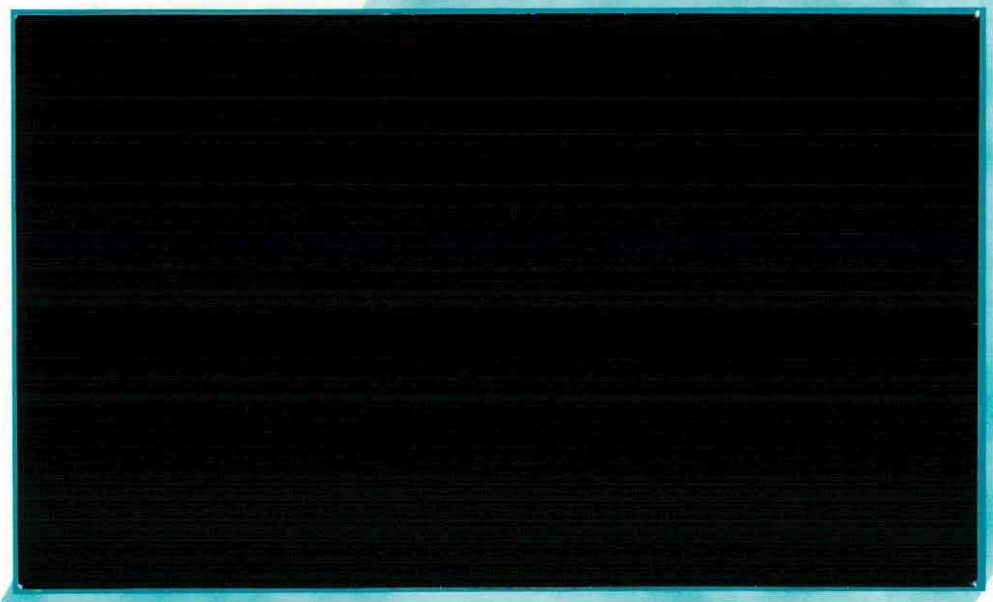
Institute of Terrestrial Ecology



Centre for Ecology & Hydrology

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ITE has six Research Stations throughout Britain, which allows the efficient use of resources for regional studies and provides an understanding of local ecological and land use characteristics. The Institute's administrative headquarters is at Monks Wood.

ITE sites

Monks Wood
(Admin HQ)
Abbots Ripton
HUNTINGDON PE17 2LS
Telephone 01487 773381-8
Fax 01487 773467
Email MONKSWOOD@ITE.AC.UK

Merlewood Research Station
GRANGE-OVER-SANDS
Cumbria LA11 6JU
Telephone 015395 32264
Fax 015395 34705
Email MERLEWOOD@ITE.AC.UK

Edinburgh Research Station
Bush Estate
PENICUIK
Midlothian EH26 0QB
Telephone 0131 445 4343
Fax 0131 445 3943
Email BUSH@ITE.AC.UK

Furzebrook Research Station
WAREHAM
Dorset BH20 5AS
Telephone 01929 551518-9, 551491
Fax 01929 551087
Email FURZEBROOK@ITE.AC.UK

Banchory Research Station
Hill of Brathens
Glassel, BANCHORY
Kincardineshire AB31 4BY
Telephone 01330 823434
Fax 01330 823303
Email BANCHORY@ITE.AC.UK

Bangor Research Unit
University of Wales, Bangor
Deiniol Road
BANGOR, Gwynedd LL57 2UP
Telephone 01248 370045
Fax 01248 355365
Email BANGOR@ITE.AC.UK

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Project No. T01069a5 Contract No. CR0212

INSTITUTE OF TERRESTRIAL ECOLOGY

MASQ: MONITORING AND ASSESSING SOIL QUALITY

First Quarterly Report To
Department of Environment, Transport
And the Regions
April 1998 - July 1998

Helaina Black
Soil Ecology Section
ITE Merlewood
Windermere Road
Grange-over-Sands
CUMBRIA LA11 6JU

25th September 1998

Background

The Royal Commission on Environmental Pollution on Soil Sustainability (1996) identified the development of indices of soil biological activity and diversity as a key research priority. The major difficulty in developing such indices is the need for baseline data from which a set of standards can be developed. Currently, such a dataset does not exist and requires strategic development; the proposed programme of work is seen as the first major stage in this process. In addition, issues related to the contamination of soil by past, present and future economically valuable activity involving chemical use and disposal, are proving difficult to resolve in the absence of a framework of national information on soil contamination that is related to land use type.

A recent review by ITE (SOILPACS, 1996) has shown that existing data are inadequate to develop bioindicators of soil quality, as the data are poorly structured and inconsistent in methodology and objectives. A nationwide survey is necessary if we are to establish a comprehensive baseline dataset. This task requires considerable logistical commitment, since soil biological sampling is meaningless without additional site information (e.g. land use/land use history, soil type, climatic data, soil chemical data on inorganic and organic soil contaminants).

Countryside Survey 2000 (CS2000) provides a cost-effective framework for integrating a soil biological survey with existing and subsequent soil and land use data. A programme of sampling by the field surveyors operating under CS2000 (a) has been designed which will provide suitable soil material for subsequent laboratory evaluation of faunal diversity and microbiological status. The sampling is targeted to enable field surveyors to re-sample points used in the 1978 survey (ca. 1280 soil samples with data on pH, loss on ignition, basic soil descriptions).

Aims

Soil fauna. Characterisation and quantification of the **meso-fauna** in each one of the CS2000 soil samples by the extraction of returned samples using conventional extraction techniques. The most important groups (collembola, mites) to be identified, where practicable, to species level.

Soil microflora. Assessment of microbial diversity will be assessed in terms of metabolic potential, using the BIOLOG approach for quantifying and assessing the ability of the microbial populations in each soil sample to degrade a variety of simple and complex substrates. This approach is becoming an accepted rapid index for microbial diversity and functional capability.

Soil chemistry

As noted above, some 1280 soil samples were collected during the Countryside Survey 1978 and analysed for pH and loss on ignition. Analysis of the CS 2000 samples for pH and loss on ignition will allow, in combination with the data available from 1978, an evaluation of change in these parameters over the 20 year period between the two surveys. The data from CS2000 will also provide important contextual information for the outputs from the biological studies. Analysis of the full set of CS 2000 samples for heavy metals and for a suite of organic compounds will establish a large and robust national baseline against which future sampling and analytical programmes could be compared. Organic chemical analyses of soils will concentrate on important micro-pollutants such as PCBs, PAHs, and certain persistent organochlorine pesticides. Where possible marker chemicals (single chemicals representative of whole groups) will be used to help constrain analytical costs and increase the resources available for interpretation of the data. Other substances may also be considered for analysis, with organic extracts archived for later work. Some samples will be subjected to more extensive GC-MS investigations, as ITE already has indications of the surprising range of chemicals that may be found in certain UK soils.

Progress

Staff

Three short-term staff were recruited in April 1998. Two staff worked full-time on the preparation of the field equipment and in the setting up of the extraction equipment. The third person was taken on in a part-time capacity to work with Drs Ineson and Black to co-ordinate the purchasing and preparation of the field equipment to be dispatched to CS 2000 Surveyors at each ITE station and in the preparation of the protocols. At the start of the survey in late May, two short-term staff were employed on a six-months basis to work full-time on the processing of samples as they arrived at ITE Merlewood. The part-time person continued to co-ordinate day-to-day project matters and the input of new data onto spreadsheets on a part-time basis.

Field sampling equipment and protocol

In the first two months of this project, there was significant activity in the development, testing and production of sampling protocols for soil faunal and microbial assessments and soil chemical analyses. A two core-size approach was adopted. This would: (i) ensure continuity in sample size, (ii) minise soil disturbance for faunal assessments and (iii) support a consistent sampling protocol.

For soil faunal and microbial samples, two paired samples would be taken using 8 cm long x 4 cm wide plastic cores. After several trials, this core size was identified as the optimum for posting through letter boxes. The elimination of any postal problems was considered a priority since the biota cores needed to be returned to Merlewood as soon as possible. The survey teams could not be expected to be able to get to a post office during opening hours while rural post box entrances are often small!

Cores for soil chemical analyses would be taken at the same location as the soil biota cores. These, however, had to be comparable with soil samples taken in 1978. A plastic core of 15 cm x 5 cm was identified as the most appropriate. These cores would be stored at each ITE station and collected at regular intervals by ITE staff.

The sampling equipment and protocols to be used by the CS2000 surveyors were tested at both Merlewood and at the ECN site at Moorhouse by ECN staff. The final

protocol was incorporated in the CS2000 sampling handbook in early May. Dr Ineson demonstrated the protocol to the CS2000 surveyors at the CS2000 Training Course on the 22nd of May at the Crooklands Hotel, Cumbria.

From April to May 22nd, several people worked on the preparation of the field sampling kit for each survey team (30 in total) and each Station Co-ordinator (6). Each survey team kit consisted of all sampling items additional to those already in the CS2000 field kit (e.g. cool box, knife, labels, pens) and a copy of all sampling protocols. Each Co-ordinator was issued with complete sampling packs for all squares to be sampled in their area. Each pack contained stamped addressed envelopes, to ITE Merlewood, for each X plot (sampling location) which contained two white cores plus plastic stoppers in labelled plastic bags, one each for faunal and microbial samples, and a black plastic core for the soil chemistry sample. During April and May, over 1000 m of plastic pipe were cut to size!

Sample processing and protocols

Laboratory space

A large external storage building at Merlewood was renovated to provide the necessary space for processing, extracting and storing the large number of soil samples expected from CS2000. This required a substantial amount of work to up-grade the electricity supply and install suitable benching and storage facilities for a large number of preserved specimens. This laboratory area is currently dedicated to the processing of MASQ samples.

Soil faunal extraction equipment

Tullgren funnels (72 in 6 x 12 banks) were purchased from Burkhard Scientific who produced them as a special order for Merlewood to ensure that the equipment was ready for the survey start date. These funnels are now housed in the dedicated laboratory and used in the dry extraction of soil mesofauna. Standard dry extraction protocols were tested in May 1998 and modified to ensure optimum extraction efficiency from each core.

The majority of equipment for the extraction and storage of faunal samples was

purchased during April and May 1998. This included 2000 x 100 ml vials, 50 x storage trays, 2000 x labels, 200 x 25 W light bulbs, 2000 plastic bags, latex gloves, dust masks, insect proof door netting etc.

Soil Microbial Cores

A processing and storage protocol was developed and tested in May 1998 along with the soil faunal protocols; these two cores should arrive at Merlewood at the same time (see Appendix). A minus 87°C freezer was purchased for the storage of CS2000 soil cores for microbial assessments.

Soil Chemistry Cores

A protocol for processing the soil chemistry cores as they arrive at Merlewood was developed and tested in May 1998. The soil chemistry samples are processed to allow wet and dry pH to be assessed, loss-on-ignition to be determined and the remaining sample to be stored for future chemical analyses. Additional facilities and laboratory space for processing, mainly for drying and sieving samples, were identified in May 1998. All necessary equipment was purchased, including two pH electrodes for accurate and consistent pH readings and a 1.6. kg max. balance for accurate determinations of core weights.

Sample monitoring and recording

A working practice was established using two recording systems. The first system is used to log-in all the soil biota samples, monitor the processing of these samples and identify storage details. The second system is used to log-in all the soil chemistry cores and again monitor processing progress up to storage. Record sheets are up-dated every day by the staff processing the samples and the data are transferred to spreadsheets at regular intervals.

Deliverables/outputs

1. Table 1 indicates the number of samples received and processed for soil biota (the number is the same for both the for fauna and microbial assessments) and chemistry in each month.

Table 1 Cores received to date (31 Aug 1998)

Month	Biota cores	Chemistry
June	244	65
July	239	156
August	218	148
TOTAL	717	369

2. Protocols for sampling soils for biotic and chemical analyses as part of CS2000 incorporated into the CS2000 field handbook and protocols for processing, extracting and storing soils for biotic and chemical analyses have been produced. See Appendix for copies.

3. The wet pH has been determined on all soil chemical samples in Table 1. and 50% of the data have been entered on an EXCEL spreadsheet. Dry pH has been determined in over 50% of these samples.

4. Over 75% of the soil chemistry cores in Table 1 have been air-dried, sieved through a 5 mm sieve and stored in plastic pots for further analyses.

5. Soil fauna have been extracted from all faunal soil cores in Table 1 and a stored in 70% ethanol for identification.

6. All microbial cores in Table 1 have been frozen.

APPENDIX A:

CS2000 MONITORING AND ASSESSING SOIL QUALITY

Soil Sampling Protocols

Appendix A

CS2000 MONITORING AND ASSESSING SOIL QUALITY

Soil Sampling protocols

Soil Ecology Section, ITE Merlewood

BACKGROUND

The Royal Commission on Environmental Pollution report on soil sustainability stressed the need for the assessment and monitoring of soil quality and identified the development of indices of soil biological activity and diversity as a key research priority. The major difficulty in developing such indices is the need for baseline data from which a set of standards can be developed. Such a dataset requires strategic development and the proposed programme of work is seen as the first major step in this process. CS2000 will provide a national, spatially referenced set of soil samples which will be collected from the same squares used in the 1978 survey which provide a representative number of samples from each ITE Land Class and Land Cover type.

In each of these squares, five replicate samples will be taken for soil chemistry analyses (pH, loss on ignition and heavy metal concentrations), soil fauna diversity assessments (using Tullgren funnels) and soil microbiological status (using BIOLOG GN plates). These samples will be sent to ITE Merlewood where they will be processed and stored for subsequent analyses.

It is important that the two shortest pipes (for soil fauna diversity assessments and soil microbiological status) are processed as quickly as possible as they have a relatively short "shelf-life". To enable this, these two samples will be sent by First Class post while the longest pipe (soil chemistry) sample will be collected from field teams by each regional coordinator from whom Soil Ecology staff at Merlewood will collect by car.

EQUIPMENT DISTRIBUTION

All items marked with an asterisk (*) in the list are distributed to each team by the regional coordinators. Items marked with a flower (✿) are distributed to each team in an order corresponding to the allocation of squares amongst the field teams. All the other items are part of the standard equipment provided by CS2000.

EQUIPMENT

* Cool box (to be kept in boot of car)

* Trowel

* Long blade knife

Measuring tape

Hammer

Aluminium plate

✿ Large plastic bag labelled with corresponding ITE square number with the following inside each bag:

- 5 padded stamped addressed (SAE) envelopes, addressed to ITE Merlewood, with square and 'X' plot number in left hand bottom corner, *with the following inside each envelope*
- 1 sealable plastic bag with 1 long black pipe (15 cm long x 5 cm diameter) inside
- 2 sealable plastic bags each with 1 short white pipe (8 cm long x 4 cm diameter) and 2 white plastic end caps

Envelopes and bags are numbered according to the ITE square and x plot numbers

* One large plastic bag containing spare envelopes, bags and pipes

SAMPLING PROCEDURE

Three soil samples will be taken using one **black** pipe (15 cm length x 5 cm diameter) and two **white** pipes (8 cm length pipes x 4 cm diameter) at approx. 15 cm N of the north corner of the centre quadrat in each X-plot of every square. Sampling procedures for each pipe type are detailed below. The two white pipes, capped and in sealed plastic bags, should be posted to ITE Merlewood as soon as

possible in the SAEs provided. After sampling, the larger black pipes in plastic bags should, ideally, be kept in a cardboard box in the boot of a car until collected by the regional coordinators. If there are problems with taking any of the soil samples or wish to make any specific comment on the sampling then please put a written note in the envelope (e.g. *"large tree roots - 1st soil core taken 1 m N of centre quadrat"*).

DETAILED SAMPLING PROCEDURE

At the centre quadrat in each X-plot

1. Locate the North corner of the centre quadrat.

2. Locate the spot 15 cm north of this corner (USEFUL TIP = use the black core for distance as it is 15 cm long) and mark the spot. Move vegetation, as required, to gain access to the soil surface. If the vegetation and/or roots are too dense then move the sampling point to the nearest convenient point. Write this location on a note and put the note in the plastic bag along with the pipe.

3. Take the **first** soil sample at this point using the long black pipe and the following steps :-

✷ Take the black pipe out of the envelope and remove from the plastic bag

✷ Hold the pipe upright on the soil surface

✷ Using the knife around the bottom edge of the pipe, cut vertically down into the soil and through any roots to a depth of more than 5 cm

✷ Push pipe into the soil until it stands upright

✷ Place an aluminium plate on the top of the pipe and hold onto one corner of the plate

✷ Using the claw hammer firmly but carefully drive the pipe into the soil until the aluminium plate is level with the soil surface; if you are doing this in pairs then one person can hold the corner of the plate while the other hammers the plate from the opposite corner - please be careful not to hammer fingers or heads !!!

✷ Use the trowel to remove the pipe from the soil, being careful not to lose soil from the bottom or top of the pipe (especially in sandy soils)

✷ Scrape any lumps of soil from the exterior of the pipe using the knife

✷ Place into the bag and seal

✷ Store this sample in a cardboard box the boot of the car until it is collected by your regional coordinator

4. At 15 cm to the East of the first soil sample, take the **second** soil sample using one of the short white pipes (8 cm long x 4 cm diameter).

✷ Take one of the white pipes from the envelope and remove from the plastic bag

✷ Move vegetation, as required, to gain access to the soil surface

✷ Hold the pipe upright on the soil surface

✷ Using the knife around the bottom edge of the pipe, cut vertically into the soil and through any roots to a depth of more than 5 cm

✷ Push pipe into soil until it stands upright

✷ Place an aluminium plate on the top of the pipe and hold onto one corner of the plate

✷ Using the claw hammer, carefully drive the pipe into the soil until the aluminium plate is level with the soil surface; again, if you are doing this in pairs then one person can hold the corner of the plate while the other hammers the plate from the opposite corner.

✷ Use the trowel to remove the pipe from the soil, being careful not to lose soil from the bottom or top of the pipe (especially in sandy soils)

✷ Scrape any lumps of soil from the exterior of the pipe using the knife

✷ Remove any stones and soil which protrude from the bottom end of the pipe.

✷ Push the white caps into each end of the pipe

✷ Place the pipe into the bag and seal

✷ Place the bag into the envelope with the pipe **lengthways** across the bottom of the envelope. <u>This is important as it allows the package to fit into a post box !!!</u>

5. At 15 cm to the West of the first soil sample, take the **third** and final soil sample using the second white pipe, using the same method as in 4 above.

6. Seal the envelope with the two capped and bagged white pipes inside.

7. When back at the car, store the envelope in the cool box and the black core in a cardboard box.

8. At the first opportunity, post the envelope into a post box or at a post office.

9. Repeat for each centre quadrat in each X-plot (giving a total of five soil sampling locations in each square).

APPENDIX B:

Flow chart/instructions used by

Staff assembling sampling kits

1385 pieces of black pipe @ 15 cm length

2770 pieces of black pipe @ 15 cm length

316 SAE envelopes + labels +stamps (£1.)

1565 self-seal plastic bags

286 large plastic bags

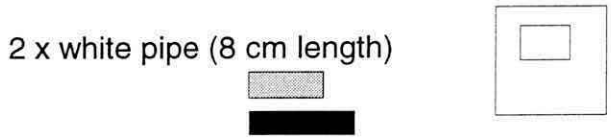
32 cool boxes

35 trowels

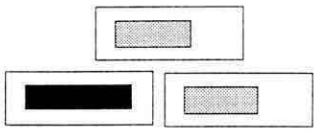
35 long blade knives

35 large roll of extra strong tin foil

plastic bag labelled by permanent marker pen with square/x-plot

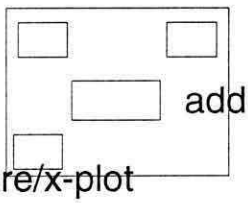


pipes into individual bags

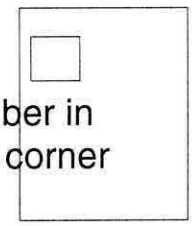


pipes into envelope

SAE envelope



envelopes for each x-plot (1 - 5) into plastic bag



large plastic bag stapled closed at top

large plastic bags for relevant squares (see excel sheet)

10 plastic bags
2 SAE envelopes
4 white pipes
4 black pipes

place into large plastic bag

trowel
roll of tin foil
knife

large plastic bag

one per cool box

one per cool box

COOL BOX

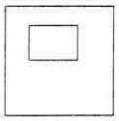
one for each team

to each regional coordinator on friday 18th May at Crooklands Hotel = a total of 30 teams

Bush = 4 teams; Banchory = 5 teams; Merlewood = 6 teams; Monkswood = 5 teams; Bangor = 5 teams; Furzebrook = 5 teams

LABELLING

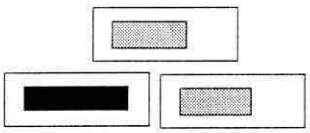
plastic bag labelled by permanent marker pen with square/x-plot



2 x white pipe (8 cm length)

1 x black pipe (15 cm length)

pipes into individual bags



pipes into envelope

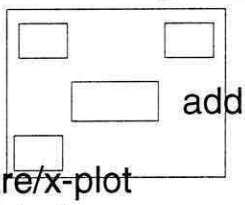
SAE envelope

soils info label

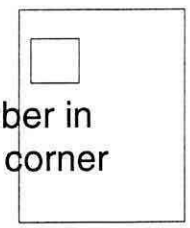
£1. stamps

address label

square/x-plot label



envelopes for each x-plot (1 - 5) into plastic bag



square number in top left hand corner

large plastic bag stapled closed at top

large plastic bags for relevant squares (see excel sheet) in one carboard box for each regional coordinator by Friday 22nd May

Bush
Banchory
Merlewood
Monkswood
Bangor
Furzebrook

3 small self seal plastic bags labelled with the same square and x-plot numbers in middle white line

SAE envelopes as shown one labelled for each sqaure and x--plot

1 large plastic bag labelled for with each square number

1 large box (in abstracts room) labelled with region.

10 plastic bags
2 SAE envelopes
4 white pipes
4 black pipes
4 white caps

place into large plastic bag

trowel
roll of tin foil
knife

large plastic bag

one per cool box

one per cool box

COOL BOX

one for each team

to each regional coordinator
on friday 22nd May at
Crooklands Hotel
= a total of 30 teams

Bush = 4 teams
Banchory = 5 teams
Merlewood = 6 teams
Monkswood = 5 teams
Bangor = 5 teams
Furzebrook = 5 teams

APPENDIX C:

Flow chart/instructions used by

Staff handling biological core samples

Following receipt at Merlewood

CS2000 POSTED CORES

check box in reception for core envelopes after each post delivery (usually 8 am and 4 pm)

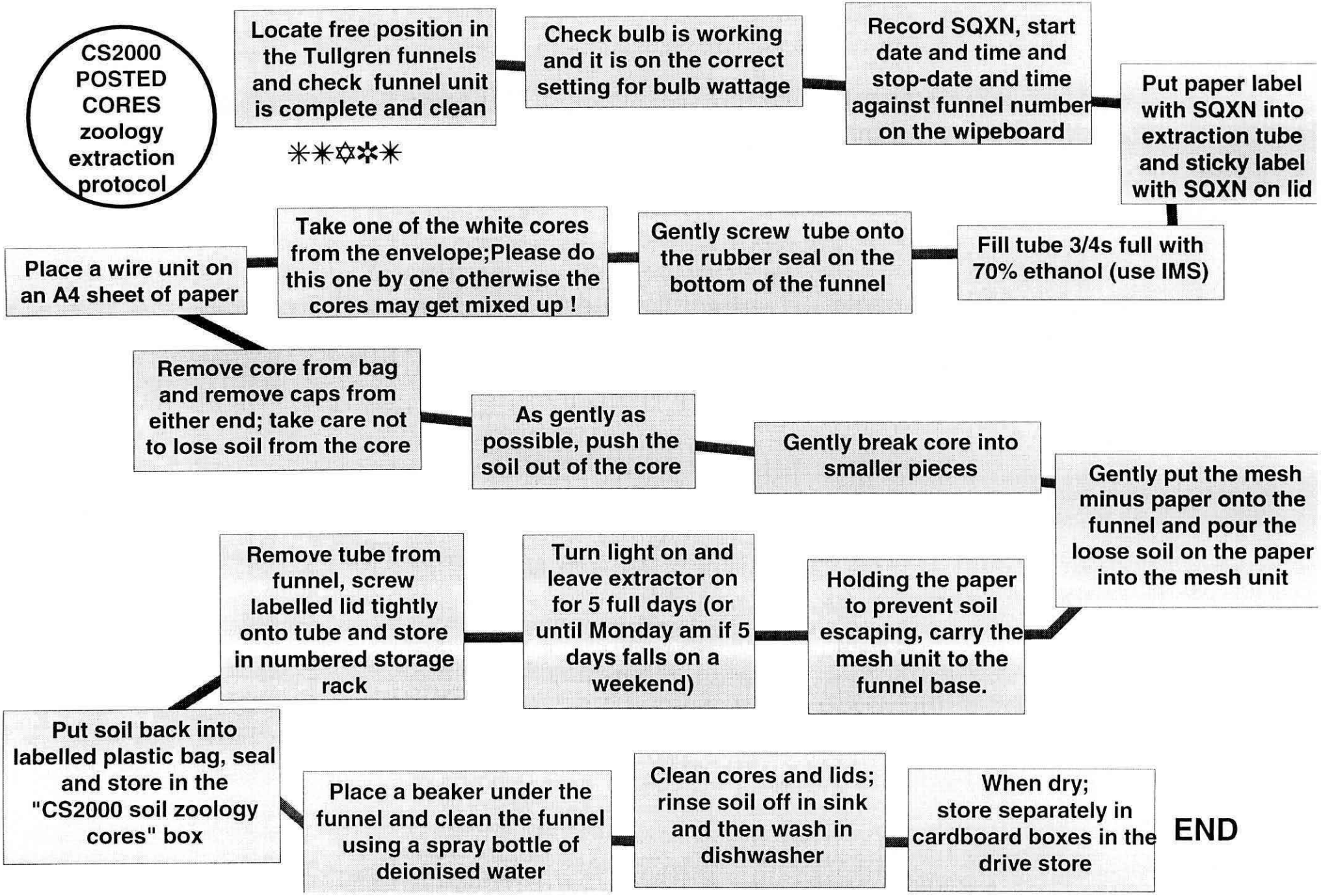
take envelopes to drive store for processing

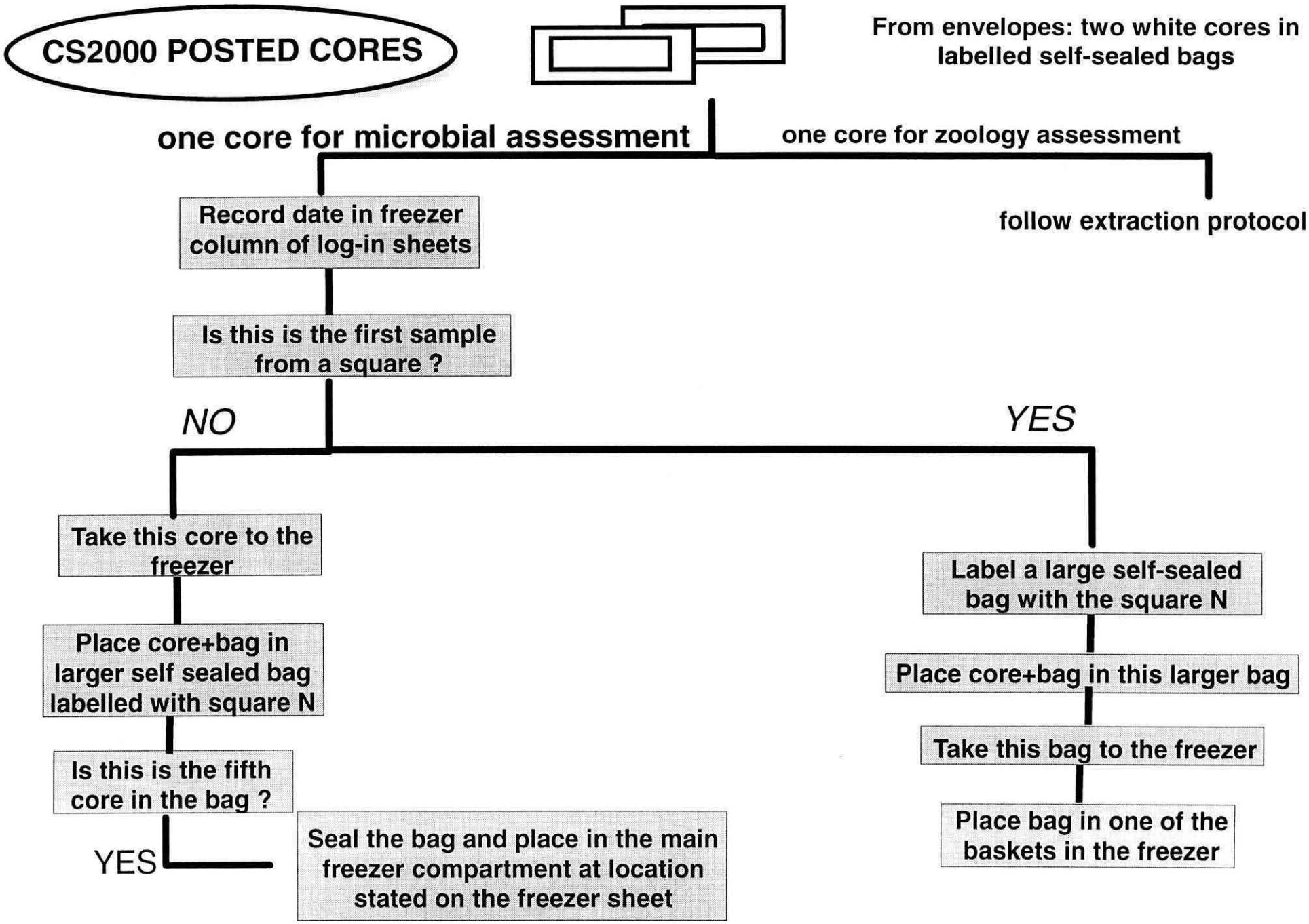
record date of arrival and, if visible, post mark date and/or written date on envelope on the log-in sheets

remove cores from envelopes

check for written comments in or on the envelope. Copy comments to limerick file (T:\HBL\CS2000\limer.doc)

Each day record todays arrivals - envelope numbers - and any notes - in the processing diary


CS2000 POSTED CORES zoology extraction protocol
Locate free position in the Tullgren funnels and check funnel unit is complete and clean
Check bulb is working and it is on the correct setting for bulb wattage
Record SQXN, start date and time and stop-date and time against funnel number on the wipeboard
Put paper label with SQXN into extraction tube and sticky label with SQXN on lid
Fill tube 3/4s full with 70% ethanol (use IMS)
Gently screw tube onto the rubber seal on the bottom of the funnel
Take one of the white cores from the envelope;Please do this one by one otherwise the cores may get mixed up !
Place a wire unit on an A4 sheet of paper
Remove core from bag and remove caps from either end; take care not to lose soil from the core
As gently as possible, push the soil out of the core
Gently break core into smaller pieces
Gently put the mesh minus paper onto the funnel and pour the loose soil on the paper into the mesh unit
Holding the paper to prevent soil escaping, carry the mesh unit to the funnel base.
Turn light on and leave extractor on for 5 full days (or until Monday am if 5 days falls on a weekend)
Remove tube from funnel, screw labelled lid tightly onto tube and store in numbered storage rack
Put soil back into labelled plastic bag, seal and store in the "CS2000 soil zoology cores" box
Place a beaker under the funnel and clean the funnel using a spray bottle of deionised water
Clean cores and lids; rinse soil off in sink and then wash in dishwasher
When dry; store separately in cardboard boxes in the drive store
END

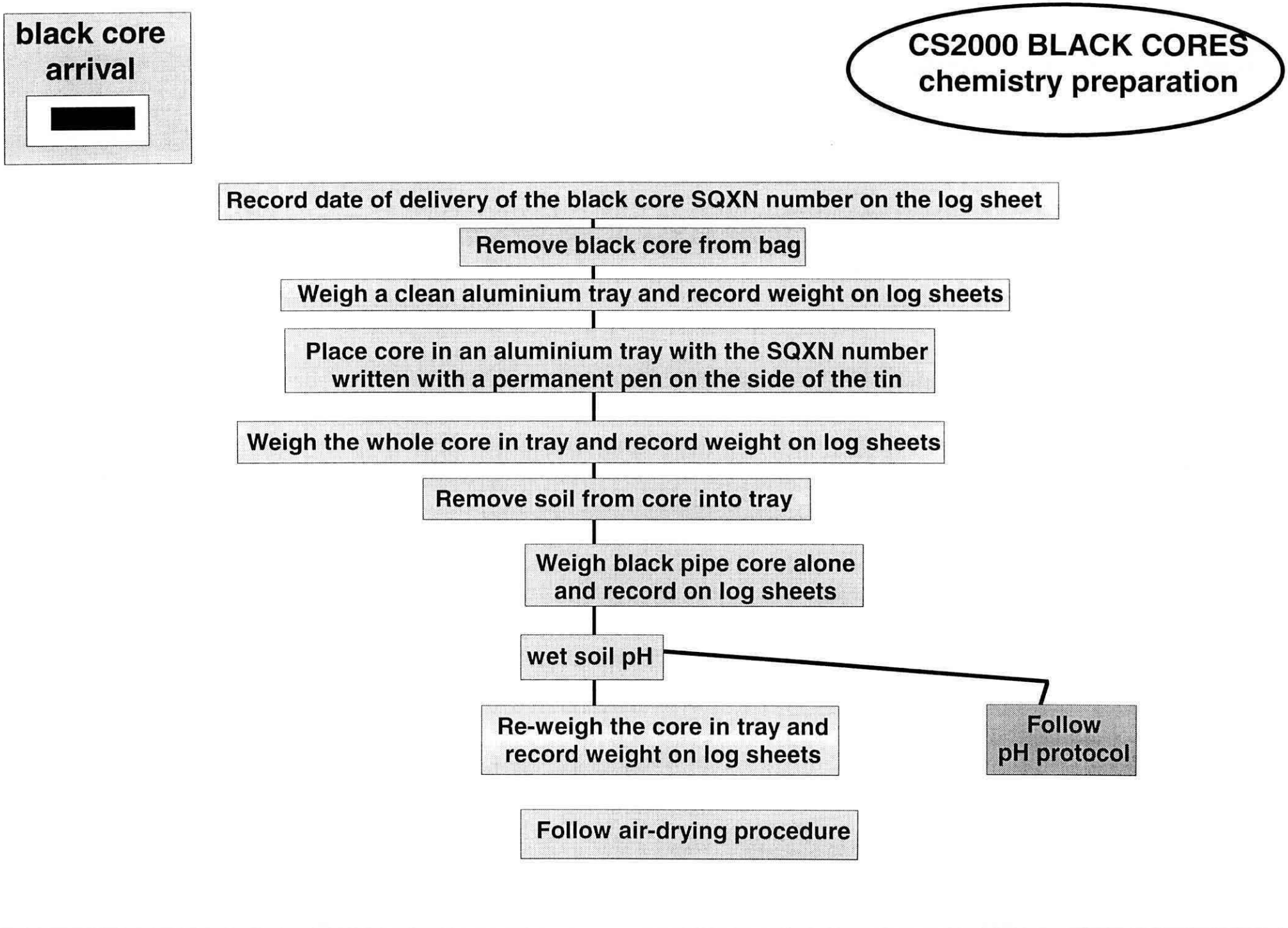

CS2000 POSTED CORES
From envelopes: two white cores in labelled self-sealed bags
one core for microbial assessment
one core for zoology assessment
follow extraction protocol
Record date in freezer column of log-in sheets
Is this is the first sample from a square ?
NO
YES
Take this core to the freezer
Place core+bag in larger self sealed bag labelled with square N
Is this is the fifth core in the bag ?
YES
Seal the bag and place in the main freezer compartment at location stated on the freezer sheet
Label a large self-sealed bag with the square N
Place core+bag in this larger bag
Take this bag to the freezer
Place bag in one of the baskets in the freezer

APPENDIX D:

Flow chart/instructions used by staff handling

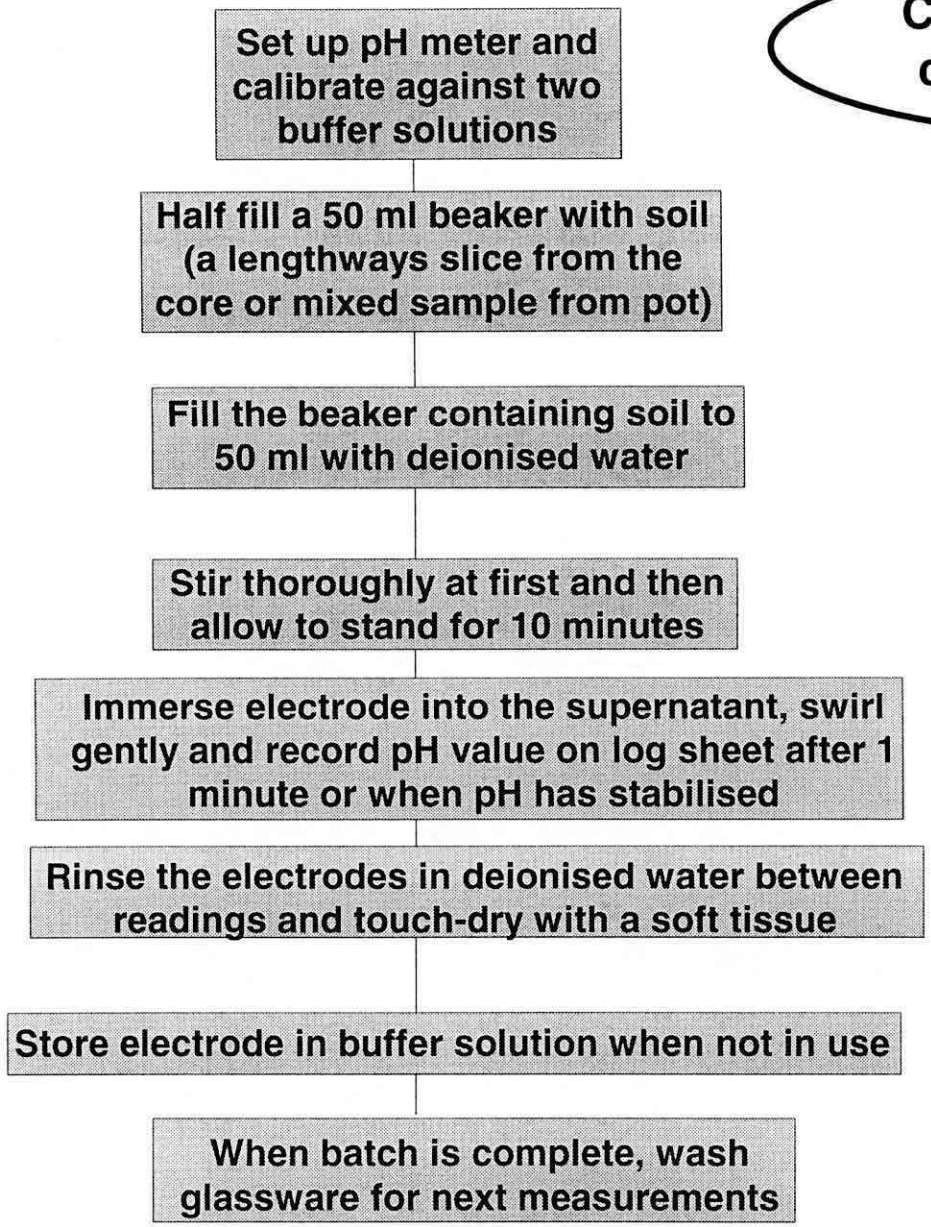
Chemistry core samples following receipt

At Merlewood


black core arrival
CS2000 BLACK CORES chemistry preparation
Record date of delivery of the black core SQXN number on the log sheet
Remove black core from bag
Weigh a clean aluminium tray and record weight on log sheets
Place core in an aluminium tray with the SQXN number written with a permanent pen on the side of the tin
Weigh the whole core in tray and record weight on log sheets
Remove soil from core into tray
Weigh black pipe core alone and record on log sheets
wet soil pH
Re-weigh the core in tray and record weight on log sheets
Follow pH protocol
Follow air-drying procedure

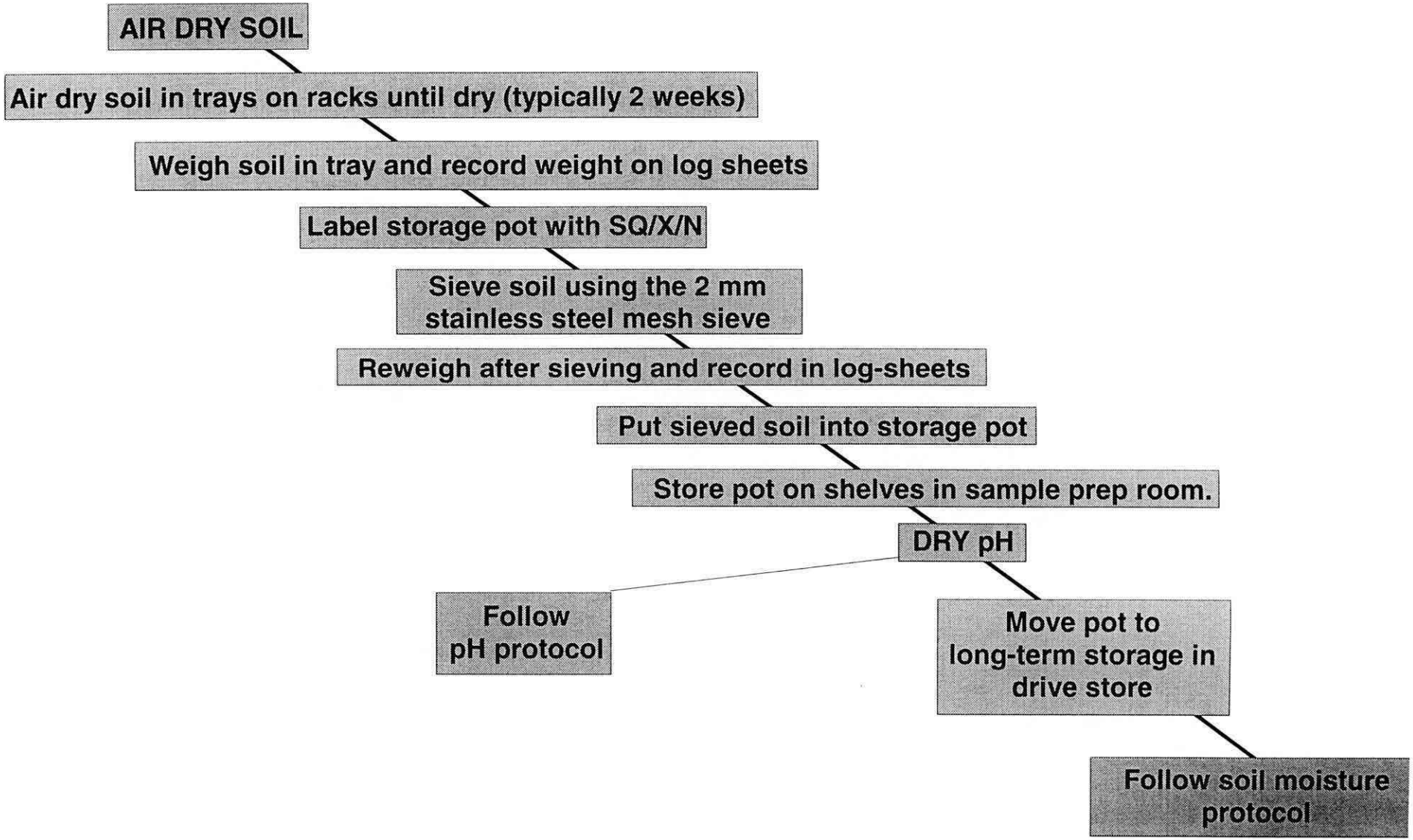
pH protocol

CS2000 BLACK CORES chemistry preparation



AIR DRYING SOIL

CS2000 BLACK CORES chemistry preparation



SOIL MOISTURE PROTOCOL

CS2000 BLACK CORES chemistry preparation

- Identify 50 stored samples for soil moisture analyses
- Set oven at 105oC
- Lable and weigh 50 dry, clean crucibles
- Place 1 g of soil from storage pot into labelled crucible
- Place soil in crucible in oven
- Dry soil to constant weight (3 hrs usually sufficient)
- Cool in a desiccator
- Weight sample and record weight in log-in sheets
- Follow loss-on-ignition protocol

CS2000 BLACK CORES
chemistry preparation

LOSS-ON-IGNITION PROTOCOL

- place moisture sample in a muffle furnace
- Allow temperature to rise slowly to 555oC
- Allow to remain at this temperature for 2 hours
- When cool transfer to a desiccator, cool to room temperature (~ 30 mins)
- Weight sample and record weight in log-in sheets

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