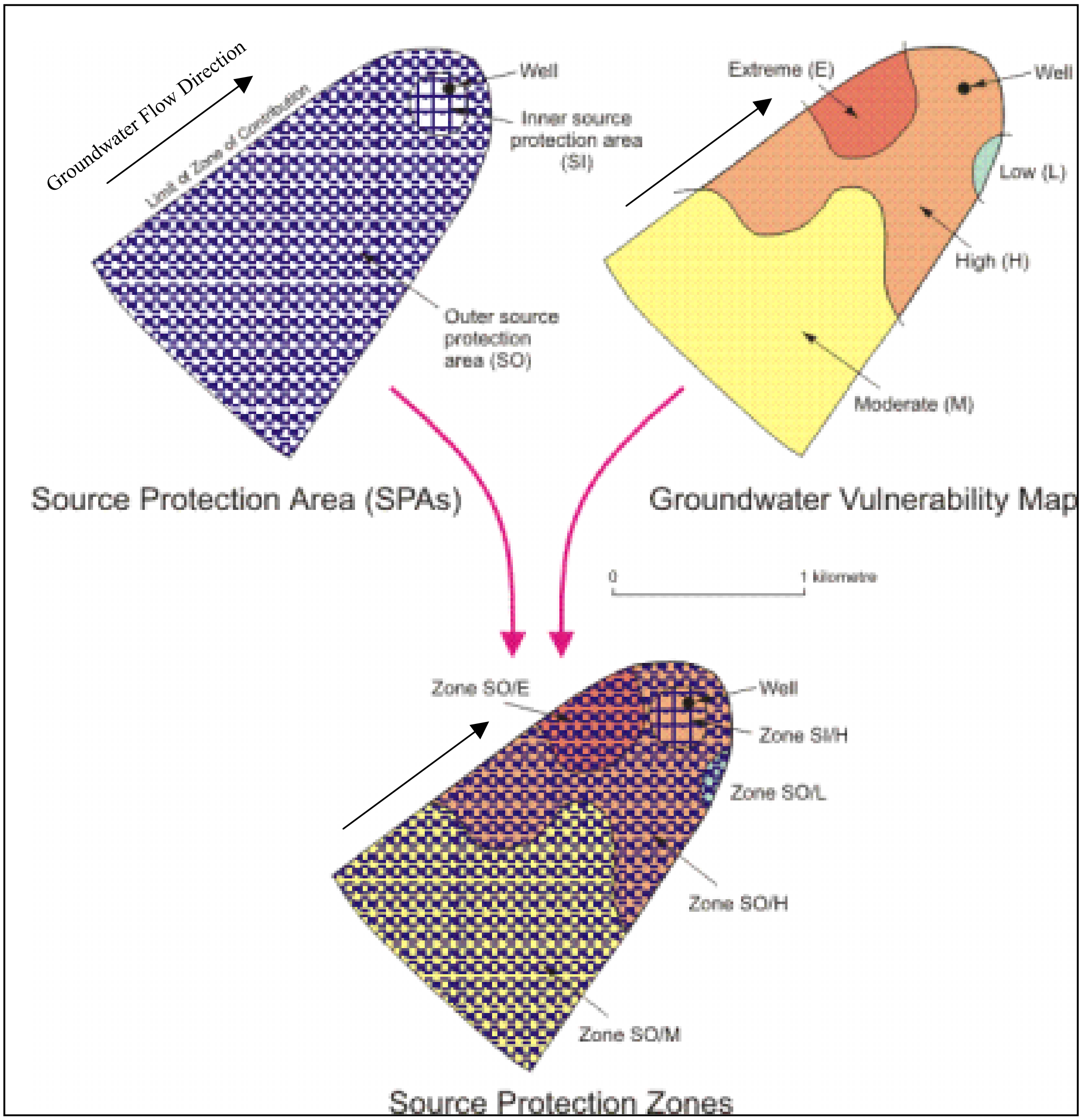
Figure 1: Aquifer Map of Co. Monaghan (Courtesy of Groundwater Section, GSI)

Along with the protection of aquifer resources, it must be noted that groundwater sources, particularly public, group schemes and industrial well or spring supplies are also important and must be protected. The areas delineated around groundwater sources to provide protection from potentially polluting activities are termed **Source Protection Areas**.

The two Source Protection Areas delineated around a groundwater source are the:

Inner Protection Area (SI) Outer Protection Area (SO)

The **Inner Protection Area** is designed to protect the groundwater source from microbial contamination. It is defined by the 100-day time of travel (TOT) from any point below the watertable to the groundwater source. In practical terms, this relates to a radius of about 50m around a private source and 300m around a public source. These are general figures and should be increased if the gradient is considered steep (greater than 1 in 6), as per EPA guidelines.



* Technical terms are defined in the glossary.

Figure 2: Delineation of Source Protection Zones around a well (DoE/EPA/GSI, 1999)

It should also be noted that groundwater flow velocities in karst aquifers are greater (i.e.

several kilometres per day) than flow velocities in non-karstified aquifers (1m – 2m per day) (Karst Working Group, 2000). Therefore, special consideration should be given, on a case by case basis, to increasing the radius around the source when delineating the Inner Protection Area in karst areas.

The **Outer Protection Area** covers the remainder of the zone of contribution (or complete catchment area) of the groundwater source. It is defined as the area needed to support an abstraction from long-term groundwater recharge.

2.3 Groundwater Protection Responses

The Groundwater Protection Responses for Landspreading of Organic Wastes for intensive agricultural activities (see DoE/GSI/EPA publication, 1999) recommends that a consistent minimum thickness of 2m of soil/subsoil must be demonstrated (by site investigations or other observations) overlying Regionally Important Aquifers with Extreme Vulnerability, before landspreading is considered to be acceptable. A consistent minimum thickness of 1m of soil/subsoil must be demonstrated overlying Locally Important Aquifers and Poor Aquifers before landspreading is considered to be acceptable.

Further restrictions on spreading are also made within Source Protection Areas delineated around major groundwater sources. Spreading is not acceptable within the catchment of the groundwater source if the vulnerability is classified as Extreme, or if it classified as High within the Inner Protection Area (designated to protect the source from microbial contamination). If the vulnerability is classified as Moderate or Low, spreading is generally not acceptable within the Inner Protection Area, unless no alternative areas are available and detailed evidence is provided to show that contamination will not take place. Spreading within the Outer Protection Area, in areas classified as High, Moderate or Low, is also restricted to a maximum organic nitrogen load not exceeding 170 kg/hectare/yr.

In karst limestone areas, karst features such as swallow holes, caves and streams connected to karst systems, must be taken into account. Landspreading should not occur within 30m of karst features.

Table 2: Groundwater Protection Responses for Landspreading – Summary (DoE/EPA/GSI, 1999)

Groundwater Protection Responses for Landspreading

Response Matrix

VULNERABILITY RATING	SOURCE PROTECTION AREA		RESOURCE PROTECTION Aquifer Category					
			Regionally Important (R)		Locally Important (L)		Poor Aquifers (P)	
	Inner	Outer	Rk	Rf/Rg	Lm/Lg	Ll	Pl	Pu
Extreme (E)	R4	R4	$R3^2$	$R3^2$	$R3^1$	$R3^1$	$R3^1$	$R3^1$
High (H)	R4	$R2^1$	R1	R1	R1	R1	R1	R1
Moderate (M)	$R3^3$	$R2^1$	R1	R1	R1	R1	R1	R1
Low (L)	$R3^3$	$R2^1$	R1	R1	R1	R1	R1	R1

R1 Acceptable, subject to normal good practice.

$R2^1$ Acceptable subject to a maximum organic nitrogen load (including that deposited by grazing animals) not exceeding 170 kg/hectare/yr.

$R3^1$ Not generally acceptable, unless a consistent minimum thickness of 1 m of soil and subsoil can be demonstrated.

$R3^2$ Not generally acceptable, unless a consistent minimum thickness of 2 m of soil and subsoil can be demonstrated.

$R3^3$ Not generally acceptable, unless no alternative areas are available and detailed evidence is provided to show that contamination will not take place.

R4 Not acceptable.

- If contamination by nitrate (or other contaminants) is a problem in any particular area, then more restrictive responses may be necessary. Monitoring carried out under any Local Authority or Agency authorisation will assist in determining whether or not a variation in any of these responses is required.
- The total nitrogen (organic and inorganic) load applied should not exceed Teagasc's nutrient recommendations for growing crops.
- No spreading should be allowed within 50 m of groundwater sources.
- In karst limestone areas, features such as swallow holes, caves and streams connected to karst systems, must be taken into account. Landspreading should not occur within 30 m of karst features.
- Landspreading should coincide with the growing season so that the nutrients applied will be utilised by the growing crop.
- Landspreading should be avoided when soil conditions prevent infiltration or when heavy rain is forecast within 48 hours. It is generally unacceptable to carry out landspreading during the period November to February inclusive. Operators who are considering landspreading during this period should consult the relevant authority.
- Site investigations (e.g. trial pits, auger holes, boreholes) should reach sufficient depths to show that the minimum required subsoil thickness is present.

****

3 UNDERTAKING A VULNERABILITY ASSESSMENT

The first step is to retain the services of a suitably qualified person (as defined in the glossary), who can assist in the development of the assessment. This person may be a contractor or a consultant (agricultural or environmental), whose job is to co-ordinate the return of information and to limit extensive study on unsuitable lands.

Identifying unsuitable land is an important aspect of the assessment. The Groundwater Protection Responses for Landspreading of Organic Wastes in fact states that the applicant is encouraged to use lands away from the likes of Source Protection Areas, Extremely Vulnerable Areas, etc.

The key elements of a vulnerability assessment are:

- A Desk study
- Questionnaire completion (local information)
- Verification of surveyed information
- Soil/Subsoil Depth Investigations. The process is summarised in Figure 3.

3.1 Desk Study

It is recommended that a desk study of the Aquifer types and Regional Groundwater Vulnerability is undertaken *prior* to any land being signed up for the proposed spreadlands. Groundwater Protection Schemes for a number of counties are available for consultation at the Geological Survey of Ireland and at the relevant Local Authorities (County Councils). Refer to Appendix A for details on the information available.

Once these schemes and their accompanying maps have been consulted, broad areas (of higher risk) can be identified and avoided. It should then be possible to sign up the most suitable land for the proposed spreadlands, while at the same time, avoiding land underlain by the highest risk categories such as Regionally Important Aquifers or land classified as Extreme Vulnerability.

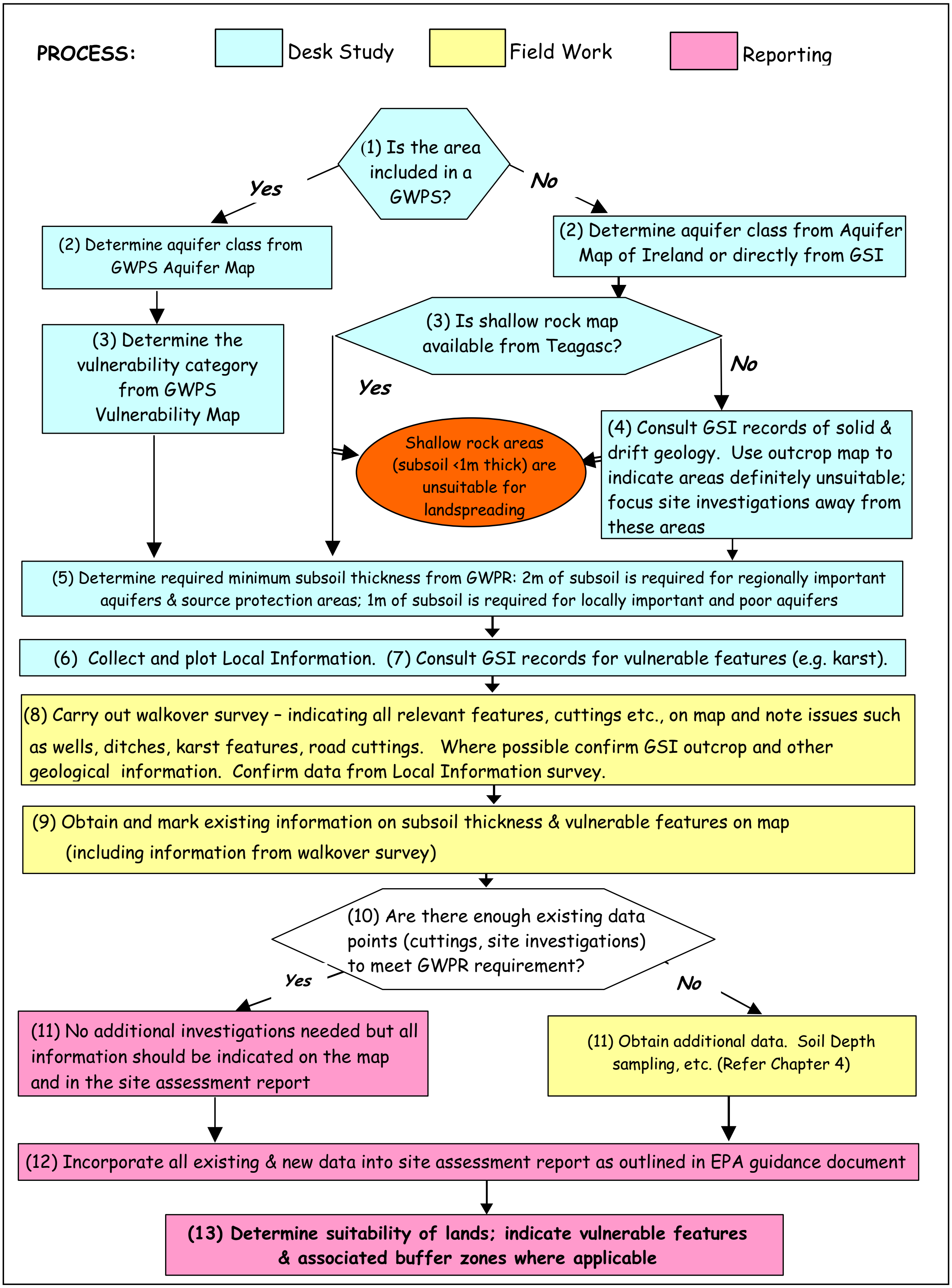


Figure 3: Step-by-step approach to determining suitability for landspreading.

Information for counties where a Groundwater Protection Scheme has not been started is now being compiled on a River Catchment basis, rather than per county. This River Basin District mapping is being undertaken by the GSI for the new Water Framework Directive (2000/60/EEC). Refer to Appendix A.

3.2 Use of Local Information

While initially drawing up the proposed spreadlands and signing up land, it is recommended that hydrogeological information be obtained by the person (e.g. agricultural consultant) signing up the land. A sample of a questionnaire for the compilation of relevant information is included in Appendix B.

A map of each farm plot should be obtained from the landowner. This should then be marked with any houses and other meeting places, such as churches, schools, hospitals, nursing homes, proximal to the proposed spreadland plot. These buildings may also indicate the location of boreholes. Any water bodies (i.e. streams, rivers, drainage ditches), known karst features (swallow holes, caves etc.) and public roads should also be highlighted. Public or group scheme boreholes should be identified at this stage, and information on their depth and construction details (depth of liner etc.) obtained where available. It should be possible to consult with the local authority regarding this aspect.

There can be a wealth of local information available on a farm and use of a questionnaire can provide a checklist to compile relevant information from the landowner with regard to:

- size of the farm plot,
- location and depth of drainage channels, streams and rivers
- details on, and locations of, any excavations undertaken recently or *at any time* in the past on the farm. Information on minimum depths recorded and subsoil types noted should be gathered. These excavations could be purpose-dug drains or foundations, excavations for slatted units, burial sites or percolation areas and road cuttings.

- location of boreholes and springs on or adjacent to the farm plot

- depth to rock from boreholes or wells

- location of steep slopes, rock outcrop or subcrop

- location of karst features (swallow holes, caves etc.)

- location of water logged ground.

Plate 3: Filling out the questionnaire (Courtesy of Landfeeds Environmental)

This information may relax the requirement to test subsoil depths but may have to be verified by a suitably qualified person, during a follow-up walkover survey (discussed below).

3.3 Verification of the desk study and local information

Further hydrogeological information for the proposed spreadlands should be compiled by a suitably qualified person. The complete hydrogeological assessment should include a desk study and a walkover survey. In all cases of extreme vulnerability it must be demonstrated that there is a consistent minimum thickness of 1m or 2m (depending on the aquifer type) of soil/subsoil. In some cases this may be provided by existing local information (ditches/well logs etc.).

3.3.1 Hydrogeological Desk Study

The information gathered during the sign-up and questionnaire stage of the assessment should be verified by a suitably qualified person who should also correlate this data with recorded/published information on the bedrock geology, outcropping bedrock, karst features, regional subsoil mapping, and locations of significant (public or group) water sources.

Information on bedrock type is available from the published Bedrock Geology 1:100,000 Series that covers most of the country. Information on the location of outcropping bedrock has been recorded on archive 6 inch to 1 mile scale (1:10,560) maps. A summary of the types of information available is as follows;

- Aquifer maps
- Bedrock geology
- Depth to rock (borehole information)
- Boreholes, wells, springs
- Karst features
- Outcrop maps
- Teagasc shallow rock map
- Vulnerability map

This information can be obtained from the GSI for a nominal charge by forwarding a location map outlining the proposed spreadlands at a scale of 1:50,000. Other sources of information may become available in time.

3.3.2 Hydrogeological and Vulnerability walkover survey

Following the desk study and compilation of all available information, a walkover survey should be carried out by a suitably qualified person to verify the location and depths of drains, noted outcrops, karst features or boreholes. This walkover should be used to finalise recommendations for the subsoil depth testing programme.

Plate 4: Walkover Survey (Photo: D. Kelly)

3.3.3 Recommendations for Subsoil Depth Investigations

Recommendations can then be made on where subsoil depth sampling should be concentrated, if required, based on information from the desk study, questionnaire and walkover. Exact locations for each investigation point need not be indicated at this stage, unless there are specific areas, e.g. over suspected shallow soils, which need to be investigated.

The recommendations should highlight any constraints or obstacles to the subsoil depth investigation programme, which should have been noted during the walkover or from information gathered during completion of the questionnaire. These sources of data provide information on whether the ground is currently accessible to tractor-mounted augers or diggers, with regard to ground drainage, ground firmness and whether crops are currently growing or not.

The recommendations should also highlight the need for investigations at the appropriate density, based on the aquifer and groundwater vulnerability classifications. The recommended density for subsoil depth information is as follows:

- **Groundwater Protection Scheme available**

  In cases of Regionally Important Aquifers and Extreme Vulnerability areas (estimated subsoil depths less than 3m) or within Source Protection Zones, at least one data point per hectare is required. In areas of Locally Important and Poor Aquifers with an Extreme Vulnerability rating, the frequency of data points is one per five hectares. In areas of Low, Medium and High Vulnerability a walkover survey is necessary to confirm the vulnerability rating established in the Groundwater Protection Scheme (GWPS) for the land.

- **Groundwater Protection Scheme NOT available**

  Where a GWPS has not been completed and the vulnerability has not been mapped, one investigation point per hectare is required in areas of Regionally Important Aquifers where the vulnerability is likely to be extreme based on existing local information. However, in areas where, based on existing information, the area is not likely to have extreme vulnerability then a reduction to 1 point per 5 hectares may be acceptable, as in these areas the risk of groundwater pollution is reduced due to the thickness of the subsoil. In areas of Locally Important and Poor Aquifers one data point per five hectares is required.

- **Source Protection Areas**

  In general landspreading of organic wastes should not be carried out within the source protection area (SPA) of a water supply. However, there are cases where if the subsoil is sufficiently thick it may be deemed acceptable subject to conditions.

Within the Outer Protection Zone a minimum thickness of 3m of subsoil should be demonstrated at a minimum depth to rock data point frequency of **one point per hectare**.

Within the Inner Source Protection Zone, landspreading is not generally acceptable unless there is no alternative area available and detailed evidence is provided to show that contamination will not take place. It must be shown that the area has been defined as having moderate vulnerability (i.e. > 10m of moderate permeability subsoil or > 5m of low permeability subsoil) overlying the aquifer. The depth to rock should be demonstrated at a minimum frequency of **one point per hectare**.

It should be noted that investigation points can take into account information already made available as part of the farm survey. If sufficient and reliable information is available with regard to subsoil depths in wells, deep drains, road cuttings, borrow pits etc., the density of additional investigation points required may be relaxed.

There may be situations whereby the desk study indicates a Moderate or Low vulnerability rating for a site with no outcropping bedrock in the vicinity of the farm. There may also be available information from a number of boreholes in the vicinity of the farm that indicates depth to bedrock is consistently greater than 10m. All information points used to estimate depth to bedrock should be clearly shown on a map. In a situation such as this, the required density of additional investigation points could be reduced or where a GWPS exists for the area, may not be required. The above case is an *example*, and one that may not readily exist in practice. However, it indicates that there may be flexibility in the density of investigation points required, on a *case by case* basis and *if sufficient information* is previously available. This information should be professionally verified by examination of the drains, road cuttings.

These requirements are summarised in Table 3 overleaf.

Table 3: Summary of sampling requirements.

GWPS exists	**Vulnerability**	**Sampling Requirements**
	LOW MEDIUM HIGH	Simple walkover survey to confirm what has been established in the GWPS, i.e., no evidence of outcrop, depth to bedrock information from wells, etc.[1] If walkover survey indicates that the lands do not have sufficient thickness of subsoil (i.e. rock outcrops) then site specific information may be required.
	EXTREME[2]	Regionally Important Aquifers - Prove that 2m depth of soil/subsoil cover exists. Minimum of 1 data point per hectare is required.
		Locally Important and Poor Aquifers – Prove that 1m depth of soil/subsoil cover exists. Minimum of 1 data point per 5 hectares is required.
GWPS does not exist	**Aquifer Type**	**Sampling Requirements**
	Locally Important / Poor Aquifers	Prove that 1m depth of soil/subsoil cover exists. Minimum of 1 data point per 5 hectares is required. Site investigation points can be based on existing information. New information only required where existing information is insufficient.
	Regionally Important Aquifers	Prove that 2m depth of soil/subsoil cover exists. Minimum of 1 data point per hectare is required. Site investigation points can be based on existing information. New information only required where existing information is insufficient.
Source Protection Areas[3]	**Source Protection Zone**	**Sampling Requirements**
	Outer	A minimum thickness of 3m of subsoil should be demonstrated at a minimum depth to rock data point frequency of one point per hectare.
	Inner	It is not generally acceptable to landspread unless there is no alternative area available and that the area has been defined as having moderate vulnerability (i.e. > 10m of moderate permeability subsoil or > 5m of low permeability subsoil) overlying the aquifer. The depth to rock should be demonstrated at a minimum frequency of one point per hectare.

1. The classification to Low/Medium/High class as part of GWPS indicates that minimum of 3m soil/subsoil depth can be anticipated.
2. To give a rough picture of 'extreme vulnerability' areas we can use: GSI Outcrop data & Teagasc Shallow Rock data.
3. In general landspreading of organic wastes should not be carried out within the source protection area (SPA) of a water supply. However, there are cases where if the subsoil is sufficiently thick it may be deemed acceptable subject to conditions.

4 SUBSOIL DEPTH INVESTIGATIONS

The steps of the assessment outlined above enable information on the underlying aquifers, subsoil types, subsoil depths and groundwater vulnerability to be compiled. However, it is usual that the desk studies and walkover surveys will provide *limited* site-specific information on the nature and thickness of subsoils for areas within the farm plots.

As has been outlined previously, the required density of investigation points is dependent on the risk of contamination of the groundwater and the availability of existing data.

4.1 Choosing Sampling Locations

The exact locations for the subsoil depth investigation points should be chosen before investigations commence. The investigation points should be located where obvious gaps in the collected information exist. At this stage the likely risk associated with the activity, the density required, and the location of streams, road cuttings and other subsoil depth information should be known.

The locations chosen should avoid areas where spreading is to be excluded for other reasons. Excluded areas may include land next to rivers, on shallow soils (outcropping bedrock), within 30m of karst features, areas classified as heritage areas, on steeply sloping areas, or land at the top of a hill or over made ground. The land assessed during the investigation programme should be representative of the actual land that is to be spread.

Once the areas that are to be avoided have been identified, the actual subsoil depth investigation locations should be marked on each farm map at the appropriate density. The investigation locations should take conditions on the ground into account.

As indicated above, site investigations are required throughout the proposed spreadlands to demonstrate the consistency of the required subsoil thickness and determine the subsoil types and permeabilities.

Investigations undertaken away from the edges of roads are unlikely to encounter underground pipes or cables, but it is recommended that the existence or location of underground services be checked with the landowner, local authority (water mains) or relevant utility company (ESB, Eircom etc.). Information relating to the locations of buried cables or pipework on the land may be available from the landowner.

If the planned investigation locations marked on the maps (as part of the desk study) are inaccessible, due to outcrops, boggy ground, forested areas etc., it may be left to the discretion of the contractor to select a replacement location. However, this alternative location should take account of rivers, houses, boreholes and avoid areas that will not be spread for other reasons.

It must also be noted that in choosing locations for investigation, due regard must be given to access difficulties, waterlogged or soft ground and crop protection. These potential difficulties should be highlighted by the site walkover.

4.2 Choosing a sampling method

The methods available range from the simple, e.g. spiking the ground to the required minimum depth without encountering any obstructions, to the more technical / mechanical e.g. a mechanically-driven auger that reaches the required minimum depth and also allows examination of the soil/subsoil type encountered.

Some of the different methods are described below, although this is not considered to be an exhaustive list of the available methods.

- **Spiking method (hand-held or driven)**

Plate 5: Hand-held spike (Photo: D. Kelly)

A spike (as illustrated) can be used to probe the ground in the pre-determined locations. This method is quick and easy and allows a large number of holes to be probed in a short space of time (up to 50 per day). It is useful in soft ground (peat or sandy, loose subsoils). The hand-held spike causes minimum disturbance as no machinery is driven over the land. The driven spike (mounted to a tractor driven post-driver system) is also useful although the ground must be accessible for machinery. The disturbance at the locations probed is minimal and re-instatement is hardly necessary.

A difficulty associated with this method is that the spike must be driven into the ground, usually with a hammer, and then removed by pulling it out. This may be difficult in hard ground, such as stiff clays or boulder clay. It is easier in softer ground, although obstructions can be easily met in gravelly subsoils. With this method it is difficult to distinguish between a large boulder in gravel and the bedrock surface.

This method does not allow a detailed examination of the soil / subsoil being probed. This method is also usually only effective to 1m depth (without some sort of mechanical driving method) and as such is only useful in areas previously identified as being underlain by Locally Important Aquifers or Poor Aquifers.

- **Hand-held auger**

A similar method to that explained above, is the use of a hand-held auger. This method also allows an unobtrusive and quick way to investigate the minimum depths required, and is easier to operate than the hammer-driven spike. Accessibility should not be a problem as it is held by the operator and re-instatement requirements are minimal. Subsoil types can be described by examining the subsoil attached to the auger when pulled back.

Plate 6: Hand-held auger (Photo: D. Kelly)

The disadvantages of this method are similar to those of the spiking method. It is difficult to determine the exact nature of any obstructions encountered (boulder or bedrock). Although the subsoil on the auger can be examined, a detailed examination of the different horizons encountered cannot be undertaken. This method is also only effective to a depth of approximately 1m, as it is difficult to auger deeper using a hand-held implement. A maximum of approximately 20 to 25 holes could be augered in one day.

- **Tractor-mounted auger**

An auger can also be mounted onto the rear of a tractor or a mechanical digger. This allows mechanically driven holes to be augered in the recommended locations and has a depth capability in excess of 2m. As such this is the best method for areas that overlie Regionally Important Aquifers, which require at least 2m of overburden to be proven. This method is more appropriate if there is a large number of points to be investigated over a geographically wide area. The tractor can cover a lot of ground and a large number of investigation points (30-40) can be undertaken in a day depending on the geographical spread of the land to be investigated. The tractor mounted system can travel most well drained land easily, as long as a heavy-duty, 4 wheel drive tractor is used. This system does not disturb the ground as much as a mechanical digger. The auger allows a simple examination of the subsoil types encountered (as the subsoil may stick to the auger). As with most auger systems, disturbance of the ground being augered should be minimal and re-instatement easy to carry out.

Plate 7: Tractor-mounted auger Photo: J. Keohane)

Plate 8: Auger mounted onto fence post driver (Photo Courtesy of Landfeeds

The disadvantages of this system include not being able to examine in detail the different subsoil horizons encountered and possible disturbance of the ground if a mechanical digger is used instead of a tractor. It is also difficult to determine the exact nature of any obstructions encountered (i.e. boulder or bedrock).

- **Trial holes using a mechanical digger**

If there is a particularly low density of points needed, it may be possible to excavate a number of trial pits / holes using a mechanical digger. Diggers excavate the ground quickly. Any obstructions encountered in the form of boulders etc. can be easily observed and the top of the bedrock, if encountered, can be more easily distinguished from a large boulder or other obstruction. The soil / subsoil encountered can be easily examined and detailed descriptions of the different subsoil horizons encountered can be made.

Plate 9: Mechanical Digger & trial hole (Photo: D. Kelly)

Description of subsoils should be in accordance with BS 5930. An assessment can also be made of the soil / subsoil permeability. Details of the basis on which the permeability assessment is made should be provided. All information should be documented.

However, this method has a number of disadvantages. A mechanical digger is obtrusive and will disturb the ground it travels over, particularly in soft ground or through fields with crops. Re-instatement of the ground after excavation is difficult and may further disturb the ground around the excavated hole. Subsidence of the ground after re-instatement may also be a problem. This method is slow and cumbersome if a large number of points on the proposed spreadlands are to be investigated. A maximum of approximately 10 - 15 holes per day is possible depending on the depth necessary and the geographical spread of the land.

- **Window Sampler**

This method uses a portable sampling system, which is mainly used in geotechnical investigations where samples of subsoil are required. It comprises a series of specially designed hollow steel tubes, incorporating a "window" sampling slot along its length (as illustrated). The tubes are driven into the subsoil using a petrol-driven hammer. The largest diameter tube is driven into the ground and then extracted by a hydraulic jack. The sample is logged, and then the next smallest tube is driven and the process repeated until the required borehole depth is achieved.

The window sampler can be carried by the operator, so there is no need for heavy machinery to cross the lands. It can extend to 2m and beyond, and is therefore useful over regionally important aquifers. The subsoil extracted can be examined and logged easily. Up to 15 to 20 holes per day (depending on the geographical spread of the land) can be sampled using this method.

Plate 10: Window Sampler (Photo: D. Kelly)

Disadvantages associated with this method include its limited use in coarse gravels or deposits with large boulders. On meeting obstructions it cannot penetrate them. As with the augering methods listed above, it is difficult to distinguish between a large boulder in gravel and the bedrock surface. This method is also considered slower than augering methods.

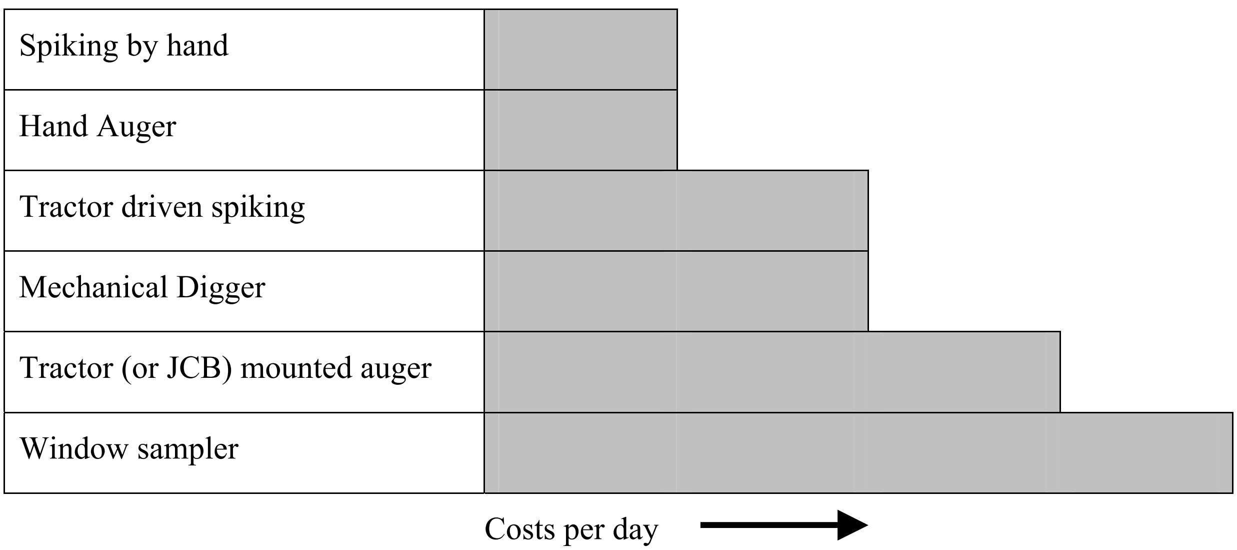
A note on Geophysics

Where good control data is available through the use of methods discussed above, then geophysical methods utilising Electromagnetic or Resistivity parameters may provide a more extensive coverage of subsoil depth assessment and may also reduce the overall number of exploration points required.

Commonly used geophysical methods include EM31 and Ground Penetrating Radar. EM31 can be a cost-effective method when combined with window sampling. It determines bulk conductivity to depths of 6 metres and can be used to indicate areas of shallow rock with the combined use of concentrated window sampling. One to two people are required in its operation and it is possible to cover 450 hectares per day.

GPR is a more expensive method. The vertical penetration is limited by a high clay content in soil/subsoil and is up to 1.5 metres.

4.3 Relative costs of the methods discussed above



The number of sample points likely to be achieved in a day also needs to be factored into the cost.

4.4 Practical considerations during subsoil depth investigations

As with all activities on farm land:

- Arrangements should be made with the landowner to gain access to the site.

- There may be areas that are inaccessible due to crops or livestock.

- If possible, locations of overhead cables should be noted and avoided.

- Any archaeological finds should be noted and recorded for subsequent reporting.

Also to be considered during the subsoil depth investigations

- Subsoil depth investigations should be undertaken to the minimum required depths at the required densities as marked on the farm maps.

- The subsoil types encountered and the minimum depths reached should be recorded carefully. Note that 1m is equivalent to 3 feet 3 inches and 2m is equivalent to 6 feet 6 inches, so that *at least* 1m or 2m (whichever depth is relevant) should be augered or excavated. Any water inflows and the depth at which they were encountered should also be recorded. This information should be referenced back to the investigation point on the map (i.e. assign a number or letter to the point on the map and to the corresponding log in a notebook).

- The information recorded should be clear and legible and should note any obstructions (boulders or rock) met during the investigation. A typical log of soil / subsoil types encountered is illustrated below. Descriptions of subsoils should be made in accordance with BS 5930, the British Standard Code of Practice for Site Investigations (used by Geotechnical Engineers).

0.0m to 0.5m	*SOFT very dark brown peaty clay topsoil*
0.5m to 1.0m	*FIRM dark brown CLAY*
1.0m to 1.5m	*FIRM black CLAY (plastic)*
1.5m to 2.0m	*STIFF light brown sandy CLAY with medium cobbles*
2.0m to 2.5m	*MEDIUM DENSE brown clayey SAND with large cobbles*

Obstruction met at 2.5m.

- It is possible that large boulders or other obstructions may be encountered during the subsoil depth investigations. If an excavator or digger is the chosen method of investigation, it may be easier to determine if the obstruction is a boulder or is in fact the top of the bedrock surface. However, owing to the nature of augered or spiked investigation points, it is more difficult to determine the nature of the obstruction. It should always be noted in the log where an obstruction is met.

- If an obstruction is met using the augering or spike method (or other methods where the nature of the obstruction is not visible), it is recommended that another investigation point be chosen a number of metres away to try to prove the minimum depth required. As explained previously, the replacement location should avoid areas where spreading will be excluded anyway (i.e. next to rivers, close to outcropping bedrock, within 30m of karst features, close to steeply sloping areas etc.).
- The ground should be reinstated, following augering or excavations in particular, to replace the subsoil that has been excavated and to restore the natural ground conditions (i.e. flattened).

5 REPORTING

Once the site investigations have been completed, a comprehensive report of the findings of all stages of the assessment (i.e. the desk study, questionnaire, walkover survey and subsoil depth investigations) should be produced. This report should comprise all the available information compiled during the assessment and recommendations for where spreading of organic wastes should be excluded based on the findings. A composite map of all recorded subsoil thickness obtained from the desk study, walkover and site investigations should be included as part of the report.

The **introduction** section of the report should outline the size of the proposed spreadlands and its general location, using information gathered during the sign up of the land (including information included in the completed questionnaire).

The next section of the report should be a **generalised description of the existing environment** and should include the information compiled during the Desk Study and compilation of the Questionnaire. This section of the report should set out the aquifer and regional groundwater vulnerability classifications for the proposed spreadlands, as identified prior to the sign up of the land. Further information as compiled by the suitably qualified person in a follow-up desk study, relating to the mapped outcropping bedrock, regional subsoil mapping, locations of karst features and known water sources (public or group schemes and private wells) should also be detailed.

The Questionnaire information should be included for each farm on the proposed spreadlands, with regard to the location of streams, drainage ditches, excavations, outcropping bedrock, karst features, steep slopes, waterlogged ground and the types of water supply (boreholes, springs, group water schemes etc.) in the surrounding area. The walkover survey should confirm any details obtained from the questionnaire such as the location of drains, outcrops and boreholes. This walkover survey enables recommendations to be made with regard to the location of, and methods to be used during, the subsoil depth investigations. This information should also be summarised in a spreadsheet. A spreadsheet is particularly easy to use and consult if there are a large number of farms. The information is clearly set out and the aquifer classification and vulnerability category for each farm can be easily consulted. Recommendations for subsoil depth investigations for each farm can also be included prior to those investigations taking place and summary results of the investigations can be included once they have been undertaken. A sample spreadsheet is included in Appendix C.

Once the subsoil depth investigations have been undertaken, the relevant information should be incorporated into the technical report. Clear maps (preferably farm maps at 6 inch to 1 mile (1:10,560) scale or other legible scale e.g. 1:2,500), which will have been obtained during the initial sign-up of the land and as part of the completion of the questionnaire, should be marked with the locations of each investigation point by the contractor who undertook the subsoil depth investigations. A log of the different subsoil types where encountered, as illustrated previously, should be provided for each investigation point.

The information from the subsoil depth investigations should be included in the technical report. This site-specific information should help to confirm the regional information on groundwater vulnerability, subsoil types and depth to bedrock collated during the desk study. An assessment can then be made of the areas where spreading should be excluded based on any investigation points that did *not* reach the minimum required depth.

A sample report is included in Appendix D. The sample report outlines data compiled during an assessment of the proposed spreadlands, recommendations for subsoil depth investigations and their findings in addition to recommendations for certain areas to be excluded from application of organic wastes.

6 REFERENCES

BS 5930:1981 British Standard Code of Practice for Site Investigations.

DoELG/EPA/GSI (1999) Groundwater Protection Schemes. Joint Publication 24pp

European Parliament and Council of the European Union Directive (2000/60/EEC) establishing a Framework for the Community Action in the field of Water Policy (EU Water Framework Directive (WFD)).

FÁS (2001) Site Suitability Assessments for On-site Wastewater Treatment Systems: Course Manual (Vol. 2).

Karst Working Group, GSI (2000) The Karst of Ireland – Limestone Landscapes, Caves and Groundwater Drainage Systems.

Teagasc/Coillte (1999) Forest Inventory and Planning System (FIPS) project. Draft Soils Mapping.

Appendix A

Groundwater Protection Schemes

Available Geological and Hydrogeological Information

The Geological Survey of Ireland produces maps of Groundwater Resources (Aquifers) and Vulnerability to contamination (Groundwater Vulnerability). These are combined to produce a map of Groundwater Protection Zones. This overall map is then combined with the groundwater protection responses (page 11) to produce a Groundwater Protection Scheme. Examples of the main map types are shown below.

Groundwater Protection Schemes have been completed for a large proportion of the country. Refer to the Groundwater Section of the Geological Survey of Ireland or relevant Local Authority for further information and copies of the maps.

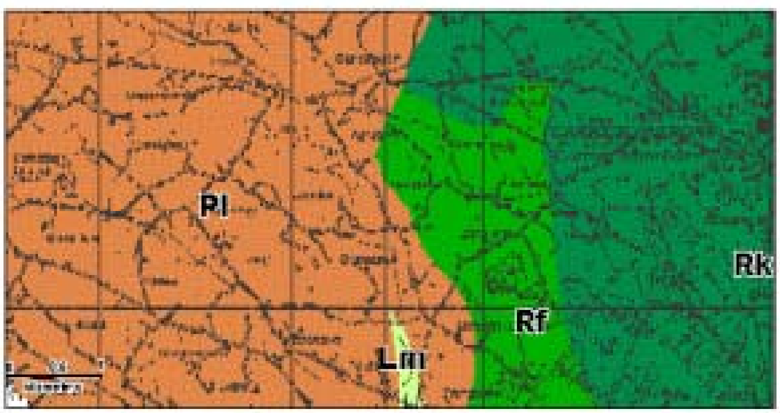


Figure 5: Example of part of an aquifer map (Courtesy of Groundwater Section, GSI)

Note: If aquifer maps have not been completed by the GSI, as part of a Groundwater Protection Scheme, it is possible to obtain aquifer classifications, once the bedrock units have been identified (following consultation of the Bedrock Geology, 1:100,000 Series Maps).

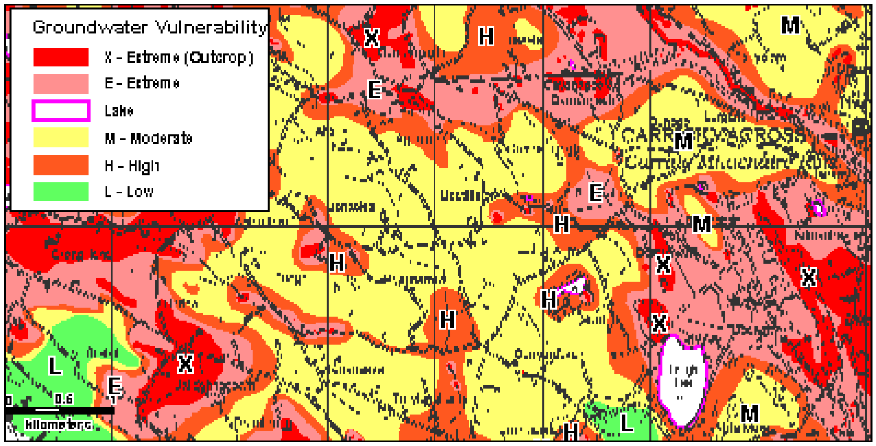


Figure 6: Example of part of a Groundwater Vulnerability map (Courtesy of Groundwater Section, GSI)

Note: If a Groundwater Vulnerability Map has not been produced by the GSI for a particular area, it may still be possible to estimate the regional groundwater vulnerability by consulting the archive 6 inch to 1 mile scale maps that show outcropping bedrock. These maps can be used (in conjunction with any depth to bedrock information) to estimate areas of Extreme Vulnerability (i.e. depth to rock less than 3m).

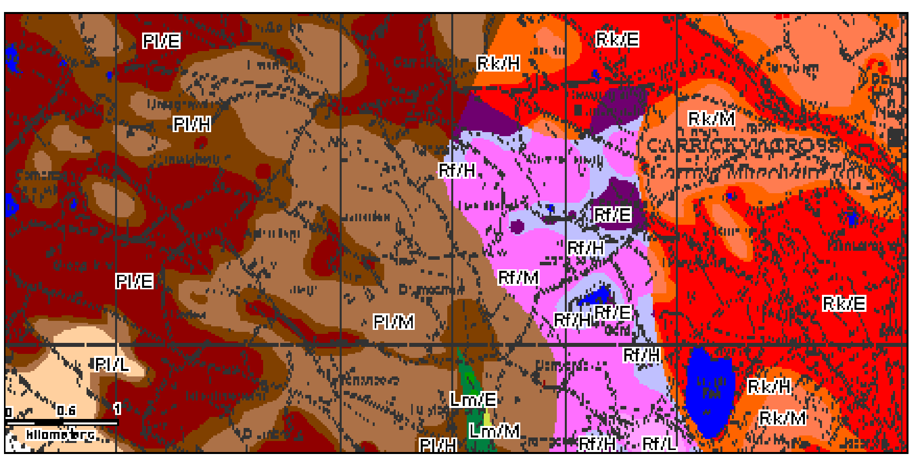


Figure 7: Example of part of a Groundwater Protection Zones map (Courtesy of Groundwater Section, GSI)

Hydrogeological data (on wells, boreholes and springs) is available from the "Geodata" well database in the GSI that also holds information on depth to bedrock and well yields. Information on karst features is available from the Karst Database, also held by the Groundwater Section of the GSI.

There are areas (as illustrated previously) for which no Groundwater Protection Scheme exists. As part of work required under the new Water Framework Directive (2000/60/EEC), the GSI are currently characterising the River Basin Districts of the country (rather than county by county) which includes the delineation of "Groundwater Bodies" (similar to the aquifer classifications previously undertaken). As part of this characterisation, preliminary maps of extreme groundwater vulnerability (i.e. areas with <3m soil and subsoil and areas in the vicinity of karst features) are being produced.

If part or all of the proposed spreadlands is in an area not yet characterised by the GSI, and where no groundwater vulnerability information exists, it is recommended that an approach similar to that used to implement the Water Framework Directive be adopted. The production of a map showing extremely vulnerable areas should use existing data, available from the GSI, i.e. location of outcropping bedrock and karst features and existing depth to bedrock data from their well databases. From this, areas of shallow subsoils (rock within 1m of surface) can be delineated. This can then be used in the desk study of the proposed spreadlands.

Where information from the GSI well and karst databases is used in a desk study, the townland in which the feature is located (or more specific location if available) should be highlighted on a map of the proposed spreadlands.

Appendix B

Sample Questionnaire for Relevant Information

QUESTIONNAIRE FOR RELEVANT INFORMATION

1. Farm Name & Location:____

2. Farm Code:______

3. Proposed Spreadland Area:______Hectares / _________Acres

4. Current Land uses: ______% Grassland

______% Tillage

______% Other (Forestry, Horticulture etc.)

5. Any Rivers / Streams / Springs passing through <u>or</u> bordering the land?

Yes / No (Mark locations on farm map)

Bank depth or thickness ______________

6. Any Artificial drainage ditches or channels passing through <u>or</u> bordering the land?

Yes / No (Mark locations on farm map)

Ditch or channel depth _______________

7. Any buried mole or field drains through any of the fields?

Yes / No (Mark locations on farm map)

Drain depth ________________________

8. Details of *any* previous excavations on farm (i.e. for drainage, foundations, percolation areas, road cuttings) at *any* time, whether visible / in-filled now or not. Details to include location (mark on map), depth, subsoil type encountered and other general observations

____

____

____

9. Has outcropping bedrock or subcrop been noted on the farm?

Yes / No (If yes, mark location on farm map.)

10. Are there any karst features (swallow holes, caves etc.) on the farm?

Yes / No (If yes, mark location on farm map.)

11. Are there any areas of water logged / soft ground / boggy ground on the farm?

Yes / No (If yes, mark location on farm map.)

12. Are there any steep slopes or abrupt changes in slope on the land?

Yes / No (If yes, mark location on farm map.)

13. General observations on subsoil depths or subsoil profiles throughout farm: ________

____

____

14. Water Supply type: Private supply (i.e. own borehole or well): ______________

Group Scheme: ____________________________________

Public / Council Supply: ____________________________

Other Supply (i.e. surface water): _____________________

15. If there is a private water supply at the farmhouse or farmyard, or if details are known on a nearby group scheme or council supply, then mark their locations (and mapped source protection areas if available), on a farm map & include details on:

Depth drilled: ____

Depth of liner (indication of depth to bedrock): ___________________________________

Water level: ____

Well protection (i.e. covered, in pumphouse etc.):_________________________________

Any installation problems: ____

16. Are there other houses, buildings (schools, churches etc.) located around or within the proposed spreadland area?

Yes /No (If yes, mark location on farm map)

17. Are there any other boreholes / dug wells etc. bordering the land?

Yes /No (If yes, mark location on farm map)

18. If yes, provide the following information:

Depth drilled: ______________________________

Depth of liner (indication of depth to bedrock): ______________________________

Water level: ______________________________

Well protection (i.e. covered, in pumphouse etc.):______________________________

Any water quality problems: ______________________________

19. Are there any buried services?

Gas Yes /No (If yes, mark approximate location on farm map)

Electrical Yes /No (If yes, mark approximate location on farm map)

Eircom Yes /No (If yes, mark approximate location on farm map)

Water Yes /No (If yes, mark approximate location on farm map)

Sewer etc Yes /No (If yes, mark approximate location on farm map)

Appendix C

Sample Summary Spreadsheet

Summary Spreadsheet detailing Hydrogeological Characteristics and subsoil depth investigation results on farms on the landbank												
Farm Code	**Field numbers**	**Usable area of plot (ha)**	**Farmer**	**Location / townland, County**	**Geological Formation**	**Aquifer Classification**	**Groundwater Vulnerability**	**Outcrops on Plot y/n?**	**Number of Investigation points on plot**	**Other depths identified on farm (drains, adjacent farm etc.)**	**Depth and soil type**	**Sufficient Depth**
1	1-4	18	XX	Stannagh, Meath	Fieldstown Fm	Pl	Extreme	None on plot, some outside SE corner	2	2 drains,	1.2-1.8m sandy CLAY Drains > 1m	Yes
2	1-5	25	XX	Mountfort Meath	Rathkenny Fm	Pl	High in south, extreme elsewhere	None, some to west of plot	1	4 drains	1.2-2.0m silty CLAY Drains > 1m	Yes
3	1-3	10	XX	Newtown, Meath	Rathkenny Fm	Ll	Moderate & High	None	-	2 drains, 1 borehole	3.2m drains,11m borehole clayey SILT	Yes
4	1-6	19	XX	Starina, Louth	Knockkerk Fm	Pl	Probably Extreme	None, some to south of plot	3	1 drain	0.6 – 2.0m CLAY Drains > 1m	Yes but exclude area in SW (see map)
5	1-5	20	XX	Newlands, Wexford	Campile Fm	Rf	Probably Extreme & High	Yes in NW	15	5 drains	0-3.5m sandy silty CLAY	Yes but exclude area in NW & N (see

Appendix D

Sample Report

Hydrogeological Assessment with Subsoil Depth Investigations

NOTE: Sections 1 – 3 should include:

ü Introduction to the report, including geographical location and sources of information

ü Generalised description of the existing environment, including background information on the geology and hydrogeology of the spreadlands, details on the desk study and walkover survey and the physical aspects of the spreadlands (drainage, slopes etc.)

ü risk assessment of landspreading of organic wastes in general

4. ASSESSMENT OF LANDSPREAD AREAS

4.1 Introduction

<This section is where the site-specific information gathered during the desk study, completion of questionnaires, walkover surveys and soil/subsoil depth investigations are laid out and discussed and the recommendations for areas to be excluded from the landbank are made>

The proposed landspread area comprises <*size of landbank in hectares*> of land, owned by <*number of*> farmers. The farms are located <*general description of where landbank is located and how far it extends, as described in Section 1*>.

An initial desk study was undertaken prior to signing up the land so that the distribution of aquifer classifications and groundwater vulnerability classifications in the area could be assessed. During signing up of the land, the land owners were asked to complete a questionnaire to provide details on the size of the farm or portion of the farm to be landspread, the land use, presence or absence of rivers, streams, drainage channels, outcropping bedrock, karst features, soft or boggy ground, steep slopes. <*It must be noted that these questionnaires may come back incomplete and that the quality of the information provided may range from good to poor*> The questionnaire also provided information on the water supplies in the immediate area along with some specific information on the minimum soil/subsoil depths on each farm.

A further desk study was undertaken by the consulting Hydrogeologist to gather further information on bedrock geology, mapped outcropping bedrock, mapped distribution of subsoils and locations of karst features and significant water sources. A visual assessment was undertaken to verify some of the information collected to date and to inspect the depth of drainage ditches and excavations <*there may be few incidences where a drainage ditch is deep enough to confirm the required minimum depth,* *especially in cases where 2m of soil/subsoil is required. However, the assessment is useful to confirm the presence of reported outcrops or boreholes and to assess the overall drainage, ground conditions, access and location of steep slopes>*

Once all the relevant information was made available, <*and summarised in a spreadsheet, if necessary, to be included at the back of this report*>, recommendations were made for the subsoil depth investigation phase of the hydrogeological assessment. The investigation point locations were chosen to fill in gaps in the collected information. These locations, along with recommendations on the minimum depth required at each location, were passed on to the contractor with indications of soft ground, fields that were inaccessible to heavy machinery, due to being too soft or currently under crops.

The subsoil depth investigation was undertaken following the recommendations made and the resulting information incorporated into this final report.

The farms are described <*below, if only a few farms or are summarised in the spreadsheet at the back of the report, if there are a large number of farm on the landbank*> in terms of physical attributes, geology, hydrogeology and local features. Draft information on the regional groundwater vulnerability has been made available by the GSI <*if a Groundwater Protection Scheme has been completed by the GSI*>. However, site specific vulnerability is also assessed on the basis of soil/subsoil depth information collected throughout the landbank.

The areas deemed unsuitable are discussed below and have been marked on <*individual farm maps*>. <*These maps, showing the amended spreadland areas are included as part of the overall submission*>.

4.2 Landspread Assessment

<To be completed for each farm if there are just a small number on the landbank. If there are a large number, this information can be summarised on a spreadsheet with the geological and hydrogeological characteristics of each farm plot being the most important>

<Sample Farmcode 1>

Physical Features

The main surface water features in the area are <*as those identified on the maps and as part of the completion of the questionnaire and verified during the walkover survey*>. There are also a number of artificial drainage channels on a number of the farms <*as identified during completion of the farm questionnaires and verified during the walkover survey*>.

The topography of the farm is best described as <*information made available during completion of questionnaire and verified during walkover survey*>.

The farm comprises mainly <type of land use as included in questionnaire>. In general, the ground was found to be <*firm, soft, boggy etc. as noted during walkover survey*> underfoot.

The surface runoff susceptibility for this farm is assessed as <*high, moderate or low as assessed from information included in completed questionnaire and verified during walkover*>.

The lands in this farm are situated in an area of <*high or low, based on maps and information in completed questionnaire*> housing density.

Geology and Hydrogeology

Reference to the relevant geological information indicates that the farm is entirely underlain by the <*formation name and description as outlined in Section 2.2.1*>. The <*bedrock formation name*> is classified as <*Aquifer classification*>.

The Quaternary information, available from the Geological Survey of Ireland, indicates <*type of subsoil as mapped by GSI*> under the farm. <*Can include an assessment / estimation of the permeability of the subsoil type*>.

Rock outcrop is recorded (on the 6 inch to 1 mile scale archive maps held at the GSI) in the <*area of farm where rock recorded, which was indicated during desk study*>. A number of additional rock outcrops are visible in some fields on the farm <*these may have been identified by the landowner during completion of the questionnaire and verified during the walkover survey*>.

Information from the Karst database held at the GSI indicates Karst features are recorded in <*area of the farm where recorded or indicated during the desk study or questionnaire*>. A number of <*e.g. swallow holes*> were visible in this location <*during the walkover survey*>.

Depth to bedrock information for the area is sparse. Available information <*from the Geological Survey of Ireland, obtained during the desk study phase*> suggests average subsoil thicknesses between <*range of thickness' as per available information, which may be very sparse*>. Further information from the landowner <*made available during completion of the questionnaire*> indicates

<*a number of*> boreholes adjacent to the land, with known depths to bedrock of <*number of metres*>.

Other indications of minimum subsoil thickness were available from the completed questionnaire. Deep drains had been excavated in the past by the farmer and although they have since been covered in, at least <*number of metres / minimum depth*> of soil / subsoil was encountered. Current drainage ditches on the land indicate <*for example: the minimum required thickness in areas underlain by Poor Aquifers i.e. they are at least 1m deep. Subsoil depth investigations will not be required close to these drains. However, in the areas underlain by Regionally Important Aquifers, the drains do not extend to 2m depth, so extensive subsoil depth investigations will be required in these areas*>. A road cutting was identified by the landowner in the <*part of the farm*>. This was verified during the walkover survey and indicates at least <*number of metres*> of soil / subsoil in the profile. This depth is <*sufficient*> for the aquifer that underlies this part of the farm.

Based on the available information on groundwater vulnerability, presence of outcrops, depth to bedrock and minimum subsoil depths, recommendations for subsoil depth investigations were made. The recommended locations were compiled onto farm maps. The density of the investigations required adhered to the published guidelines, although this density was reduced in certain areas of the farm, where it is considered that there is sufficient information. <*Note: Without prior agreement the Agency, on receipt of the report, might not agree to the reduction and ask for more investigation*>. The required minimum depth, based on the aquifer classification, for each location was also noted and this information, along with the farm maps was passed onto the contractor, with indications of soft ground, fields that were inaccessible to heavy machinery, due to being too soft or currently under crops.

A total of <*number*> points were investigated on the farm. The main soil and subsoil types encountered comprised <*description of main soil / subsoil types encountered as per individual logs to be included in appendix to report*>. <*A number*> of these investigation points encountered obstructions at various depths <*insert details and note if they confirm where shallow subsoil depths indicated, i.e. are they near outcrops etc.*>. However most of these continued to the <*required minimum thickness for the relevant aquifer type*> without encountering any obstructions.

The regional groundwater vulnerability of the farm was assessed as <*vulnerability classification*>. <*The soil/subsoil depth investigations did not reach definite bedrock and as such site specific groundwater vulnerability classifications cannot be made. However, obstructions were encountered at the locations close to outcropping bedrock and this may confirm the Extreme Vulnerability* *classification in this area>.*

When the aquifer classification is considered in association with the groundwater vulnerability rating, a **Resource Assessment** is made. For this farm, the resource assessment is considered to be <*resource protection category, e.g. Pl/E or Rf/H etc.*>. Reference to the EPA/GSI Groundwater Response Matrix indicates that spreading within the proposed spreadlands is acceptable over <*the relevant aquifer type*> with a minimum consistent thickness of <*the corresponding relevant depth in metres*> of soil/subsoil.

These soil/subsoil depth investigations <*for example: confirmed that there is sufficient depth of soil / subsoil over most of the farm, as was indicated by the drains and road cuttings, although there are a number of areas where insufficient depth of subsoil is present, as indicated by the presence of outcrops nearby*>.

The regional groundwater flow is considered to be towards the <*identified main river in the same hydrological catchment*>. Localised groundwater flow may be controlled to some degree by the smaller streams adjacent to the farm and the local topography.

The water requirements for domestic houses and farms in this area are met by <*private boreholes OR group scheme wells OR surface water mains supply*> identified during completion of the questionnaire.

Discussion

Buffer zones require that landspreading should not be undertaken within 10m of public roads, 100m of household dwellings, 200m of sensitive buildings (i.e. schools, churches), 50m of domestic wells and 30m of karst features, 10m adjacent to small watercourses and 20m from lakes and main river channels. This cordon is a minimum distance to reduce the risk of surface run-off affecting the aquatic environment and should be increased if the slope towards the water course channel is deemed excessive (>6%).

The exact location of all wells should be located prior to spreading to ensure that the correct 50m radial cordon is established. A 100m radial cordon should be maintained around all houses, industrial buildings and commercial buildings adjacent or near the landbank.

<Areas where spreading is not recommended and which have been cordoned off have been drawn on the individual farm maps and are included in the appendices to this report>.

Other areas excluded include <*the steeper slopes noted in part of the farm, and areas around outcrops with the shallow soil/subsoil confirmed by subsoil depth investigations in these areas*>.

In most cases the subsoil depth investigations proved the minimum required thickness of <*number of metres over relevant aquifer type*>.

Elsewhere within this proposed landspread plot, spreading is deemed acceptable based on the criteria set down in the Response Matrix for Landspreading (DoELG/EPA/GSI, 1999). Provided good farm practice is adhered to, the environmental impact posed by the landspreading activity should be low.