LAND DRAINAGE AND RECLAMATION: A LOCAL STUDY

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> "Of all the improvements in Irish Agriculture, land drainage has one of the highest failure rates" (Mulqueen, 1982).

Introduction There are few ecosystems in which humans do not have either a direct or indirect effect. Man's impact on ecosystem components is greatest on those which are deliberately managed in order to maximise the output of a particular product (Tivy et al, 1981). This paper outlines the findings of a research project, conducted during the winter period of 1987-'88. In this study one particular ecosystem under management in Ireland, that of wet mineral lowland for the production of grass, was assessed.

Management of wet mineral lowland through land drainage and reclamation schemes, alter both the abiotic and biotic components of the soil. The ultimate goal of these schemes is to transform wet mineral lowlands into lands indistinguishable from naturally dry soil. The study focused attention on the abiotic components of the soil, particularly that of water. By measurement of soil moisture content, watertable levels and hydraulic conductivity, the study undertook to evaluate the extent to which man has altered the environment through drainage schemes. Gleeson (1985) underlines that to successfully accomplish this, land drainage design must be sufficient enough to

(i) lower the watertable by means of drains at an appropriate depth and spacing for a given drainage problem and rainfall rate

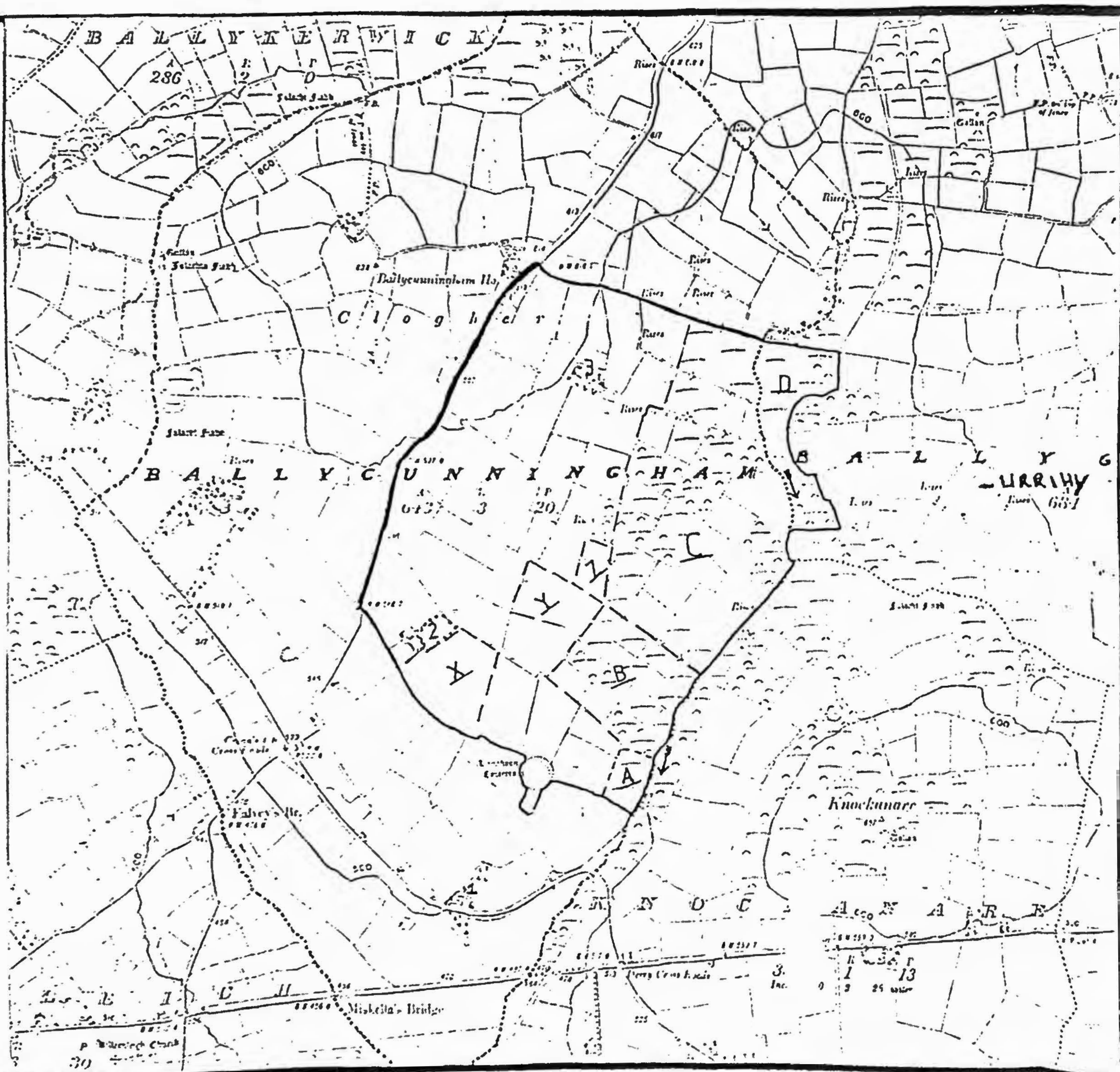
and/or

(ii) employ techniques that improve the hydraulic conductivity or break the impervious layer - (deep subsoiling or ripping).

The Study Area The study area, located is parts of the townlands of Ballycunningham and Ballygurrihy in the barony of East Muskerry, County Cork (Fig. 1).

The solid geology of the region is that of old red sandstone, part of the Armorical trend of east-west ridges of sandstone alternating with limestone valleys in Southern Ireland. The soils of this lowland area consist of brown podzols (60%), with gleys (20%) and acid brown earths (20%). Normally the lands are well drained and endowed with

Figure 1 Location of Sites Study Area



KEY:

Study Area.

Town land Boundary.

River.

Site A — A, Farm — 1

SCALE: 6" to 1 Mile

N

good mineral soils suitable for both grazing and tillage. However, where gleys occur the land is poorly drained and only suitable for rough grazing. The drainage problem associated with these lands is of seepage and springs with a resultant high watertable level.

Division of Study Area To establish the effects that man's activities have had on wet mineral lowland, comparisons between reclaimed, unreclaimed and good mineral soils were required. The study area chosen (Fig. 1), ideally fulfilled the above requirements. Not only were the required land types located within the one area, but also, different drainage methods had been applied to the adjacent reclaimed lands. The study area was subdivided as follows:

(a) 2.78 acres of newly reclaimed land
Site A - situated due east of Souterrain

(b) 15.83 acres of newly reclaimed land
Site B - immediately north from Site A

(c) 54.82 acres of reclaimed land
Site C - adjacent to Site B

(d) 11.14 acres of unreclaimed land
Site D - on eastern side of river in the townland of Ballygurrihy

(e) 8.47 acres of good mineral soil suitable for both grazing and tillage
Site X - adjacent to Farm No. 2

(f) 7.06 acres of good mineral soil classified as suitable for both grazing and tillage
Site Y - west from Site B

(g) 2.21 acres of land suitable for grazing only
Site Z - immediately west from Site C

As sites B and C are adjacent lands, then it is reasonable to assume that the drainage problems experienced by both, prior to drainage, were similar. Added to this, sites A and D, the unreclaimed lands in the study, were taken to be indicative of the former soil conditions. Sites X, Y and Z represented the standards against which the reclaimed lands were measured in order to assess the effectiveness of land drainage and reclamation.

Methods of Drainage Different drainage designs were applied to the reclaimed lands and these ultimately played a major role in the success or failure of land drainage.

Site B Drainage on this 15.85 acre tract of wetland 'bog', commenced in 1984 under the Farm Modernisation Scheme. The land was first surveyed to determine the drainage problem. To aid this survey, test pits were dug to assess ground water flow conditions. Site B, from the survey conducted, was found to require drains sufficiently deep to remove the excess water from the soil and lower the watertable. To accomplish this task detailed specifications were drawn up and these are outlined in Table 1 and Table 2. They are also shown on Figure 2.

The drains varied in length from 35 metres to 80 metres. They were laid at depths ranging from 1.35-2.25 metres using 68mm. plastic piping. To aid infiltration through to the underdrains, a porous fill, in the form of stones, was laid over the piping. These underdrains today converge into one open water course which now occupies the centre of the site. All dykes have been removed and the land reclaimed. Ploughing was to a depth of .5 metres in order to break up the gley soil. Land drainage and reclamation was completed by 1987.

Site C This 54.82 acre site has had a more chequered history. As early as the 1950s the owner carried out his own site investigation and drainage. On commencement of drainage, all dykes were removed and open drains excavated at a depth of 1 metre. These drains occupied the original position of the dykes.

In 1979 this stretch of land was once again drained. Porous plastic pipes were laid into the open drains and covered with permeable fill. Four drainage channels remained open, with two draining around the boundary of the site. To break up the clay soil, and to reclaim the land, ploughing was to a depth of .5 metres. The stages of drainage are outlined in Figure 3.

The difference in drainage design between the reclaimed lands lay in the depth of the open water courses and underdrains. Having outlined the various differences in design, there remains to determine which drainage system has succeeded in its task of lowering the watertable and removing excess water from the soil.

Table 2 SITE B

FARM MODERNIZATION SCHEME

DETAILED SPECIFICATIONS

FIELD NO.	METRIC LENGTH	DESCRIPTION
		FIELD DRAINS:
1/2	225	Construct field drains to a depth of 1.35m using 68mm plastic pipes. Place 100mm porous fill oover pipes.
		DRAIN OUTLETS:
1/2		Construct 7 drain outlets as per general spec.
		PLOUGHING:
1/2	6.37	Plough to a depth of 300mm
1/2		Pick off and haul away all stones, roots etc, resulting from these operations.

Table 1 SITE B

FARM MODERNIZATION SCHEME

DETAILED SPECIFICATIONS

FIELD NO.		METRIC LENGTH	DESCRIPTION		
			WATERCOURSES:		
			Bottom Width	Side Slope	Depth
1	BC	45	.6	2/3	1.8m at B, 1.5m at C
1/2	CDEF	185	.6	2/3	1.5
2	FG	270	.3	2/3	1.5m at F, 2.2m at G
2	GH	55	.3	2/3	2.25m at G, 1.65m at J
2	HJ	45	.3	2/3	1.65m at H, & J
1	BK	320	.3	2/3	1.8
1	KJ	105	.3	2/3	1.8m at K, 1.65m at J
1/2	DL	240	.3	2/3	1.5m at D, 1.8m at L
			CULVERTS:		
1/2 on JK & HJ			Construct 2 Culverts at 5m wide using 300mm concrete pipes, build up ends with stone.		
			SCRUB REMOVAL & LEVELLING:		
1/2		6.37	Uproot and remove all scrub. Level and grade area.		
			FENCE REMOVAL:		
1	NO	55			
	PQ	120			
	RS	55			
	CJ	300	Demolish fences.		
2	EH	285			
	MV	55			
1/2	DJ	270			

Figure 2 Site B – Drainage Specifications

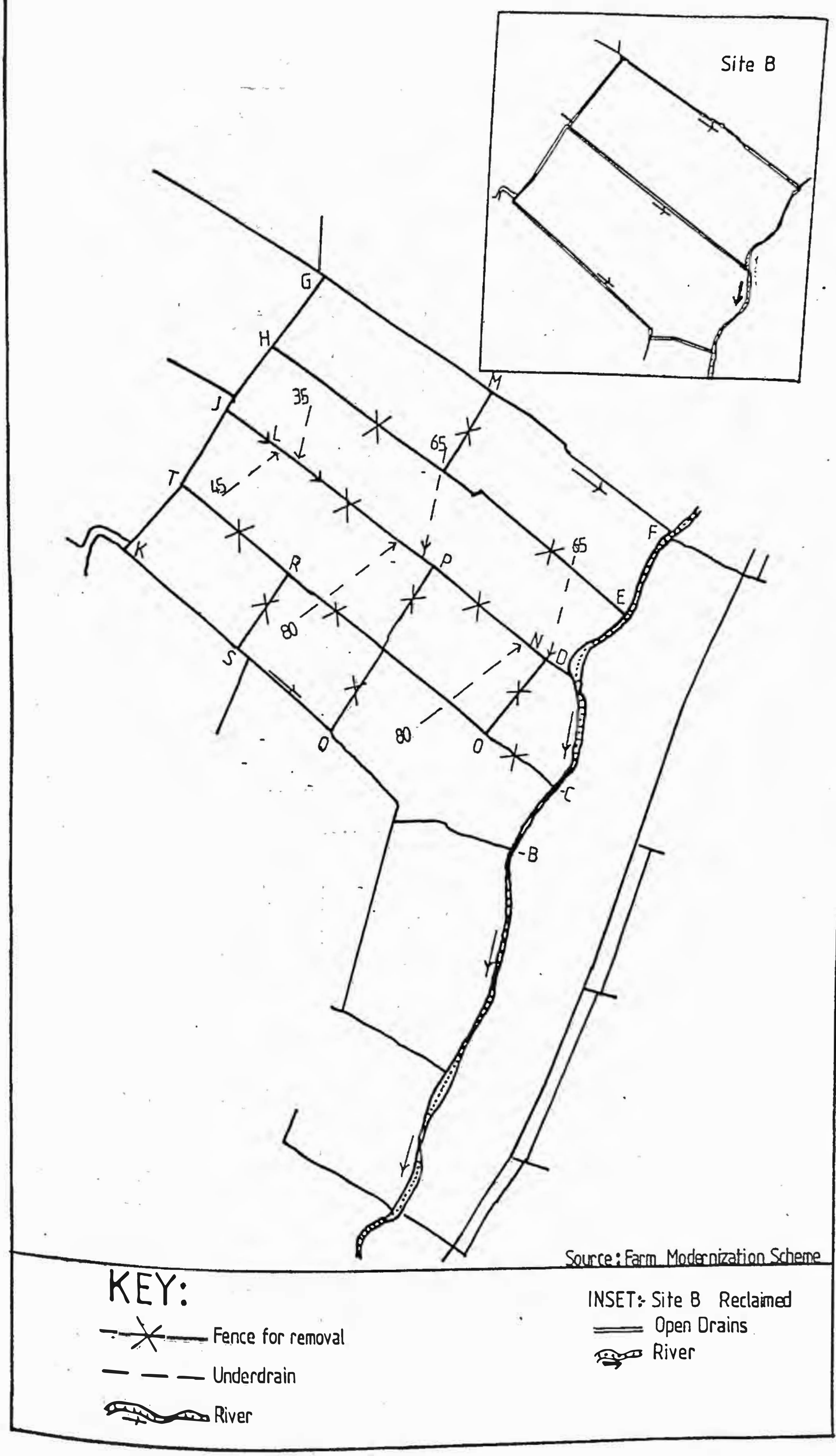
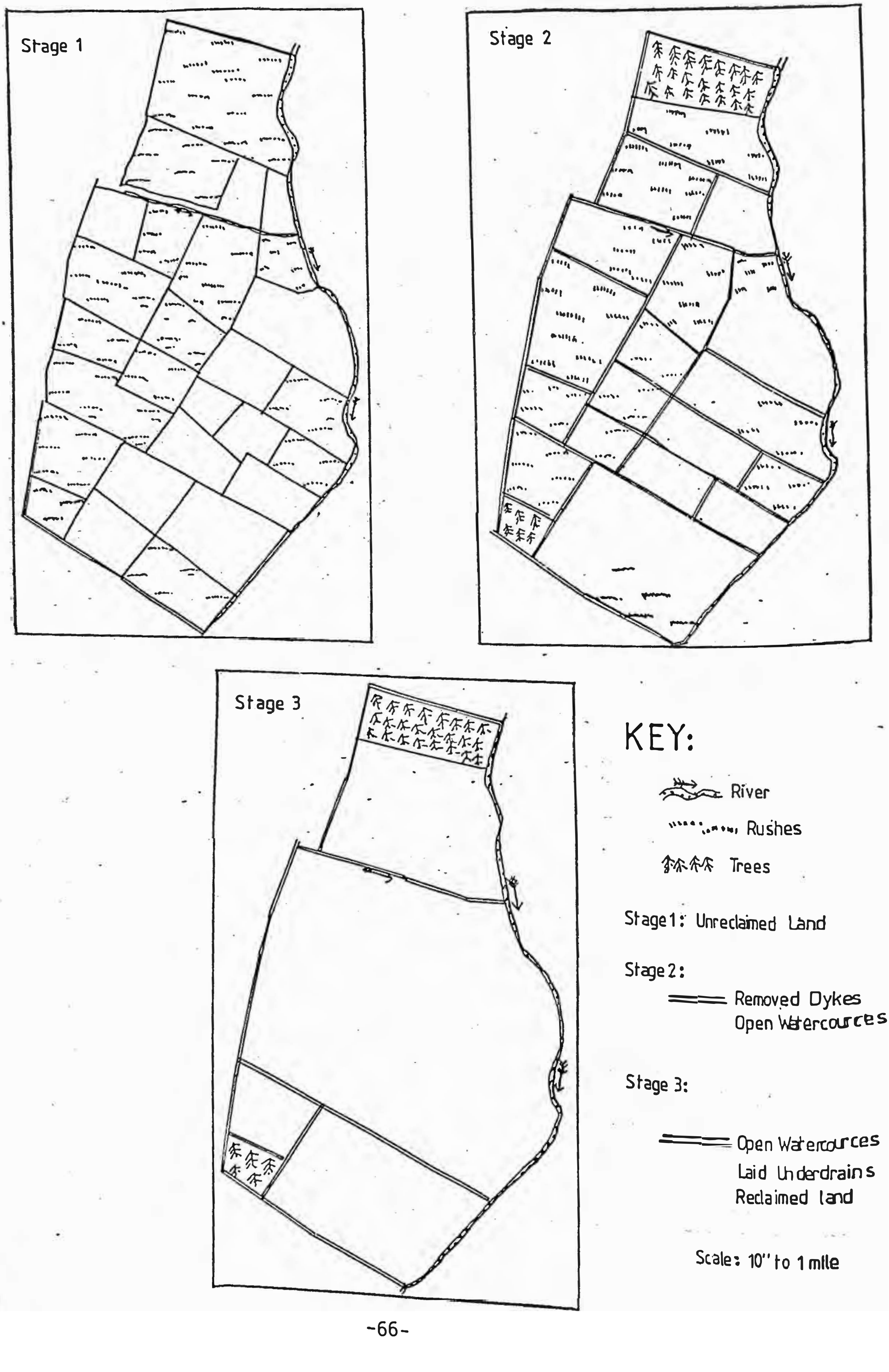


Figure 3 SITE C

Stages of Drainage



Methodology Through the measurement of soil moisture content, watertable levels and hydraulic conductivity, conclusions as to the success of land drainage, were drawn.

Soil Moisture Content While acknowledging the existence of many direct and indirect measurements of soil moisture content (i.e. porous blocks, gravimetric blocks, Neutron Probe, Tensiometers) the method applied in the study was that of oven-drying of field samples with moisture content being expressed as a percentage of dry weight.

Procedures On each of the sites a sampling area, 50 metres by 50 metres was chosen at random, from which all the samples were extracted. Within this chosen fixed area, soil samples were obtained by use of an auger. The following procedure was adopted:

Sampling (a) The auger was first drilled to a depth of 7.5cms. from the surface of the soil, from the base of the auger blade approximately 15g. of soil was carefully removed and placed in a plastic bag. This was sealed to prevent evaporation and contamination. (b) Drilling proceeded to a final depth of .3 metres from the surface. Again, the same procedure for the removal of soil sample was adhered to.

The process was repeated on two randomly chosen positions within the selected sampling area.

Measurement In the laboratory, soil samples collected were individually placed into containers and the weight of the soil was recorded. The containers were then placed in an oven, set at 105°C, and allowed to dry for 24 hours. The dried samples were then removed and their dry weight recorded. Soil moisture was expressed as a percentage of dry weight. The results are outlined on Tables 3 and 4 (see also Fig. 4).

Watertable Level The dipwell method of measurement was used. The instrument of measurement was that of a floating weight attached to a string. The dipwells were constructed at 30cm. and 90cm. from the surface. To comply with uniformity, the dipwells were located within the sampling site area. The dipwells were constructed by placing piping in each of the excavated holes and covering to prevent external water from entering.

Table 3 SOIL MOISTURE CONTENT

DATE:		Nov 17	Nov 24	Dec 8		Dec 22		Jan 11		Feb 16	
Site	Sample	1 ft	1 ft	3"	1 ft	3"	1 ft	3"	1 ft	3"	1 ft
A	1	28.3	18.9	96.6	28.3	168.1	23.1*	100.0	88.9	107.7	82.3
A	2	16.0	20.1	92.3	39.3	101.7	62.8	106.6	42.2*	81.8	27.0*
A	3	25.2	33.3	-	-	97.0	58.3	55.2*	73.1	64.7	145.5
Average %		23.2	24.1	94.5	33.8	122.3	60.5	103.3	81.0	84.7	113.9
Site	Sample	1 ft	1 ft	3"	1 ft	3"	1 ft	3"	1 ft	3"	1 ft
B	1	30.2	36.4	131.6	55.7	54.4	39.4	59.2	52.9	70.9*	32.4
B	2	20.0	23.0	94.3	22.4	59.7	21.6*	60.7	49.7	40.2	31.1
B	3	37.5	26.7	-	-	41.3	41.6	63.1	54.6	37.2	23.3
Average %		29.2	28.7	112.9	39.1	51.8	40.5	61.0	52.4	38.7	28.9
Site	Sample	1 ft	1 ft	3"	1 ft	3"	1 ft	3"	1 ft	3"	1 ft
C	1	32.7	38.1	46.8	93.2	57.0	35.4*	53.5	52.2	42.9	46.8
C	2	32.3	40.3	26.8	75.5	63.3	64.6	78.7	60.9	56.7	35.5
C	3	48.4	23.8	-	-	59.4	61.7	64.3	52.3	42.1	36.7
Average %		37.8	34.1	36.8	84.4	59.9	63.2	65.5	55.1	47.2	39.7

Sample not taken

* Sample result not included for calculations

Table 4 SOIL MOISTURE CONTENT

Date:		Nov 17	Nov 24	Dec 8		Dec 22		Jan 11		Feb 16	
Site	**Sample**	**1 ft**	**1 ft**	**3"**	**1 ft**	**3"**	**1 ft**	**3"**	**1 ft**	**3"**	**1 ft**
X	1	29.6	29.1	39.2	28.7	36.9	32.7	40.1	33.5	42.4	30.9
X	2	32.1	29.2	36.5	30.9	36.6	30.5	37.5	30.9	40.2	45.8
X	3	31.3	21.1	31.1	34.2	40.3	31.4	38.2	31.6	37.7	29.3
Average %		31.0	26.5	35.6	31.0	37.9	31.5	38.6	32.0	40.1	35.3
Site	**Sample**	**1 ft**	**1 ft**	**3"**	**1 ft**	**3"**	**1 ft**	**3"**	**1 ft**	**3"**	**1 ft**
Y	1	34.1	24.7	37.3	29.2	42.3	35.8	41.5	37.8	40.7	33.8
Y	2	30.7	24.0	38.1	28.9	34.9	32.3	39.3	32.1	41.4	44.0
Y	3	23.7	31.3	41.1	30.9	42.2	30.4	38.7	31.5	42.0	52.3*
Average %		29.5	26.7	38.8	29.7	39.8	32.8	39.8	33.8	41.4	38.9
Site	**Sample**	**1 ft**	**1 ft**	**3"**	**1 ft**	**3"**	**1 ft**	**3"**	**1 ft**	**3"**	**1 ft**
Z	1	45.5	29.3	39.8	33.5	50.8	28.2	60.3	60.2	46.5	45.1
Z	2	36.3	34.2	51.3	39.5	58.9	36.5	61.3	51.1	63.9	52.2
Z	3	40.8	37.2	-	-	57.4	27.4	73.7	50.5	62.7	58.1
Average %		40.9	33.6	45.6	36.5	55.7	30.7	65.1	53.9	57.7	51.8

\- Sample not taken

* Sample result not included for calculations

Figure 4

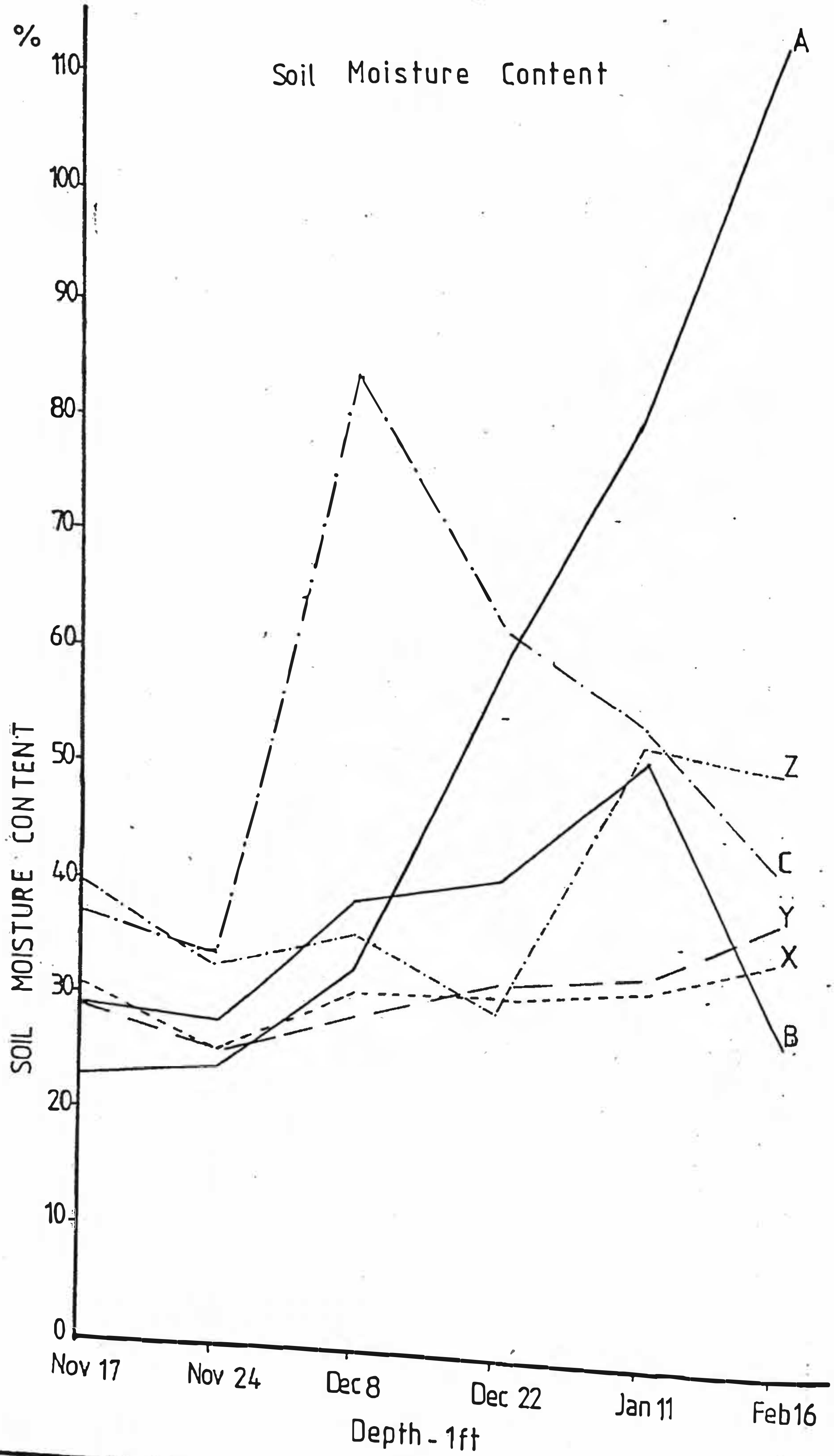

%
110
100
90
80
70
60
50
40
30
20
10
0
Soil Moisture Content
SOIL MOISTURE CONTENT
A
Z
C
Y
X
B
Nov 17
Nov 24
Dec 8
Dec 22
Jan 11
Feb 16
Depth - 1ft

Table 5 WATERTABLE MEASUREMENTS (CM)

Date:	Dec 5		Dec 13		Dec 20		Dec 27		Jan 3		Jan 10		Jan 17	
Site	1 ft	3 ft	1 ft	3 ft	1 ft	3 ft	1 ft	3 ft	1 ft	3 ft	1 ft	3 ft	1 ft	3 ft
A	11.8	21.5	4.0	36.2	S	17.3	S	8.0	S	S	S	S	S	S
B	21.5	–	23.9	77.4	16.7	71.4	12.4	68.5	11.0	72.0	10.2	73.0	15.0	74.0
C	–	32.0	21.3	24.6	S	13.8	S	8.0	S	3.0	S	4.0	S	5.0
X	–	–	–	–	–	–	–	–	–	58.0	–	60.0	–	–
Y	–	–	–	–	–	–	–	–	–	42.0	–	60.0	–	–
Z	–	–	–	–	10.6	36.5	S	21.5	S	3.5	S	4.0	S	5.0

Date:	Jan 24		Jan 31		Feb 7		Feb 14		Feb 21		Feb 28	
Site	1 ft	3 ft	1 ft	3 ft	1 ft	3 ft	1 ft	3 ft	1 ft	3 ft	1 ft	3 ft
A	S	S	S	S	S	S	S	S	S	S	S	S
B	S	–	S	–	S	78.0	S	72.0	9.0	–	17.0	–
C	S	7.0	S	15.0	S	4.0	S	S	S	15.0	9.5	35.0
X	–	–	–	–	–	–	–	–	–	–	–	–
Y	–	–	–	–	–	–	–	–	–	–	–	–
Z	S	9.0	S	11.0	S	14.0	S	30.5	–	68.4	–	–

Key:-
Dry –
Surface S

Measurement was taken at intervals of one week. The results obtained are outlined on Table 5.

Hydraulic Conductivity This is a measure of the soil's ability to conduct water and therefore is an important factor in drainage design. Course materials have large pores and high permeability while fine textured soils have small pores and low permeability. For soils with high permeability drains should be placed at wide spacings than those with low permeability.

Procedure The method of measurement of hydraulic conductivity was confined to the laboratory. Soil samples were extracted from each of the sampling sites, by use of open ended containers approximately 11cm. in height, 7cm. in diameter.

In accordance with procedure, the samples were saturated before measurement of conductivity. The soil samples, were mounted on retort stands and fixed firmly in place by clamps, yet resting gently on an empty beaker. To prevent loss of soil a gauze was placed between container and beaker. A 500ml. Erlenmeyer flask with constant head device, was filled with water and attached directly above the samples. A constant head of water was maintained on the sample as water passed through from the flask to the beaker below. The water collected was measured at 10 minute intervals. The results obtained are outlined in Table 6.

Table 6 Millilitres

	Site X	Site Y	Site B	
Hydraulic Conductivity	110	1500	26	Rate of flow at 10 minute intervals
	120	1475	16	
	72	1500	26	
	50	1500	15	
	Site A	**Site C**	**Site Z**	
	10	500	140	
	10	483	80	
	20	475	60	
	10	490	40	

Results It must be noted at this point that site D was eliminated from the study. On investigating the site, it was found to contain within it, large stretches of impermeable sandstone rock. Therefore the drainage problem of this site was not in keeping with that of remaining sites within the study area.

From the detailed land drainage specifications outlined, we note that differences in drainage depth existed between the reclaimed sites due to the differing site investigations conducted prior to land drainage. For site B, drains were excavated to depths reaching 2.25m. However, on site C drains were only level at 1m.

From watertable measurements taken at the 90cm. depth, on site B, the highest to which the water in the dipwell rose during the study, was 68cm. from the surface. The watertable on site C, by comparison, reached surface level. Therefore, we can conclude, that the watertable depth on site B had been significantly lowered as a direct result of the drainage instigated by the Farm Modernisation Scheme. Added to this as early as January 3rd, 1988, at site A, (the unreclaimed land) water surface level was recorded in its 90cm. dipwell. In comparison to the good mineral soils, site B compared very favourably proving that the drainage method applied did indeed lower the watertable.

On site B the 30cm. dipwell was the first of the dipwells to contain water (December 5th, 1987, 21.5cm. from the surface). This indicates that a "perched" watertable exists on the land. Combined with high soil moisture content recordings for December and January at the .3 metres depth, 40.5% and 52.4% respectively and (compared to site X, for example, 31.5% and 32.0% respectively) plus low hydraulic conductivity rates (26ml./10 mins.) prove that reclamation has been insufficient in combating the very nature of the soil, that of gley. To alleviate this waterlogging problem; further drainage, such as gravel moling, would be required.

On site C, high soil moisture content readings were recorded during the winter months (eg. December 8th, 84.4%, December 22nd 63.3%). By February 16th 1988, site C had the third highest soil moisture content reading at the depth (39.7%). By comparison site B, the newly reclaimed land recorded the lowest soil moisture content (28.9%), comparing very favourably with site X (35.3%) the second lowest.

From hydraulic conductivity experiments conducted on soil samples extracted from site C, the indication is that the soil has a high infiltration rate, (500ml./10 mins) potential when compared to site B (26ml/10mins) or site Y (1,500ml/10mins). However, due to the existing high watertable (surface level by February 14th), the soil will remain in its present waterlogged condition. The failure of the drainage system on site C, to lower the watertable, thus allowing infiltration, has therefore been proven to be due to the shallowness of its underdrains and open water courses. In comparison at site B, the depth of the underdrains and open water courses, needed in order to lower the watertable and remove excess soil water, varied from 1.35m. to 2.25m.

Land drainage and reclamation on site C has therefore been a failure. From the analysis of the hydrological properties of the soil, the study has shown that the key to successful land drainage lay in proper site investigation combined with good drainage design.

In conclusion, man's activities have, to some degree, succeeded in altering the hydrological properties of the wet mineral lowland 'bog'. Land drainage on site B has succeeded in lowering the watertable only. The failure of site C to attain even this has been explained in its drainage design. Therefore, land drainage and reclamation have only partially succeeded. The hydrological properties of the reclaimed lands do not equate to those of the good mineral soils.

It should be noted that the study was, however, conducted on an isolated scale and over a limited time period. Redress of these two conditions is needed therefore to accurately assess changes brought about through land drainage and reclamation on a wider scale.

BIBLIOGRAPHY

Briggs, D. 1981 Soil, sources and properties of soils, MacMillan Publishing Co. Inc., New York .

Castle, D.A., McCunnel, J. & Tring, I.M. 1983 Field drainage principles and practices , (Butterworth & Co. Ltd., England).

Gleeson, T. 1985 Drainage of lowland peats and wet mineral soils .

Mulqueen, J. 1982 Site investigation is the key to successful farming , The practical farmer, (Baggot Ltd., Dublin).

Mulqueen, J. 1986 "The use of ground water surveys in the diagnosis and solution of a drainage problem", Ir. J. Agri. Research, (An Foras Taluntais, Dublin).

Tivy, J. & O'Hare, G. 1981 Human impact on the ecosystem , (Oliver & Boyd Ltd., Edinburgh).