LANDWISE Broad-scale Field Survey Methodology

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Aim
Quantify the impact of different land use and management strategies on key soil properties that affect infiltration and water storage across the main soils type in the West Thames catchment.

Purpose of this document
Define sampling strategy and associated field and laboratory methods to determine selected near-surface soil properties and vegetation characteristics of predominantly agricultural fields under various land-based Natural Flood Management (NFM) measures.

Selected near-surface properties/characteristics: soil texture, soil organic matter (SOM), soil volumetric water content (VWC), soil dry bulk density (BD), vegetation type, height and cover, soil aggregate stability (slaking & dispersion test) and soil structure (Visual Evaluation of Soil Structure; VESS).

Sampling strategy - land use and management
Four factors or fixed effects (things we seek to control by choices made):

> Land use: *Arable*, *Grassland (permanent, established > 5 years)*, *Woodland (broadleaf, mature)*
> Management (sub-class of arable): *Arable rotation with grass*, *Arable rotation without grass*

Covariates or random effects (things we can't control, but know will likely affect outcome):

Management practices, Crop types, Rotation, Organic, Conventional Tillage, Min Till, No Till, Cover Crops, Controlled Traffic, Field Drainage, Flooding History, plus any other currently unknown factors.

Sampling strategy - soil type

Five broad soils types on carbonate and mudstone geology

Proposed soil types for survey, as used in the LANDWISE farmer survey, shaded in grey:

LANDWISE soil type (survey)	Generalised Geology	Soilscapes classes*	Soilscapes class names
Shallow chalk or limestone	Carbonate	3	Shallow lime-rich soils over chalk or limestone
Free draining loamy		5,6,7	Freely draining lime-rich loamy soils Freely draining slightly acid loamy soils Freely draining slightly acid but base-rich soils
Impeded drainage loamy/clayey		8,9	Slightly acid loamy and clayey soils with impeded drainage Lime-rich loamy and clayey soils with impeded drainage
Free draining sandy/loamy	Sandstone	10,14	Freely draining slightly acid sandy soils Freely draining very acid sandy and loamy soils
Naturally wet sandy/loamy		15	Naturally wet very acid sandy and loamy soils
Slowly permeable loamy/clayey	Mudstone	18	Slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils
Floodplain or high groundwater loamy/clayey		20,22	Loamy and clayey floodplain soils with naturally high groundwater Loamy soils with naturally high groundwater

*http://www.landis.org.uk/soilscapes/index.cfm

Sampling strategy table

Geology	LANDWISE Soil Type	Land use and management			
		Arable		Grassland (permanent, est. 5+ yr.)	Woodland (broadleaf, mature)
		Rotation with grass*	Rotation without grass		
Carbonate (Chalk, Limestone)	Shallow over chalk or limestone				
	Free draining loamy [1]				
	Impeded drainage loamy/clayey	?	(?)	?	?
Mudstone	Slowly permeable loamy/clayey				
	Floodplain or high groundwater loamy/clayey				?

* incl. grass only rotation (e.g. dairy), not just grass as break crop

[1] sometimes also over gravel superficial deposits overlying mudstone

? appear to be fewer of these combinations, based on sites known to date

Ideally, we have the same number of fields in each table cell – that would be 20 combinations (4 land use/management classes x 5 soil types). We would then try to sample as many fields as possible in each category. E.g. 8 fields or replicates in each category would be 160 fields in total (20 combinations x 8 repeat fields). There is a trade-off between number of fields/repeats and the number of samples collected in each field as we can collect 2000 samples in total (see below).

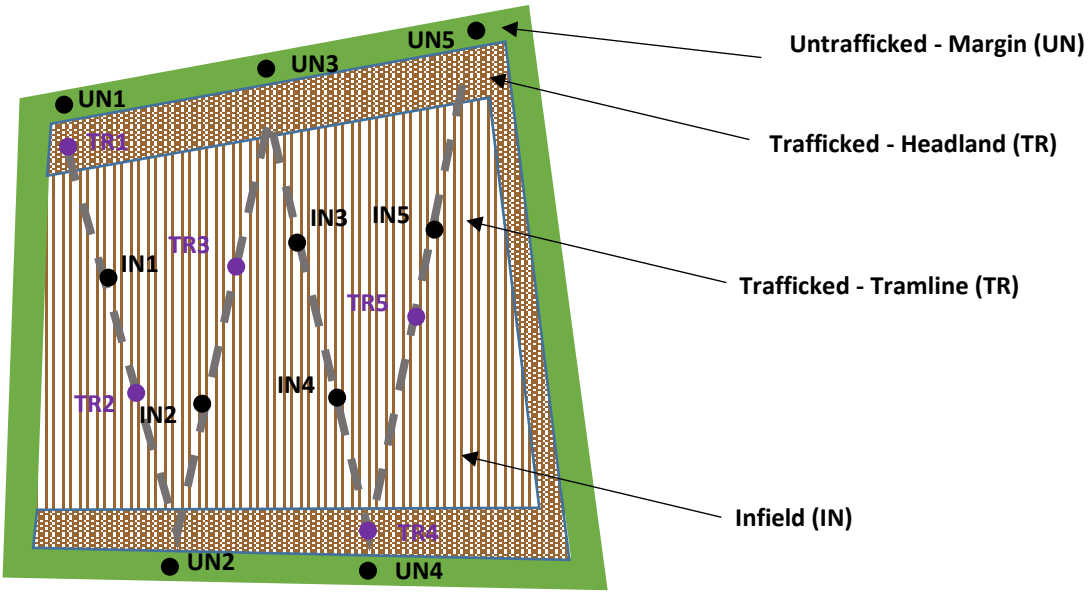
In practice, we might get a bit of variation and/or choose to focus on particular soil types in more detail, depending on the actual fields available to us. We can work on this as we scope out potential sites.

NB – should generally only have one field/plot per table cell from any particular farm (need to avoid pseudo-replicates, e.g. 3 grassland on same soil type from same farm). However, we can we sample from more than one field in the same soil/land use cell at the same site *provided the land use management is distinctly different* (21/02/19 update)

Arable sampling locations and label codes

15 sample locations per field:
5 infield
5 trafficked *(cropped headland or tramlines)*
5 untrafficked margin *(uncultivated/uncropped rough margin, avoid within 1 m of tree/hedge stems and animal burrows)*

3 VESS:
one sampling location from each of infield, trafficked and untrafficked



For trafficked sample locations, surveyor to select most apparent heavily trafficked areas, these may be tramlines, but could be headlands. Essential that potential variation across field still captured (trafficked samples not all from same area). UN and IN sampling locations should be similar for different fields. TR sampling locations will be more varied.

Grassland sampling locations and label codes

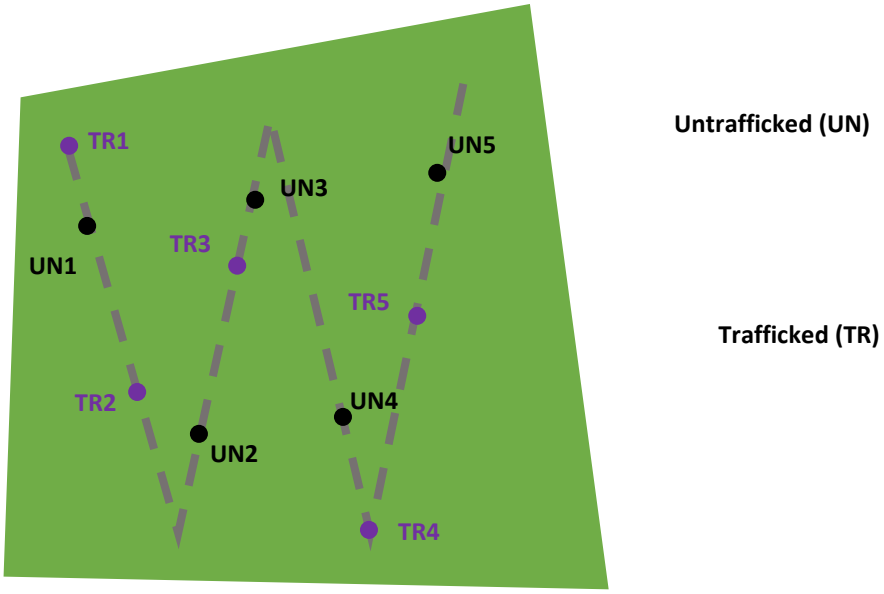
10 sample locations per field:

5 trafficked *(vehicle tramlines (associated with hay cuts), stock tracks, stock shelter areas near hedges – avoid extreme conditions, e.g. poached ground around feeders/water troughs, gateways)* or expected to be trafficked (if not obvious)

5 untrafficked *(be aware that livestock tend to lie/excrete on flatter ground at tops of slopes (NE, 2008))*

2 VESS:

one sampling location from each of trafficked and untrafficked

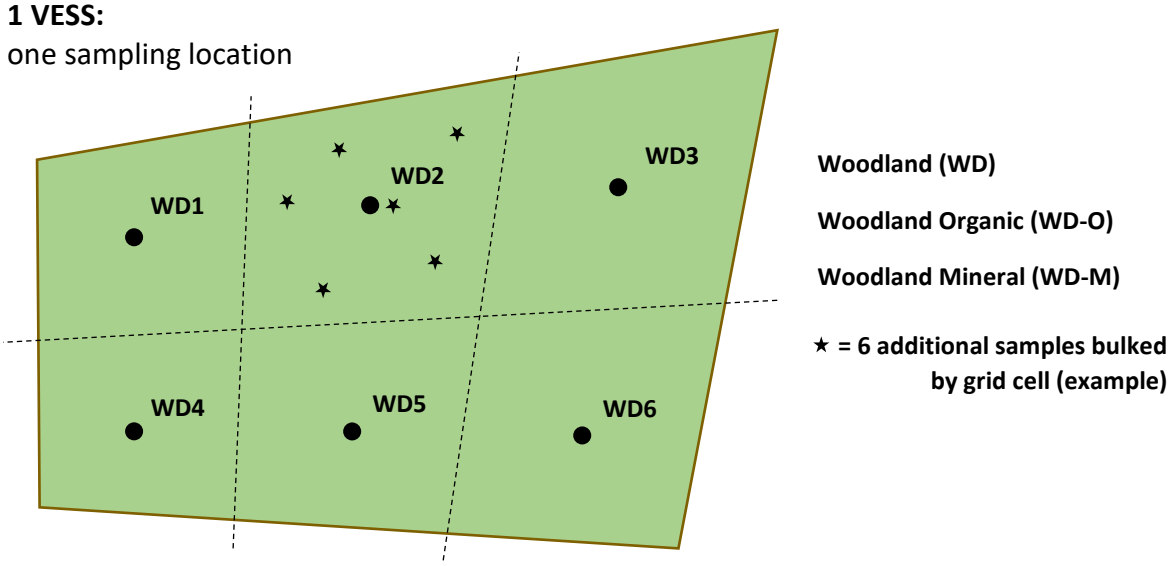


Surveyor to select trafficked sample locations, based on above criteria. Essential that variation across field still captured (trafficked samples not all from same area). UN sampling locations should be similar for different fields. TR sampling locations will be more varied.

Woodland sampling locations and label codes

6 or 12 sample locations per plot (min. size 0.25 ha):
6 surface mineral soil layer *(avoid within 1 m of tree stems, animal burrows, fresh disturbances such as windblown trees)*
6 surface organic layer *(if required, see below)*

1 VESS:
one sampling location



Take fixed volume soil samples (for BD/VWC) at the WD sampling locations:

- If the surface soil organic layer (litter, fragmentation and humus) is less than 50 mm deep, clear away loose organic material and take a single 0-50 mm bgl mineral soil layer sample (WD-M1 - WD-M6).
- If the surface soil organic layer (litter, fragmentation and humus) is more than 50 mm deep, take a 0-50 mm bgl organic layer sample (WD-O1 – WD-O6), then clear away any deeper loose organic material and also take a 0-50 mm bgl mineral soil layer sample (WD-M1 - WD-M6).

Therefore 6 or 12 fixed volume samples per plot.

Take additional soil samples (for SOM, slaking, texture etc.) over the grid cell associated with each WD-M (and, if needed, WD-O) sampling location:

- If soil organic layer less than 50 mm deep, at 6 locations in grid cell, clear away loose material and take an additional small sample (0-50 mm bgl) from the mineral soil layer. Bulk these for each grid cell *(need similar amount to volumetric samples)*
- If soil organic layer more than 50 mm deep, at 6 locations in grid cell, take an additional small sample (0-50 mm bgl) from the organic layer, clear away any deeper loose material and take another additional small sample (0-50 mm bgl) from the mineral soil layer. Bulk these small samples for each grid cell (separate organic/mineral)

Therefore 6 or 12 additional small samples for each grid cell, bulked by grid cell, to give 6 or 12 additional samples per plot

Pre-survey actions

1. Liaise with land owner/manager:
   a. send Landwise broad-scale field survey *participant information sheet* (includes *consent form*), *method summary for participants* and *record sheet (questionnaire)*
   b. obtain general farm map and identify potential sampling fields/plots based on sampling strategy table and discussion, confirming current land management and any land-based NFM measures. Check not recently ploughed (within last month)
   c. generate/obtain additional maps of potential sampling fields:
      - OS 1:10k or 1:25k OS (with field boundaries)
      - soil map (e.g. local map or NSRI SoilScapes)
      - Defra MAGIC map (https://magic.defra.gov.uk/MagicMap.aspx) showing statutory 'designated' areas (scheduled monuments, SSI's etc.)
   d. use soil map to exclude potential sampling fields with varying soil types
   e. use Defra MAGIC map to exclude potential sampling fields with statutory 'designated' areas
   f. agree survey date/time and meet-up arrangements incl. contact phone no.
2. Label press seal sampling bags (150 × 225 mm) with farm name/code, field code (F1, F2, etc.) and sample code (NB sample codes depend on land use type). Need two complete sets (fixed volume samples: 'V'; additional samples: 'A')
   e.g.
   '**UoR Sonning F1 IN4 V**'
   '**UoR Sonning F1 IN4 A**'
   '**UoR Sonning F2 WD-M1 V**'
   '**UoR Sonning F2 WD-O1 V**'
   Bulldog clip sample bags into groups
3. Obtain details of nearest A&E hospital and route

On-site actions (pre-sampling)

1. Meet land owner/manager
   a. complete participant consent form (2 copies: 1 for farmer, 1 for researcher)
   b. agree sampling fields
   c. complete land management questionnaire – side one on Landwise broad-scale field survey record sheet (one per field/plot)
   d. demonstrate soil sampling (if necessary)
   e. check any potential risks (e.g. farming activities, cattle/horses, services/cables, contaminated soil, ticks etc.)
   f. agree access routes (and follow them!)

On-site sampling procedure

1. Take photos:
   a. Landwise field ID card (e.g. Field 1, Field 2, etc.)
   b. a few general photos, incl. Landwise field ID card if possible

2. Complete field/plot general observations on Landwise field survey record sheet (side two)
3. Assess field shape to plan W-walk and/or sampling locations (see arable, grassland and woodland diagrams)
4. Walk to each approximate sampling location
5. Select a **representative sampling point** (see land use specific notes)
6. Take photos:
   a. GPS/phone location with Landwise survey card (location code and scale)
   b. vegetation surface coverage - vertical photo looking down, incl. survey card
   c. vegetation close-up – horizontal(ish), incl. survey card

7. Complete sampling location information on Landwise field survey record sheet.
   Notes:
   - GPS: record British National Grid reference to nearest metre, e.g. *(461674, 189670)* or *SU 61674 89670*
   - mobile phone: record lat/long, each to 6 decimal places
   - vegetation height – range to nearest 5 cm, e.g. 10-15 cm, 25-40 cm
8. Take near-surface (0 – 51 mm bgl) fixed volume soil sample:

   a. Fit 50 mm sample ring (50/53 mm ID/OD, 51 mm height, 100 cc volume) into hand-held hammering head with cutting edge of ring exposed
   b. Remove any 'easy to scrape' vegetation/debris/manure etc. to expose the ground surface (0 mm bgl)
   c. Drive the sample ring into the soil vertically (using weight and/or nylon impact absorbing hammer/mallet only), until the top of the ring (as indicated by marker on hammering head) is level with the ground surface. Do not use excessive force – it'll most likely be a stone – resample from nearby. Do not over-hammer and accidentally compact the soil (affects VWC and BD).
   d. Dig out the complete sample ring and hammering head using soil spatula / trowel / spade.
   e. Carefully remove sample ring from hammering head and use knife / spatula / fine hack saw blade to trim excess soil so sample flush with ring. Possible to gently push ring up/down sample to ensure complete sample. **Careful control of sample volume is crucial - if soil does not fill sample ring or stones protrude, the sample should be discarded and retaken**.
   f. **Add sampling date and time (GMT) to pre-labelled 'V'(olumetric) sample bag**
   g. Push soil sample out of sample ring into sample bag, **squeeze air out of bag** and then seal. **If the sample bag is damaged or will not seal, seal the bag within a spare bag.**

9. Take near-surface (0 – 50 mm bgl) additional soil sample *(different for woodlands – see land use specific note above)*
   a. Dig out a handful of soil (0 – 50 mm bgl) from next to the sampled location (could sample from the soil excavated to remove the sample ring). Around the same amount as the fixed volume sample.
   b. **Add sampling date and time (GMT) to pre-labelled 'A'(dditional) sample bag**
   c. Put additional soil sample in bag, squeeze air out of bag and then seal.
   d. Take an extra dessert spoon sized sample and hand texture in field following RB209 methodology (see Appendix for flow chart). Record results on record sheet and discard soil.
   e. Refill soil sampling hole with arisings and 'heel-in' / dig over to leave the surface as even as it was prior to sampling
10. If location selected for VESS (see arable, grassland and woodland notes), follow VESS method sheet. Take photos before and after block break-up, including Landwise survey card. Record result on record sheet.

11. Group soil samples for each field in a small bag, e.g. pedal bin liner, label with farm name/code and field code
12. Keep soil samplers reasonably clean using brush; thoroughly wash clean and dry before storage, silicone grease O-ring seals
13. Inform land owner/manager when leaving site (if requested)

Post-survey actions

1. Type up Landwise field survey record sheets onto electronic versions.
2. Scan original Landwise field survey record sheets (change filenames to match sampling, e.g **UoR Sonning - Field 1.pdf**)
3. Download photos and store, along with record sheet files, in folders matching sampling (with YYYY_MM_DD date), e.g. …**UoR Sonning\2018_12_17 Field 1**
4. Temporarily store soil samples in a sturdy box in a cool, dark, dry place, especially out of direct sunlight. Return samples in around 3 batches to CEH Wallingford (liaise with CEH/UoR to arrange meet up/drop-off/delivery). At CEH, samples to be stored in Chiltern Wing walk-in fridge room – used labelled storage crate.
5. Email/send Landwise signed participant consent form, field survey record sheets (electronic versions and scans) and photos to CEH.
6. Clean (wash and dry) soil sampling equipment between sites to avoid any potential cross-contamination

Equipment required (items in blue lent/supplied by CEH)

Travel
Directions to site / postcode
Land owner/manager contact details

General
Mobile phone / camera (waterproof case)
Sat Nav
GPS (set to BNG, OSGB 1936)
Spare batteries
WeatherWriter-style clipboard
Biros / Pencils

PPE and wellbeing
Safety boots
Gloves – nitrile and thicker
Coat
Over-trousers
Hat / sunhat
Dry clothes*
Hi-Vis*

Safety glasses*
Sun cream*
Insect repellent*

Hand wipes
Antibacterial spray / gel
Tissue paper roll

Drinking water
Flasks
Food

Rubbish bag(s)

First aid kit
A&E route
Torch
* = optional

Soil sampling
Farm/field maps
OS, soil and Defra MAGIC maps

Landwise field method summary (laminated)
Landwise field ID cards (laminated)
Landwise survey cards (laminated)
VESS assessment sheet (laminated)
Hand texturing flow chart (laminated)
Landwise participant consent forms
Landwise broad-scale field survey record sheets

Plastic sheeting / feed bag - white

6 Soil rings (50 mm ID, 51 mm L)
Hand-held hammering head
Impact absorbing hammer/mallet
Penknife +/ spatula
Trowel +/ spade

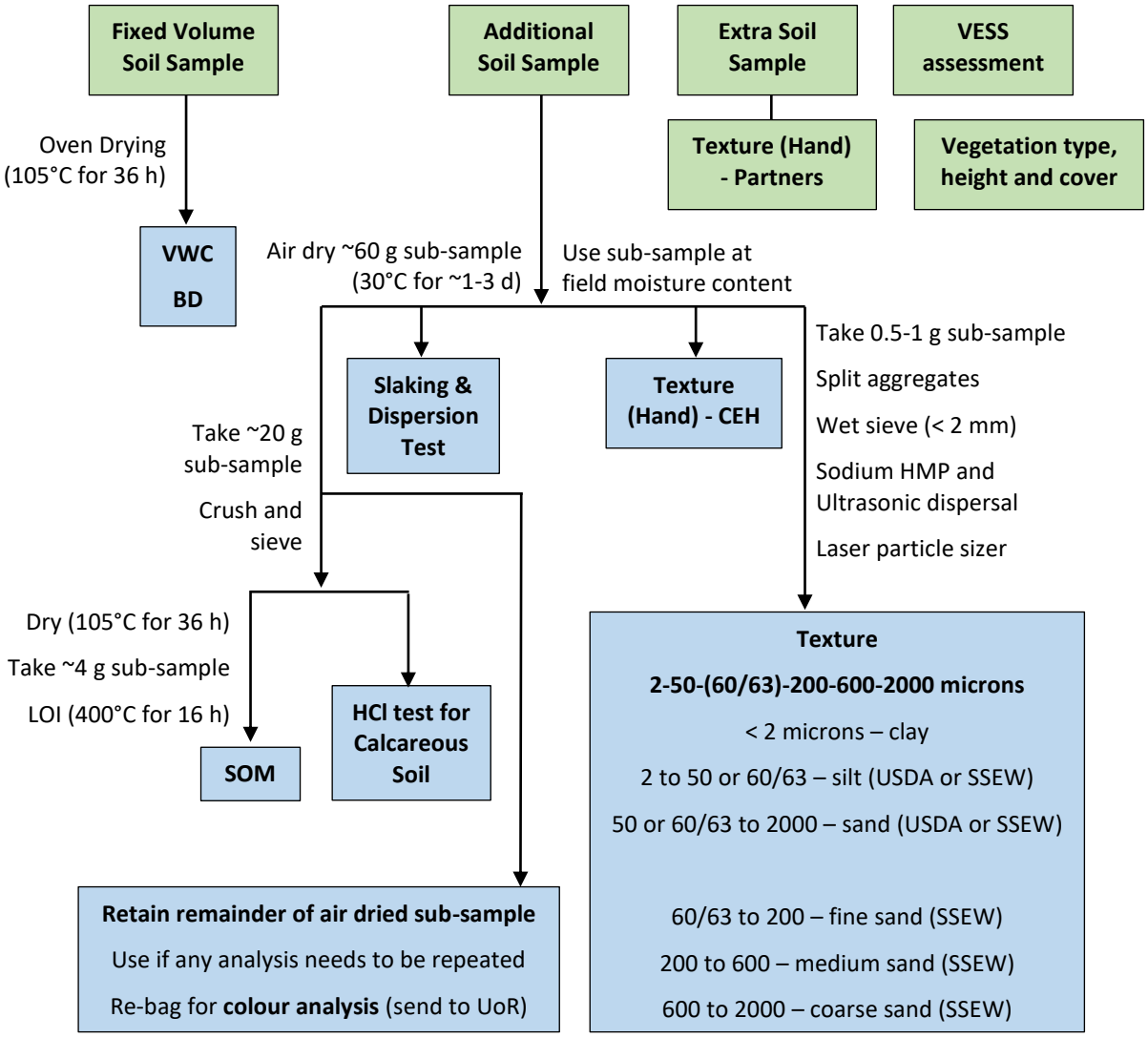
Part-labelled plastic sample bags
Bulldog clips (for sets of bags)
5 Permanent Marker Pens
Spare plastic bags (× 50?)

Large transport boxes / cool boxes with handles (for sample storage and seat)
Small bags, e.g. pedal bin liners, to group samples

Tape measure ~3m
Tape measure ~20/30 m

Silicone Grease
Cleaning brush
Metal files for repairing soil rings

Soil sampling and lab analysis schematic (green = field, blue = lab)



Notes

Soil particle size limits required for proposed pedo-transfer functions (and general texture classification)

Soil Survey of England & Wales (1980):
> 2 mm = stones
0.06(3) – 2 mm = sand
0.002 – 0.06(3) mm = silt
< 0.002 mm = clay

2-20-60-100-200-600-2000 micron England - according to Wosten (1998)
2-50-2000 USDA

0.6 – 2.0 mm = coarse sand
0.2 – 0.6 mm = medium sand
0.06(3) – 0.2 mm = fine sand (needed for some of Hollis et al. 2014 PTFs)

Landwise will use the following limits:
2-50-(60/63)-200-600-2000 microns

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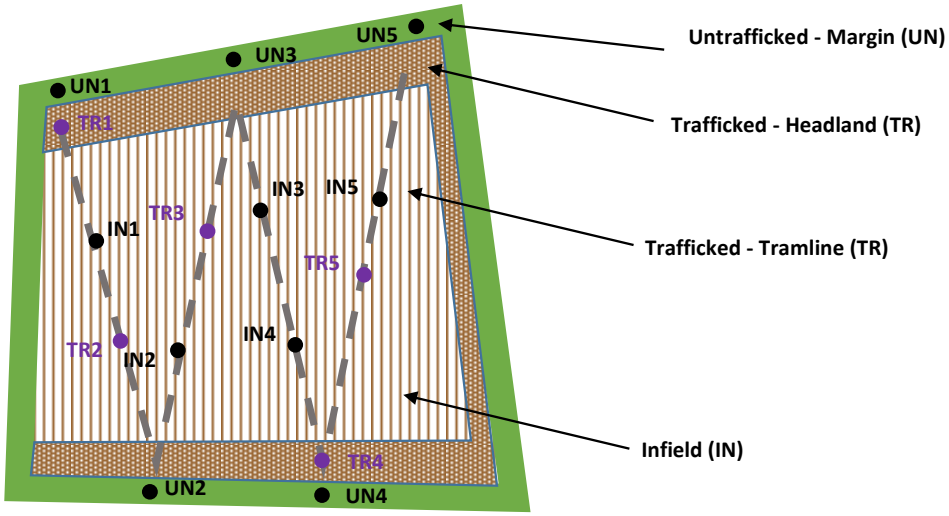
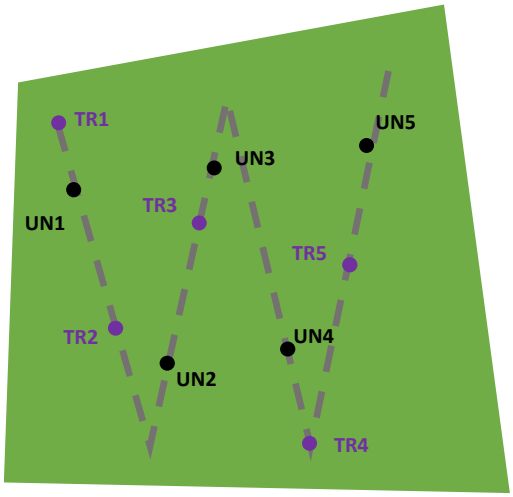
Arable



5 Infield
(1 VESS)
5 Trafficked
(1 VESS)
5 Untrafficked
(1 VESS)

V(olumetric) and A(dditional) samples

Grassland



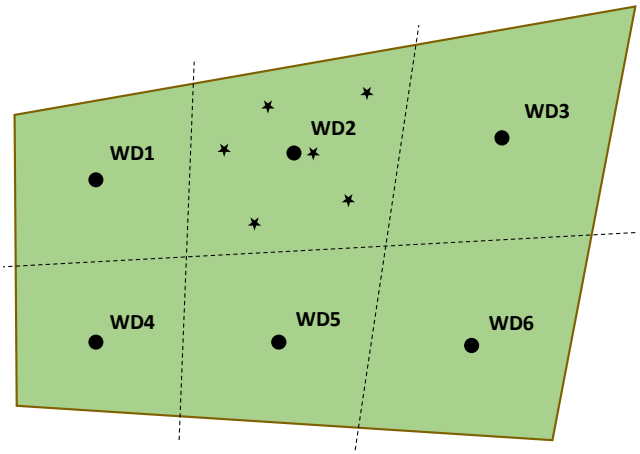
Untrafficked (UN)

5 Trafficked
(1 VESS)
5 Untrafficked
(1 VESS)

Trafficked (TR)

V(olumetric) and A(dditional) samples

Woodland



6 Mineral
(1 VESS)
6 Organic
(if >50 mm)
V(olumetric) samples

A(dditional) samples bulked from 6 locations over each grid cell

LANDWISE Broad-scale Field Survey - Method Summary - Page 2

On-site actions (pre-sampling)

1. Meet land owner/manager
   a. complete participant consent form (2 copies)
   b. agree field(s)
   c. land management questionnaire (record sheet)
   d. soil sampling demo?
   e. risks?
   f. access routes

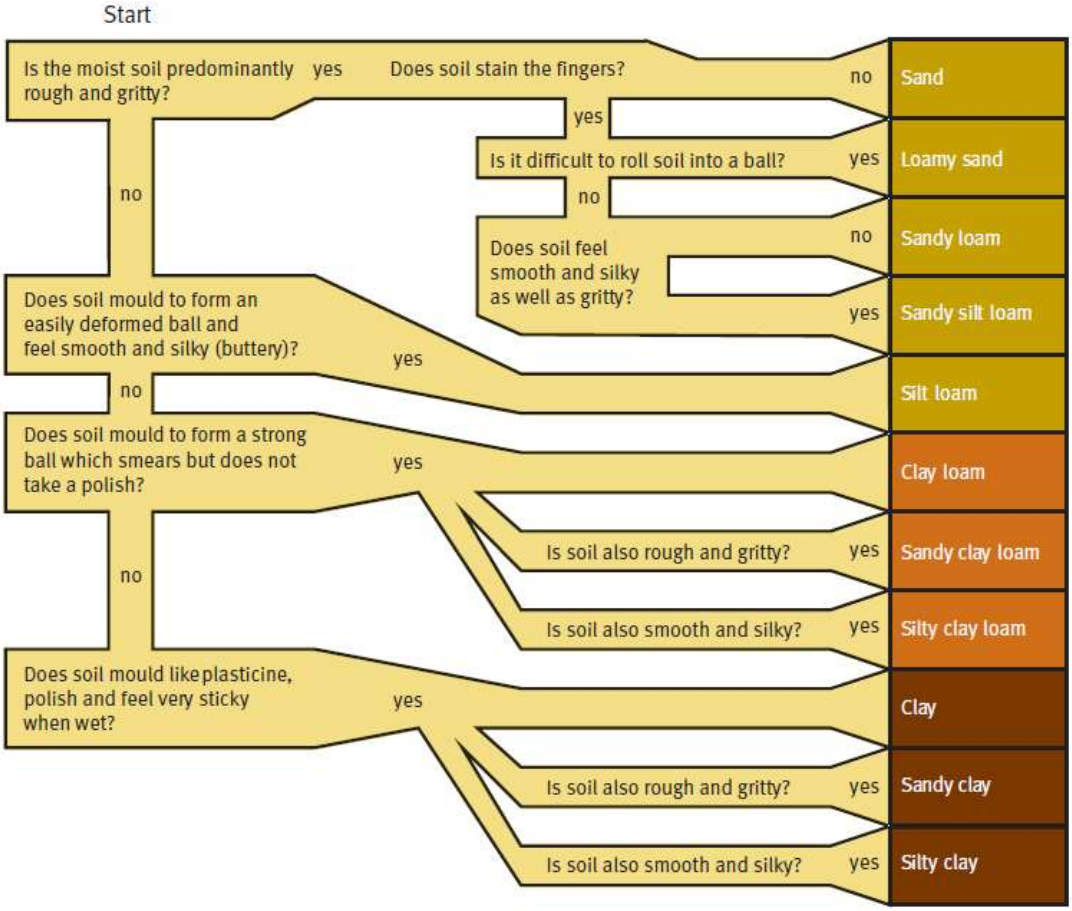
On-site sampling procedure

1. Photos:
   a. Field ID card
   b. general, with ID card
2. General observations (record sheet)
3. Plan sampling locations
4. Walk to locations
5. Select **representative** sampling point
6. Photos (incl. survey card in shot):
   a. GPS/phone location
   b. vertical vegetation
   c. close-up vegetation
7. Sampling location info (record sheet)
8. Near-surface 'V'(olumetric) soil sample
   a. fit ring
   b. expose surface
   c. hammer sampler
   d. dig out sampler
   e. remove ring and trim soil (discard & retake bad sample)
   f. label 'V' bag (add date and GMT time): e.g. *UoR Sonning F1 IN4 V Date Time*
   g. bag sample
9. Near-surface 'A'(dditional) sample
   a. dig sample (0-50 mm bgl), similar amount to 'V' sample
   b. label 'A' bag (add date and GMT): e.g. *UoR Sonning F1 IN4 A Date Time*
   c. bag sample
   d. hand texture extra sample
   e. refill hole
10. If VESS location
    a. VESS method sheet (score on record sheet)
    b. photos – before/after break-up
11. Group samples by field
12. Keep samplers reasonably clean
13. Inform land owner/manager when leaving?

Appendix

Identification of soil texture

For practical purposes you can assess soil texture by hand (follow the diagram below). Take about a dessert spoonful of soil. If dry, wet up gradually, kneading thoroughly between finger and thumb until crumbs are broken down. Enough water is needed to hold the soil together and to show its maximum stickiness.



Source: Environment Agency (2007) Think Soils - essentially the same flow chart as DEFRA (2010) Fertiliser Manual RB209 and Natural England (2008) TIN037

The following textural descriptions for each class can help confirm the decision from the flow chart:

Sands do not stain the fingers when wet. They feel gritty, lacking cohesion when wet and are loose when dry. Any water squirted onto the surface quickly disappears and the surface returns to matt.

Loamy sands feel gritty but when moist can form a weak fragile ball, but are not sticky. The ball quickly collapses. Unlike sands the surface will retain a glistening wet look when water is applied.

Sandy loams feel gritty, but easily mould to form an easily deformed ball. Rolling causes the soil to break into short threads. The wet soil is slightly sticky, unlike loamy sands.

Sandy silt loams when moist mould more easily than sandy loams because of the silt content. They feel equally gritty and soapy. The wet soil clings to fingers.

Identification by hand texturing

Clays mould to form durable balls, which are difficult to deform. The soil smears to give a polished surface. The soil can be rolled into long threads provided it is sufficiently moist. Wet clays are very sticky but do not adhere to fingers. They do not feel smooth and soapy.

Sandy clays bind together strongly. Deformation of a ball is difficult. Sand is obvious on the smeared surface. When wet it is very sticky.

Silty clays are similar to clays but feel smoother and more buttery when moist. They adhere to the fingers and are very sticky.

The feel of the soil when rubbed between the thumb and finger is affected, not only by the proportion of clay, silt, sand and organic matter, but also by the composition of the fractions, for example, some soils rich in clay-size calcium carbonate (chalk) or 'free' iron oxides, with clay fractions of unusual mineralogy, or with abnormal amounts of exchangeable sodium. Allowance must be made for these factors when texturing.

Laboratory analysis

If laboratory assessment is required then Particle Size Distribution of the sample should be requested. A value for organic matter content may also be desirable. Different laboratories may provide slightly different results depending on the method used. Results will usually be provided as a percentage of each particle size. Sand and silt are often subdivided and the values will have to be added to obtain a single value for sand, silt and clay. The values can then be plotted onto the texture triangle in Figure 1.

Texture groups

For agricultural purposes individual soil texture classes with similar properties are grouped. Texture groups are relevant to farm operations such as ease of cultivation or susceptibility to soil damage by grazing livestock. Current Defra publications on soil management and erosion use a simplified texture triangle with three groupings, sandy and light silty, medium and heavy (Figure 3). These are grouped by soil texture of mineral soils (ie less than 6% organic matter).

Source: Natural England (2008) TIN037

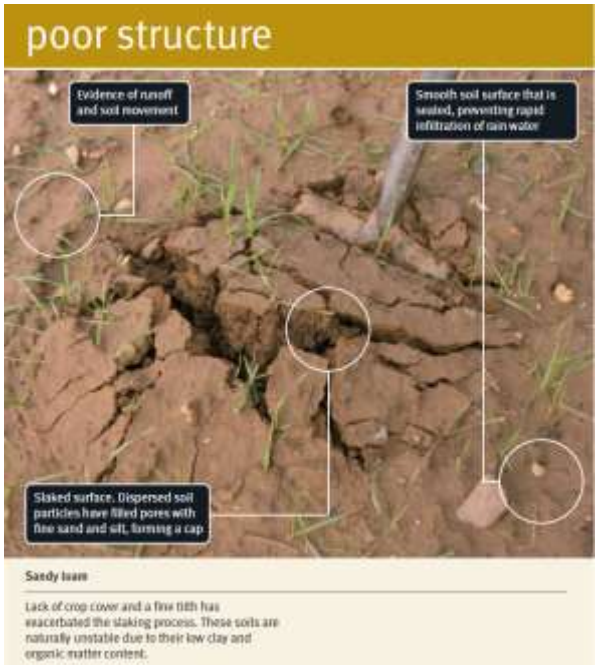
Table 3 Estimating calcium carbonate content

Field description & $CaCO_3$ class limits	Typical effects of HCl application at known $CACO_3$ contents		
	Audible (held close to ear)	Visible	% $CaCO_3$
Non-calcareous (Less than 0.5%)	None	None	0.1
Very slightly calcareous (0.5-1%)	Faintly increasing to slightly audible	None	0.5
Slightly calcareous (1-5%)	Faintly increasing to moderately audible	Slight effervescence confined to individual grains, just visible	1.0
	Moderately to distinctly audible heard away from ear	Slightly more general effervescence visible on closer inspection	2.0
Moderately calcareous (5-10%)	Easily audible	Moderate effervescence; obvious bubbles up to 3mm diameter	5.0
Very calcareous (more than 10%)	Easily audible	General strong effervescence; ubiquitous bubbles up to 7mm diameter; easily seen	10.0

Source: Natural England (2008) TIN037

Example soil surface condition photos - from Environment Agency (2007) Think Soils Manual

Sandy Loam (light soil)



Clay Loam (medium soil)

Clay (heavy soil)

Silty Clay Loam (calcareous)