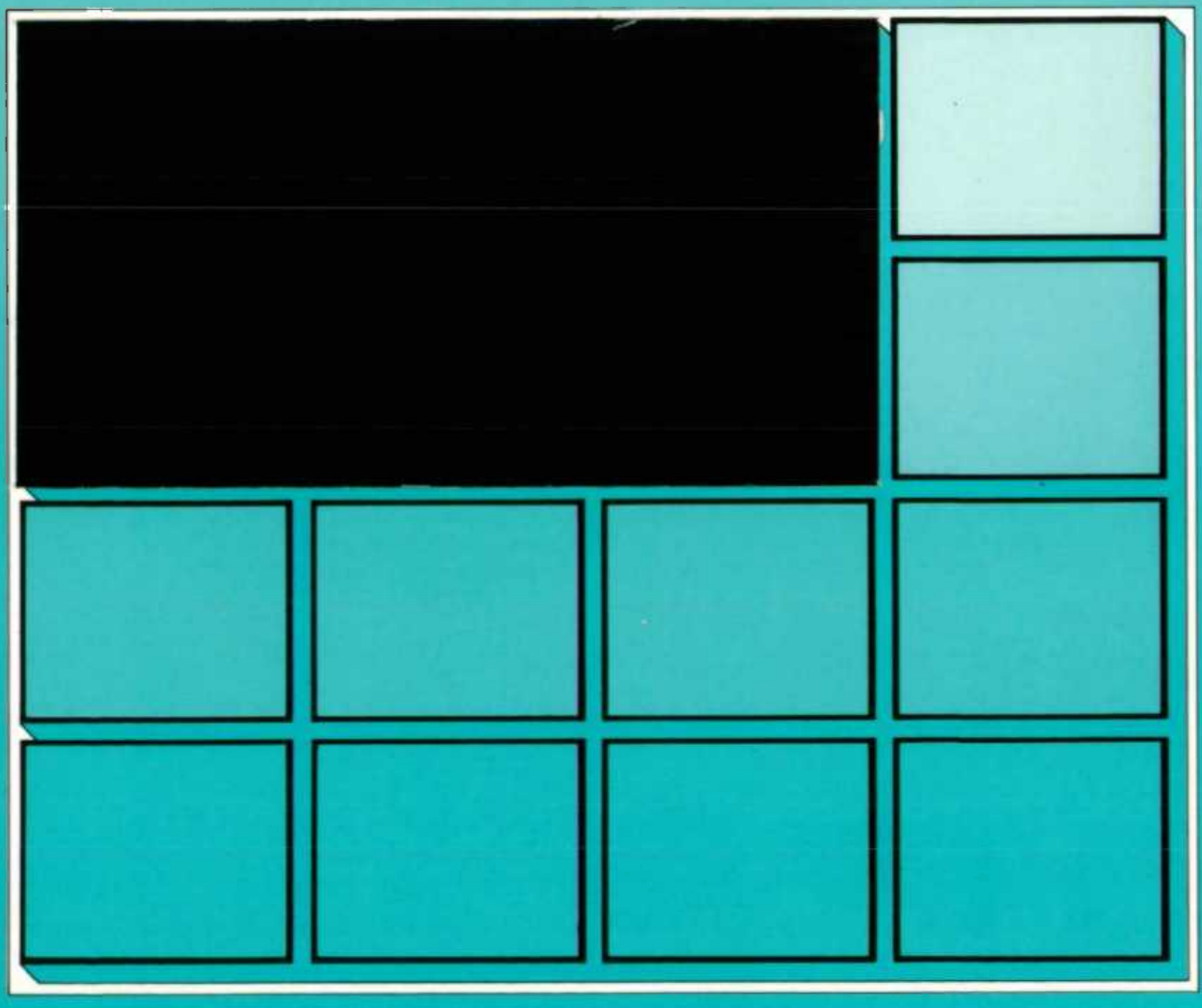
INSTITUTE of HYDROLOGY



Hydrological Studies

of

West Sedgemoor

January 1988

Hydrological Studies of West Sedgemoor

March 1986 - January 1988

Introduction

The major effort in the period from the previous meeting has been in field equipment installation, data collection and setting up a database to hold the information that is being recorded. The basic philosophy of the instrument network is, as far as possible, to measure the components of the water balance of the moor and to analyse the reaction of the drains and pumping stations to rainfall.

Primary inputs are rainfall and surface water inflow to the moor, requiring a recording raingauge and two stream gauges which have now been installed near Bowldish farm and on Wickmoor Rhyne. A smaller inflow is being current metered weekly in summer and fortnightly in winter. Outflows being due to evaporation and pumping, are being recorded by the installation of a lysimeter and metering in the new electric pumping station. Records from the old diesel pumping station are continuing to be processed as before. Change of storage within the drains and fields of the moor are monitored with a network of seven water level recorders and four dipwell transects.

The following sections describe the current network, the archiving system and some preliminary analysis of the data now assembled.

Water level recorders

During the reporting period, three water level recorders have been installed. There were initial problems with some of the water level recorders and associated loggers. These problems were compounded by the delay in installing the gauge boards (except site 3), which in turn caused a delay in loading the data on to our database and quality controlling it. The summary below details the approximate loss of data that occurred at each of the sites, up to the end of July 1987.

Water level recorder	Data lost	Date site activated
1. Main Drain near pumping station (gauge board installed during Oct 86)	1986 - 73 days 1987 - 74 days	25.2.86
2. Main Drain at Pincombe bridge (gauge board installed during Oct 86)	1986 - 181 days 1987 - 59 days	25.2.86
3. Old Rhyne near Helland bridge (gauge board already in at start of study)	1986 - 53 days 1987 - 1 day	25.2.86
4. Middle Drain near pumping station (gauge board installed during Jun 87)	1986 - 13 days 1987 - 20 days	6.11.86
5. Middle Drain near railway bridge (gauge board installed during Jun 87)	1986 - NIL 1987 - NIL	6.11.86
6. Beercrowcombe Drove Bridge (gauge board installed during Sep 86)	1986 - 56 days 1987 - NIL	25.2.86
7. Middle Drain near Fivehead Drove (gauge board installed during Jun 87)	1986 - NIL 1987 - 27 days	6.11.86

However data are now being returned regularly and with very little data loss.

Raingauge

A 15-minute recording raingauge was installed on West Sedgemoor during April 1987, at grid ref ST371271, adjacent to the site where the lysimeter was later installed. This was done (i) in order to increase the accuracy with which the water balance calculations involving the lysimeter could be carried out and (ii) because there was previously no raingauge within the area of the moor. The nearest is at West Sedgemoor pumping station (WSPS). Initial problems with the raingauge logger resulted in the data being considered valid only from the end of May 87 onwards. Loss of data will be made good by infilling with Wessex Water Authority (WWA) daily data from the gauge at WSPS. WWA are supplying daily data from four raingauges (WSPS, Curry Rivel, North Curry and Fivehead). Examination of the data from these four sites shows that from WSPS to be 11% lower on average in 1986/87, than that from the other three sites which are situated on the 'highland' surrounding the moor.

Lysimeter

A lysimeter was installed within an NCC owned field (OS ref number 0700, grid ref ST371271) on West Sedgemoor during September 1987. The lysimeter consists of a fibreglass cylinder and is constructed from two well liner sections sealed at one end. The internal diameter is 915mm (36"). The depth of soil between the internal base of the lysimeter and grass level, is approximately 800mm. Information derived from the dipwell transect in the same field during the preceding twelve months, showed this depth to be adequate. The lysimeter's soil contents were reconstituted in three layers. The top layer was cut at a depth of 300mm, the deepest consistent with being able to handle the resulting blocks of peat when the layer was sectioned and removed at the start. This depth encompassed all but the very smallest root fragments. The middle and lower layers were each about 250mm and together made up the total depth of 800mm. Each layer was cut into about 9 pieces whilst it was being removed and replaced. There is a capped 5" external diameter drilled PVC drainage tube aligned with the central vertical axis which is used to add or remove water from the lysimeter.

It is visited once a week during April-November and once a fortnight for the remainder of the year. On each visit, a measured volume of water is either added or removed in order to restore the lysimeter ground water level to that of the surrounding field. The ground both within and surrounding the lysimeter is not expected to recover completely until about April 1988 when the data will start to provide an alternative estimate of evaporation.

Wickmoor Rhyne recorder

Discussions were held with WWA on the form of a removable measuring weir which would serve the purpose of the study and also which could be raised or lowered to adjust the water level for local agricultural use. An initial proposal for a one piece movable rectangular weir plate was rejected by WWA on safety grounds as they felt it would be too heavy for their operator to handle. The existing concrete sluice at grid ref ST387268 has now been modified to incorporate a rectangular thin plate weir. A water level recorder was installed at the upstream side of the sluice to record the head over the weir. Accurate flow estimation depends upon knowing when the weir is raised or lowered. Our field staff note the crest level on monthly visits and the water level data itself when graphically displayed will show exactly when the crest was moved. The recorder became operational in October 1987.

Water is also taken in to the moor from the R. Parrett at Sedgemoor Inlet, via two regular culverts under road and rail, near Oath Farm (ST386276). Current metering of this flow started (weekly in summer, fortnightly in winter) at the same time as the Wickmoor Rhyne recorder commenced operation. The sluice seems to be closed for part of the winter.

Dipwells

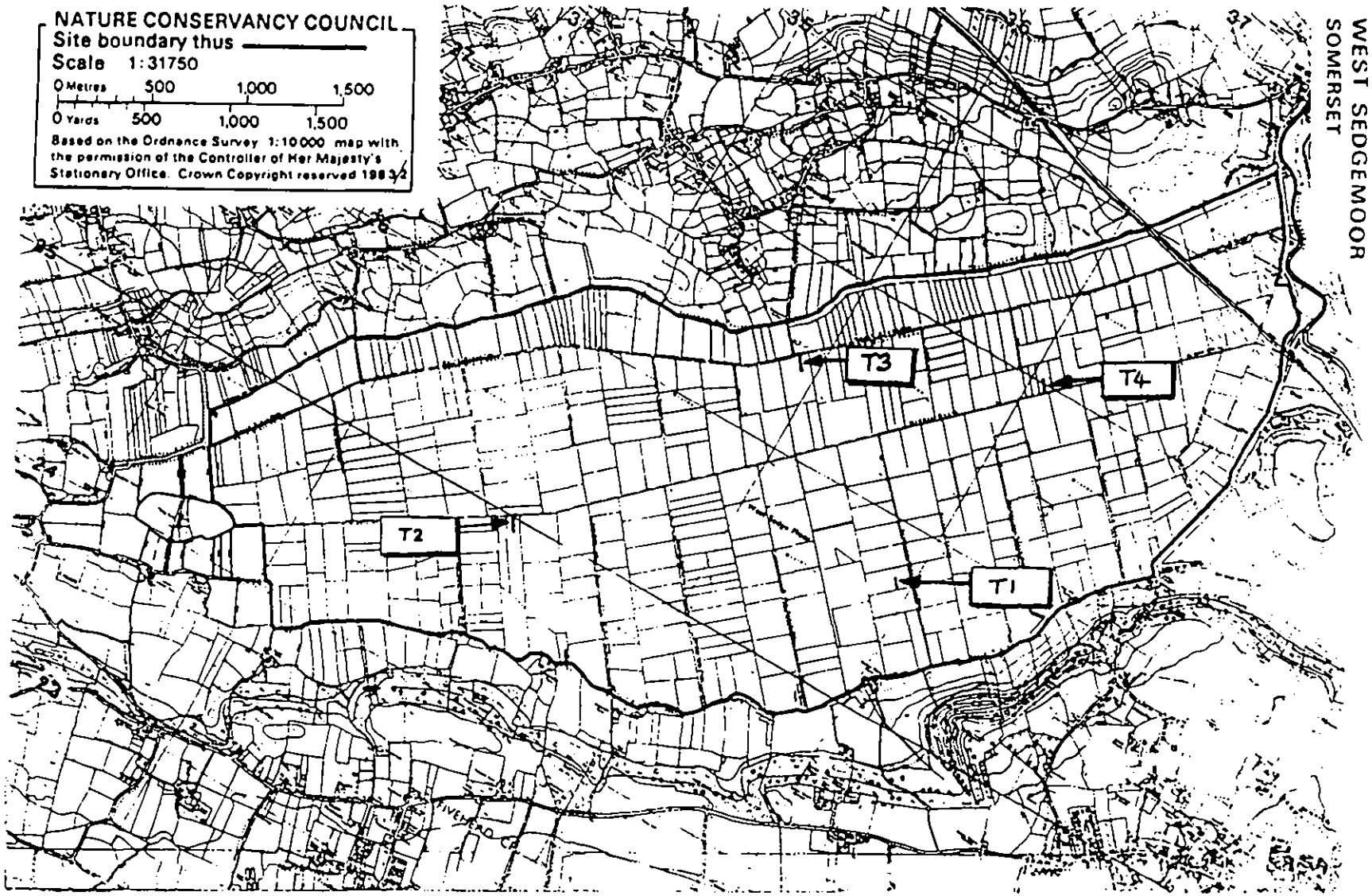
1 Installation of equipment

The ultimate purpose of water level control by pumping at the West Sedgemoor pumping station is the maintenance of groundwater levels in the fields of the Moor, appropriate to the intended land-use. The decision to pump is based in part on the water level in the Main Drain, and the effects of the pumping become less predictable with distance from this drain. There is a further uncertainty in the relationship between rhyne levels, controlled in part by the pumps, and the groundwater level in the fields. Within the field, the water table depends on climatic conditions, and at some distance from the rhyne the seasonal variation may outweigh any variation induced by changing rhyne levels.

To establish the nature of the relationship between rhyne and field water levels, twenty observation wells have been installed on West Sedgemoor, and water levels have been measured at approximately fortnightly intervals, where weather conditions allowed. These wells are grouped in four transects, each transect extending from a watercourse into the interior of a field. The distribution of the transects was dictated by the importance of obtaining a good coverage of the Moor using land owned by RSPB or NCC and subject to minimal agricultural activity. Fields were selected whose width along the rhyne edge, between lateral drains, exceeded 100 metres, and these fields are located at Beercrowcombe Drove near Burton's Dairy Farm, north of the New Cut (T1), south of the Middle Drain near Eastwood Farm (T2), south of the North Drove Rhyne at the end of Pincombe Drove (T3) and north of the Middle Drain towards the eastern end of the Moor (T4) (see Figure 1). This last field is the least subject to agricultural activity or other likely disturbance, being NCC land with very limited agricultural usage, and remote from habitation, and it has also been chosen as the site for a lysimeter.

The wells were installed in July 1986, using a Jarrett post-hole auger. Each transect was intended to follow the same plan, extending as far into the field as the distance between the transect and the nearest lateral drain. If all lateral drains were well-maintained and in good hydraulic connection with the rhynes, this would represent the point most distant from the influence of open water. In practice, three transects consist of wells arranged in a straight line perpendicular to the rhyne, at distances of 2 metres, 12 metres, 22 metres, and 32 metres from the water's edge. In the other transect (T1), the final well is 52 metres from the water.

It was recognised that there was a need to ensure that water levels could be related to OS datum, and that the effects of possible movement of the ground surface should be eliminated. For this purpose, and to provide more measurements of ground surface datum, the transects were supplemented by datum posts inserted through the peat and as deep into the underlying silts as possible using hand tools. These posts consisted of steel electrical conduit, screwed together in four-metre lengths on insertion. Each post was cut off near ground level, and located adjacent to the end well of a transect: each transect having two datum posts.


NATURE CONSERVANCY COUNCIL
Site boundary thus
Scale 1:31750
0 Metres 500 1,000 1,500
0 Yards 500 1,000 1,500
Based on the Ordnance Survey 1:10000 map with the permission of the Controller of Her Majesty's Stationery Office. Crown Copyright reserved 1983/2
T1
T2
T3
T4
WEST SEDGEMOOR
SOMERSET

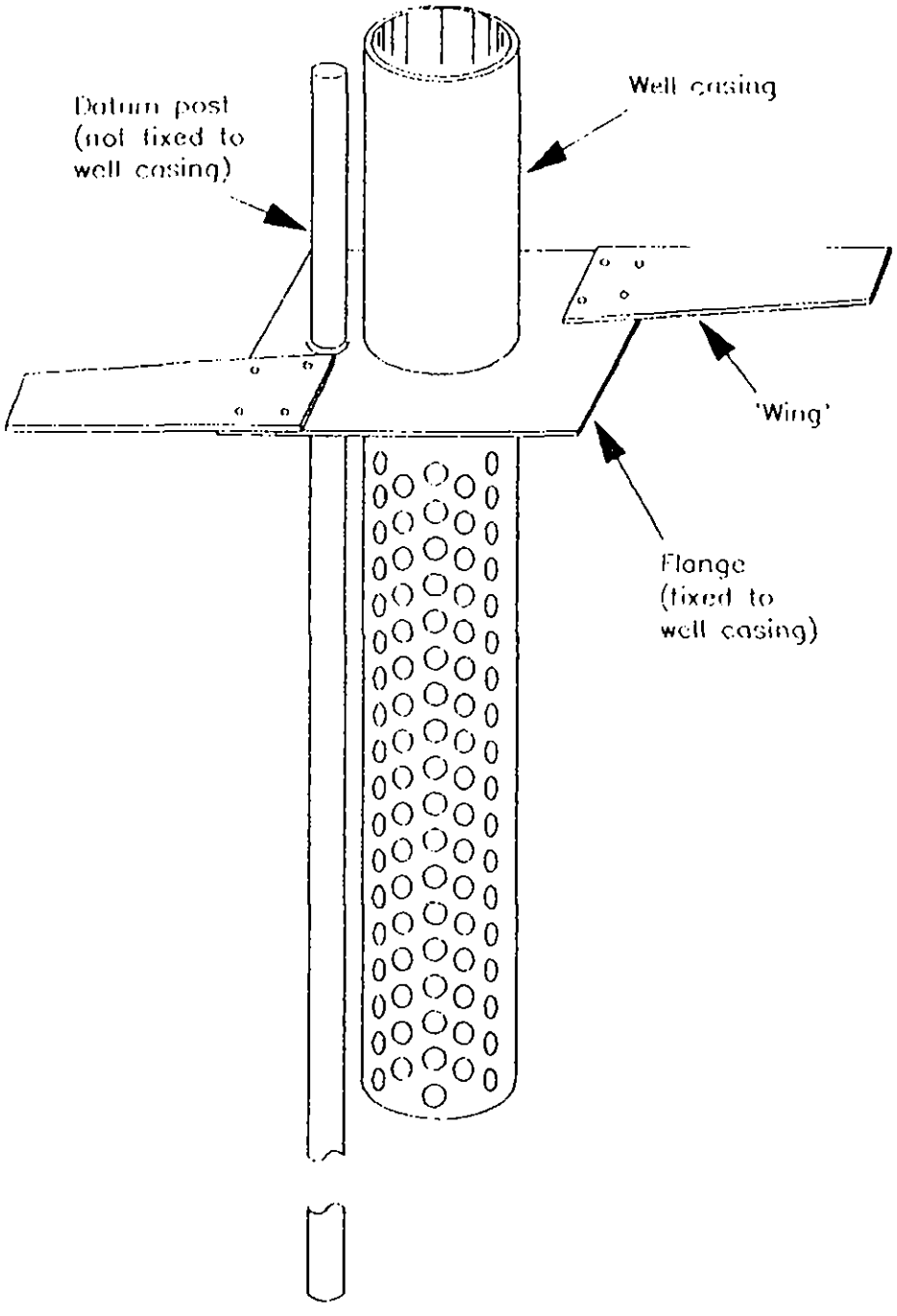
The observation wells were lined with two metres of 90mm id uPVC tubing, perforated with 10mm holes in a regular pattern over the lower 1.5 metres. Additionally, the end wells of each transect were fitted with a flange fitted with a 0.5 m square alloy plate. A 0.5 metre square pit, 0.5 metre deep, was dug around the well, and after the well casing was run down into the auger hole, the plate sat on the base of the pit, with wings extending a further 0.4 m into undisturbed peat on two sides (see Figure 2). The square pit was then filled with excavated material. It was expected that a well of this design would follow the movement of the surface horizons of the peat, and that relative movements of the ground surface and the underlying silts would show up in the relative positions of the well rim and the datum post.

2 Results

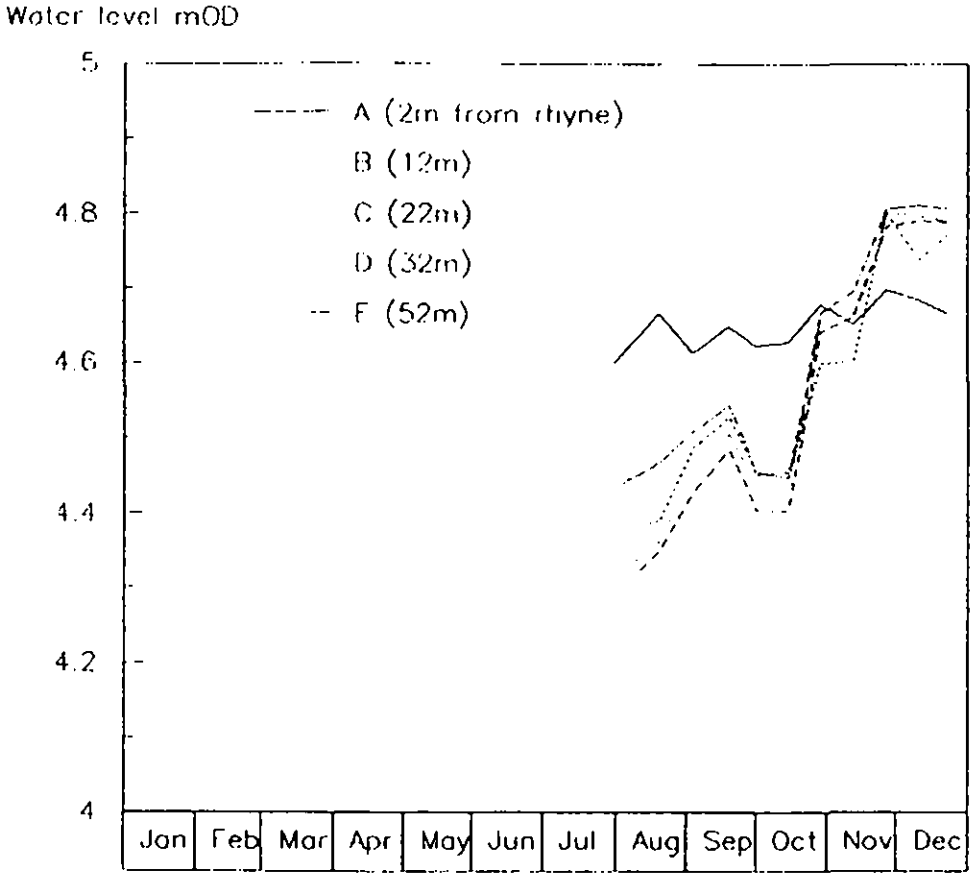
Water level measurements were made from the rim of each well, and the results related to OS datum. The variation in water levels over the period July 1986 to December 1987 is shown in Figures 3 to 10. For wells 12 metres or more from the rhyne, the broad pattern is the same for all the transects: a constant level over the winter months, from November to April, then a steep fall coinciding with the period of maximum grass growth, a continuing fall during the summer months, relieved by rainfall events, and a rise over October and November to the winter level. The annual range in the centre of each field is between 0.7 and 0.8 metres.

The nearest well to the rhyne (denoted by the letter A) behaves in a completely different way (Figures 11 & 12). This well in each transect follows a much less obvious seasonal trend, and it is probable that close to the rhyne the groundwater is influenced strongly by the rhyne water level. This hypothesis will be checked by reference to the available open water measurements. In particular there is an abrupt change in behaviour of well T2A, next to the Middle Drain, which may relate to drain clearance activity in April 1987.

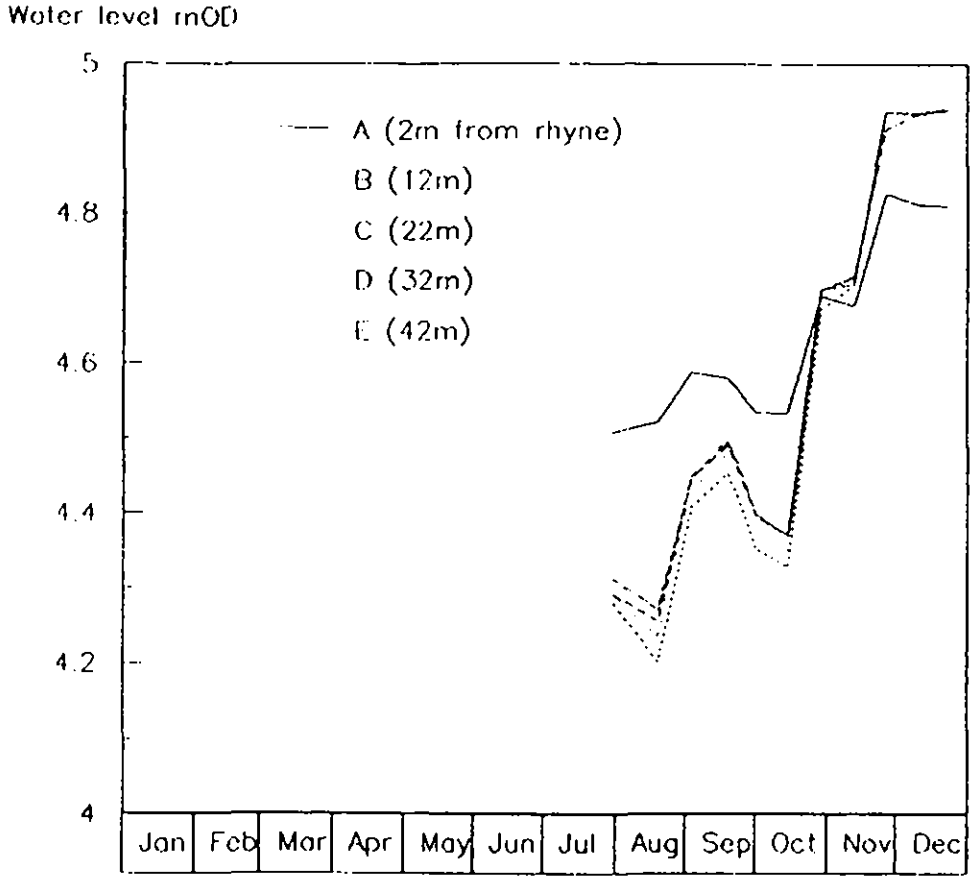
Within each transect's records, there is a clear tendency for field levels to be above rhyne levels in winter, and below in summer. Summer levels in the interior of a field reach a maximum of about 0.5 metres below the water table near the rhyne. This is seen more clearly in Figures 13 to 19, where the water levels are plotted with distance from the rhyne for seven selected dates. There is little difference in behaviour between the four transects, and this may be taken as an indication of the applicability of the data collected to other parts of the Moor.


Datum post
(not fixed to
well casing)
Well casing
'Wing'
Flange
(fixed to
well casing)

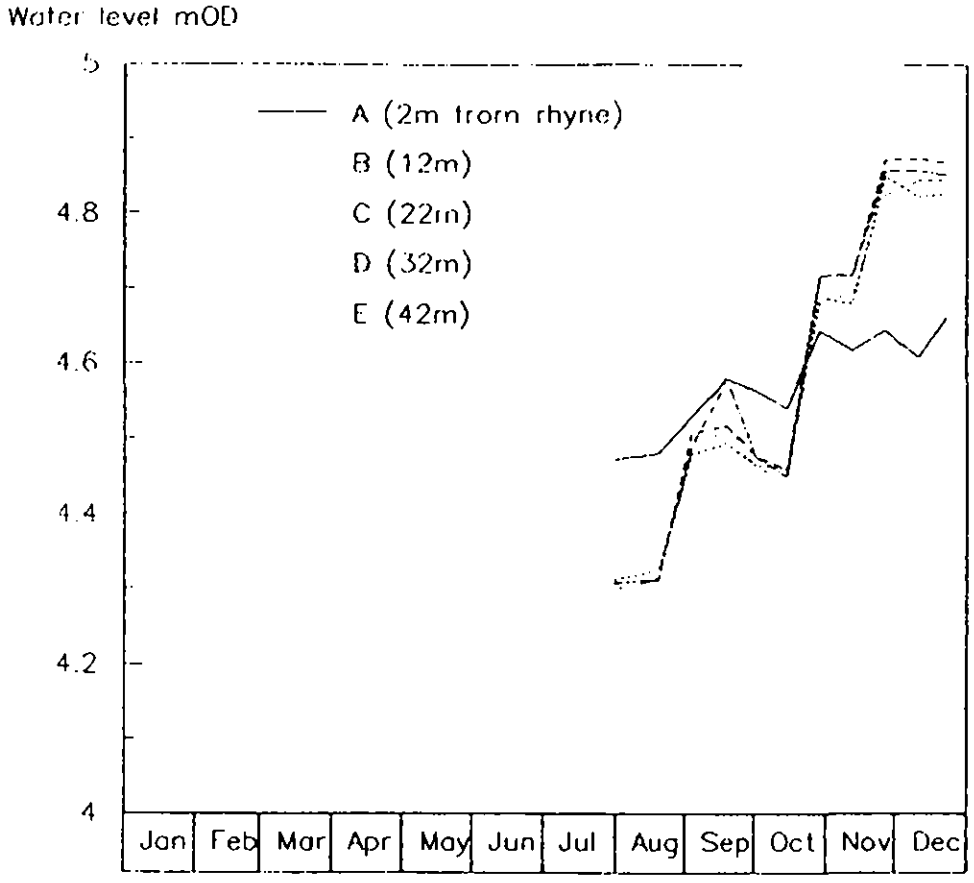
West Sedgemoor 1986
Observation well transect T1



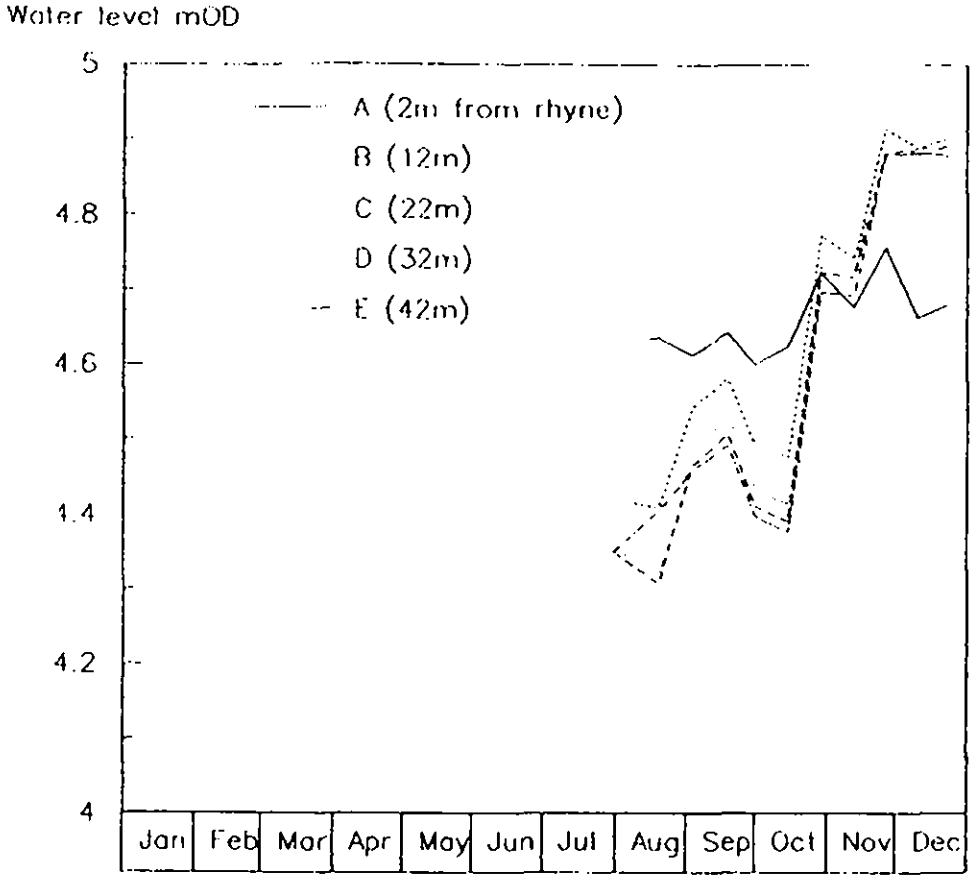
West Sedgemoor 1986
Observation well transect T2



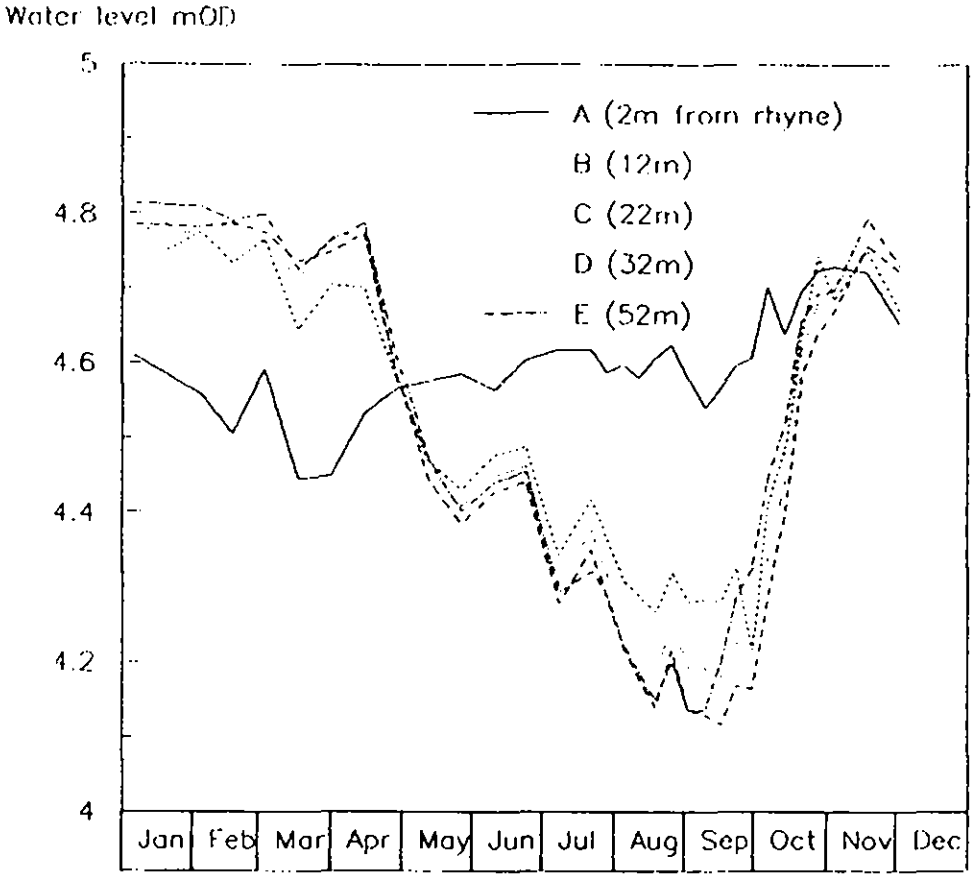
West Sedgemoor 1986
Observation well transect T3



West Sedgemoor 1986
Observation well transect T4



West Sedgemoor 1987
Observation well transect T1



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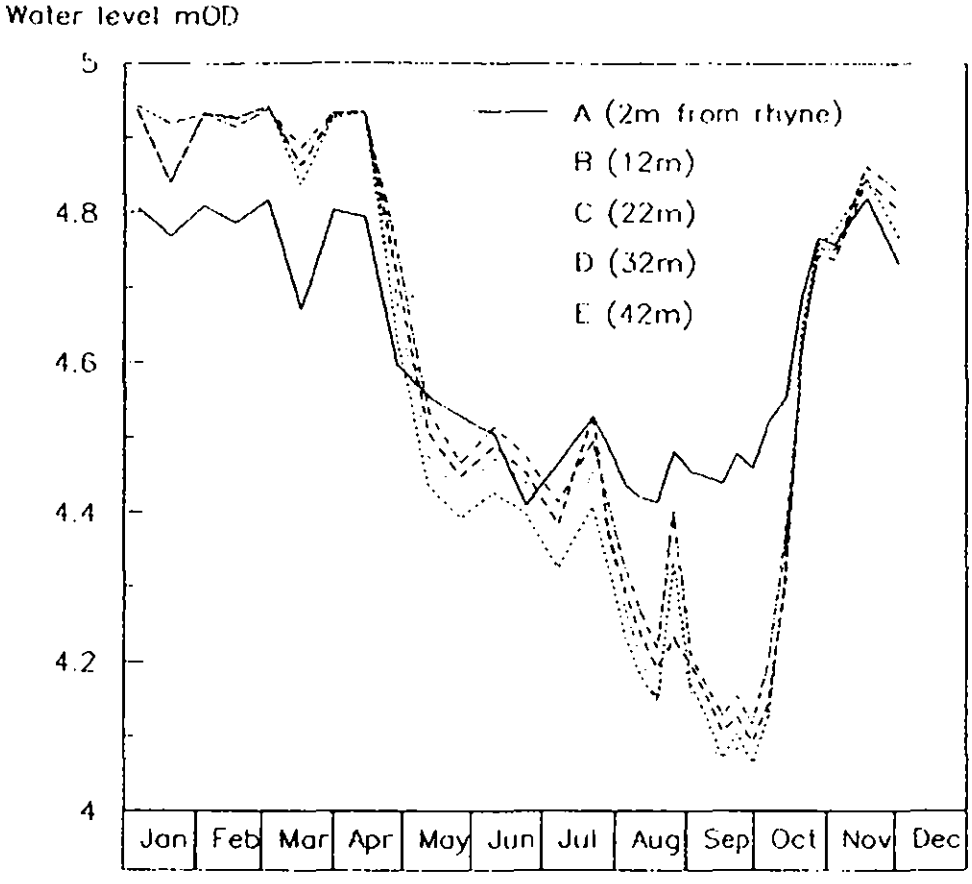
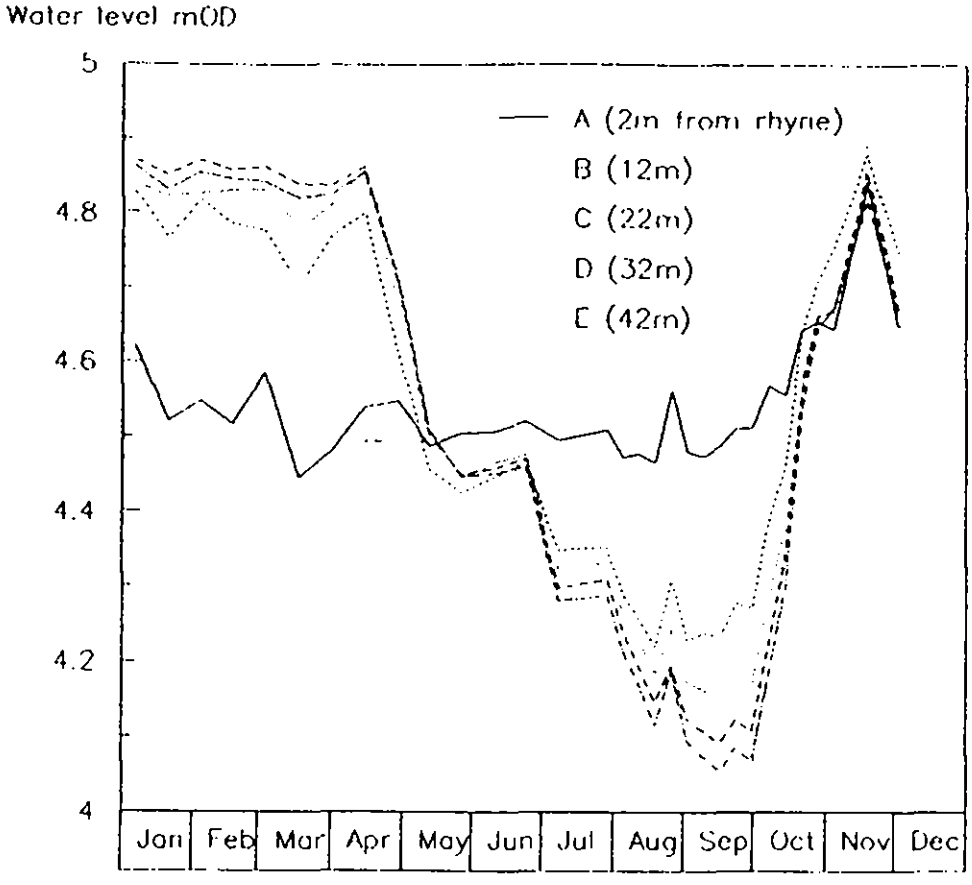
Observation well transect T2



West Sedgemoor 1987
Observation well transect T3



West Sedgemoor 1987
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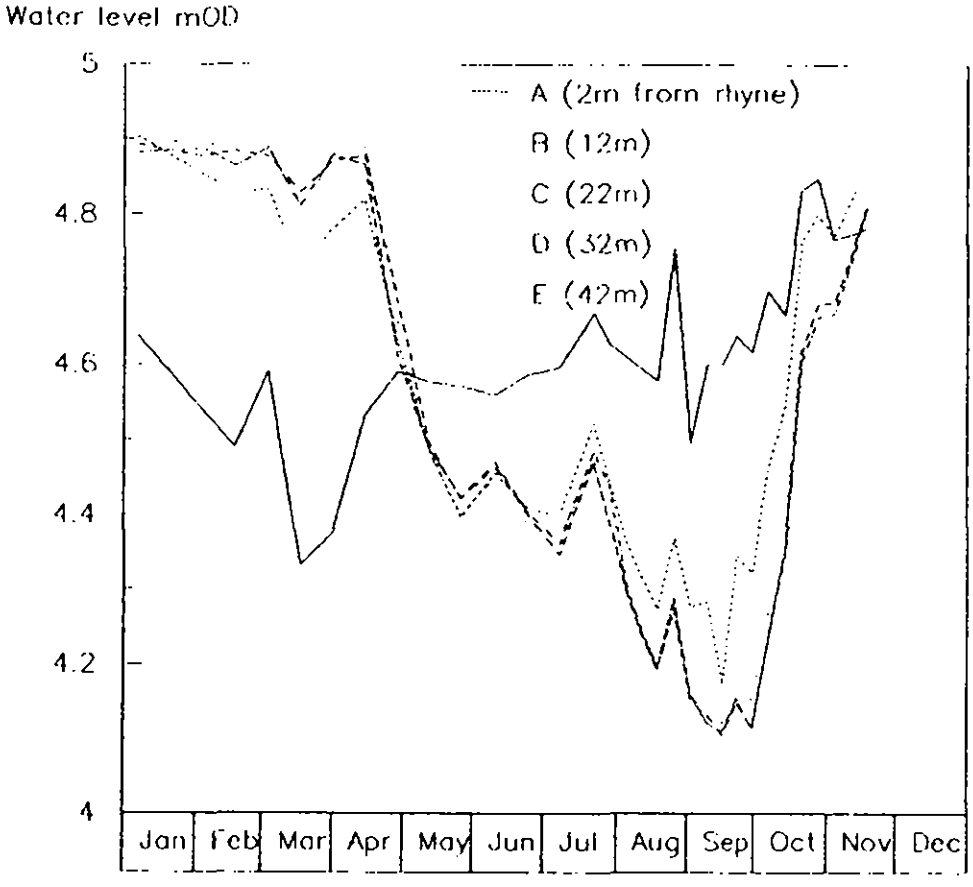
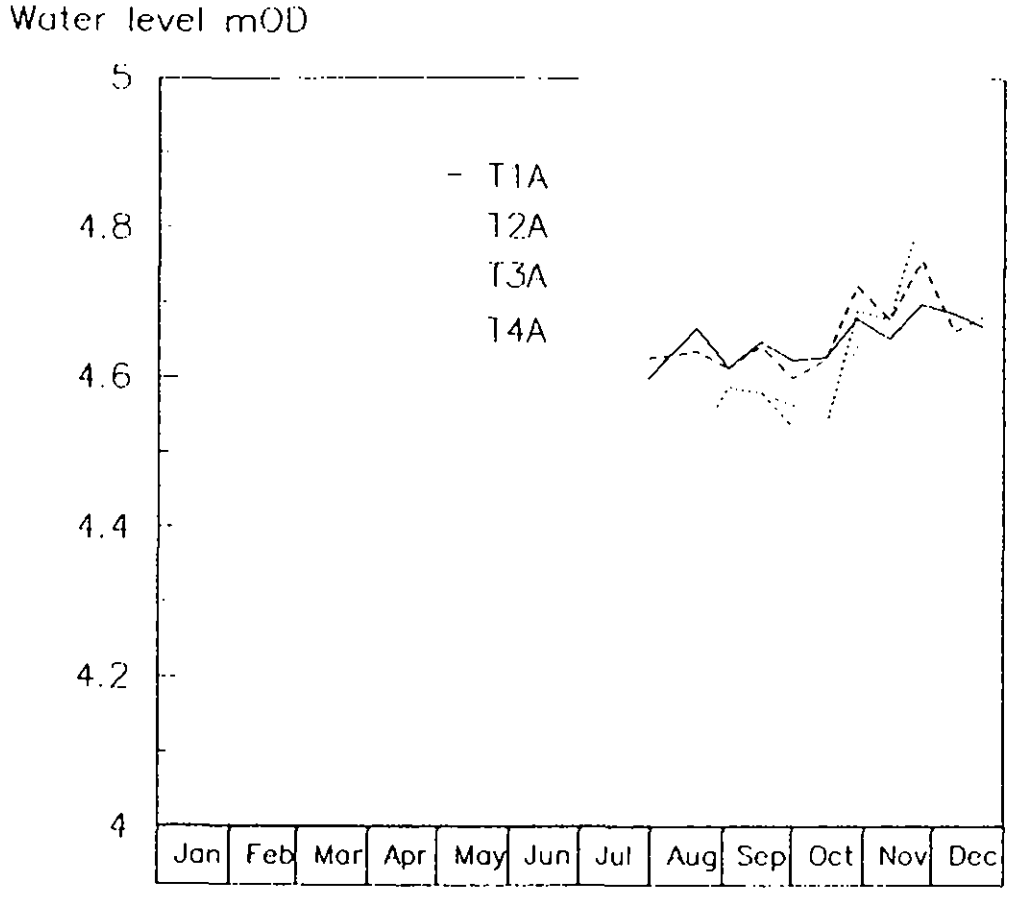
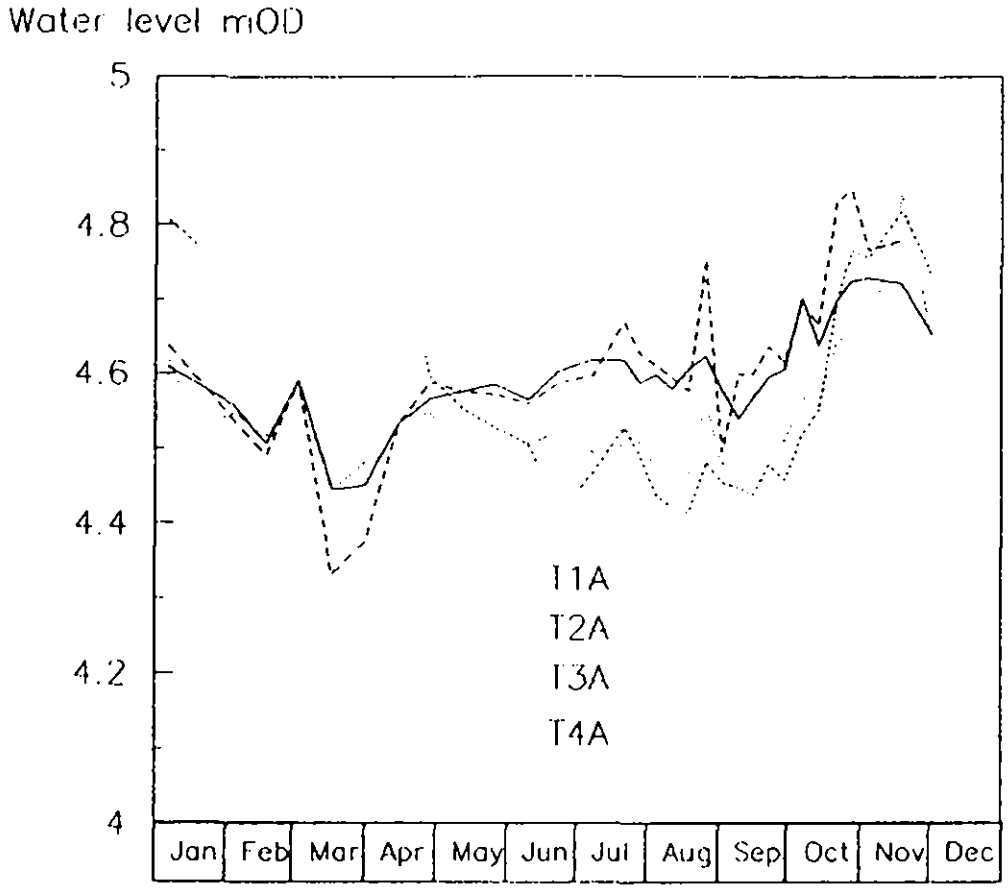


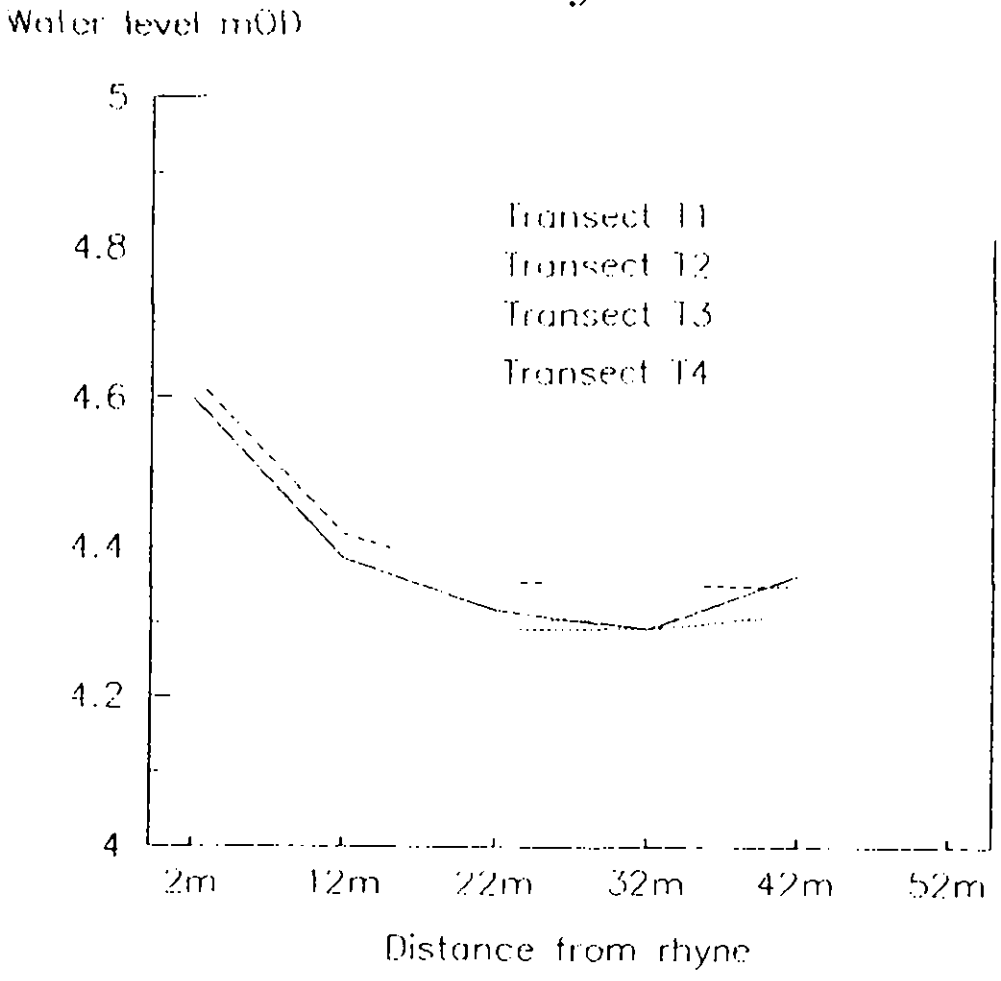
West Sedgemoor 1986
Wells 2m from rhynes



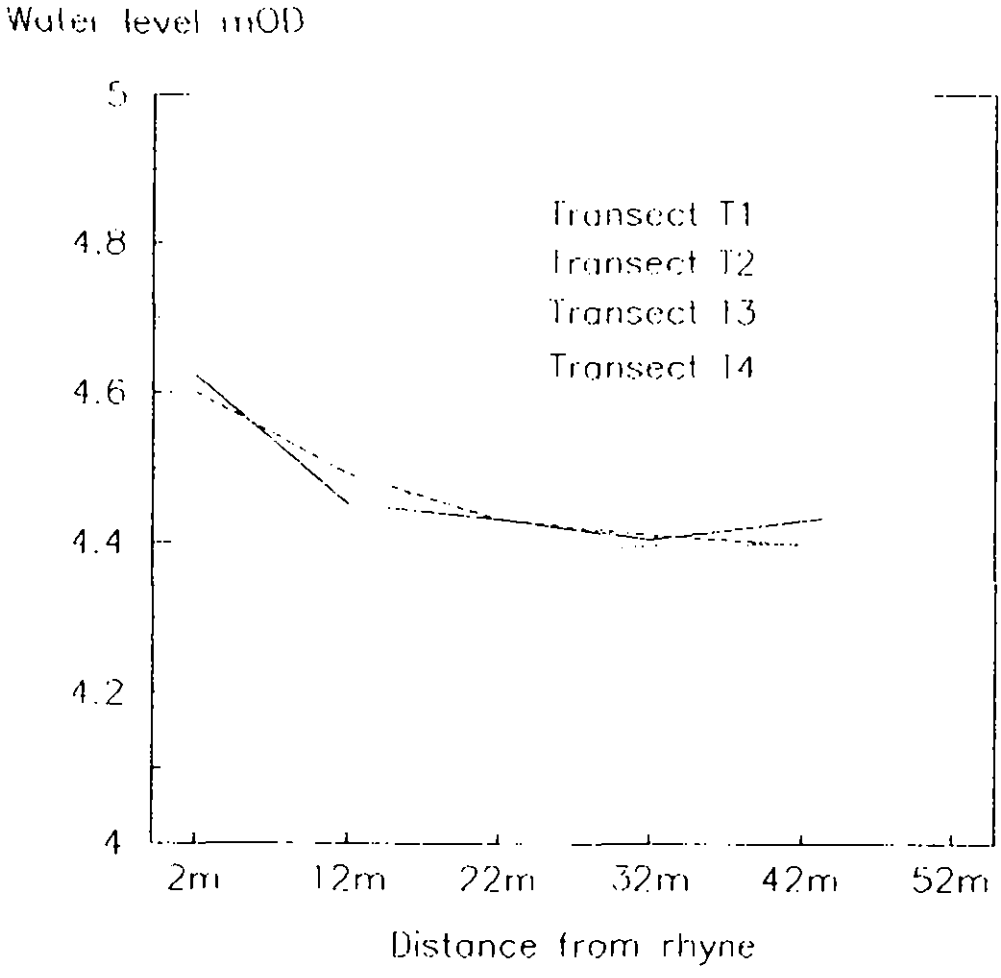
West Sedgemoor 1987
Wells 2m from rhynes



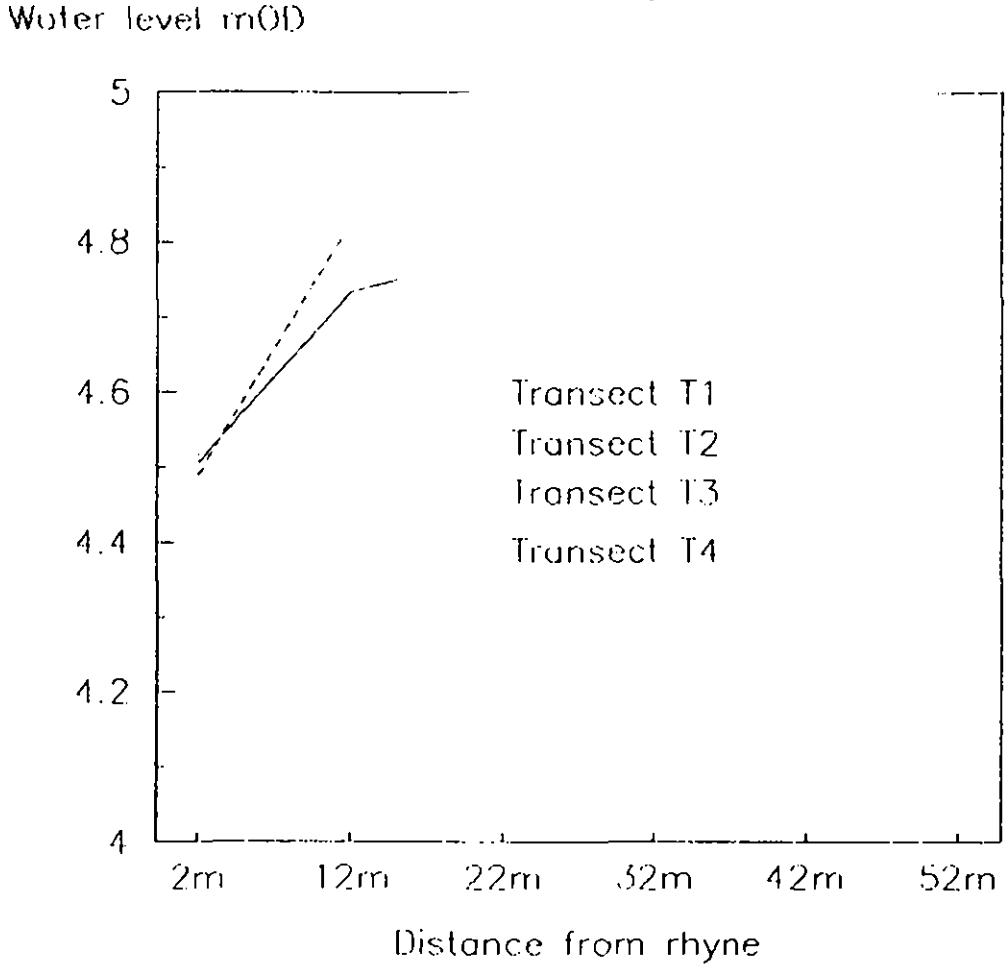
West Sedgemoor
31 July 1986



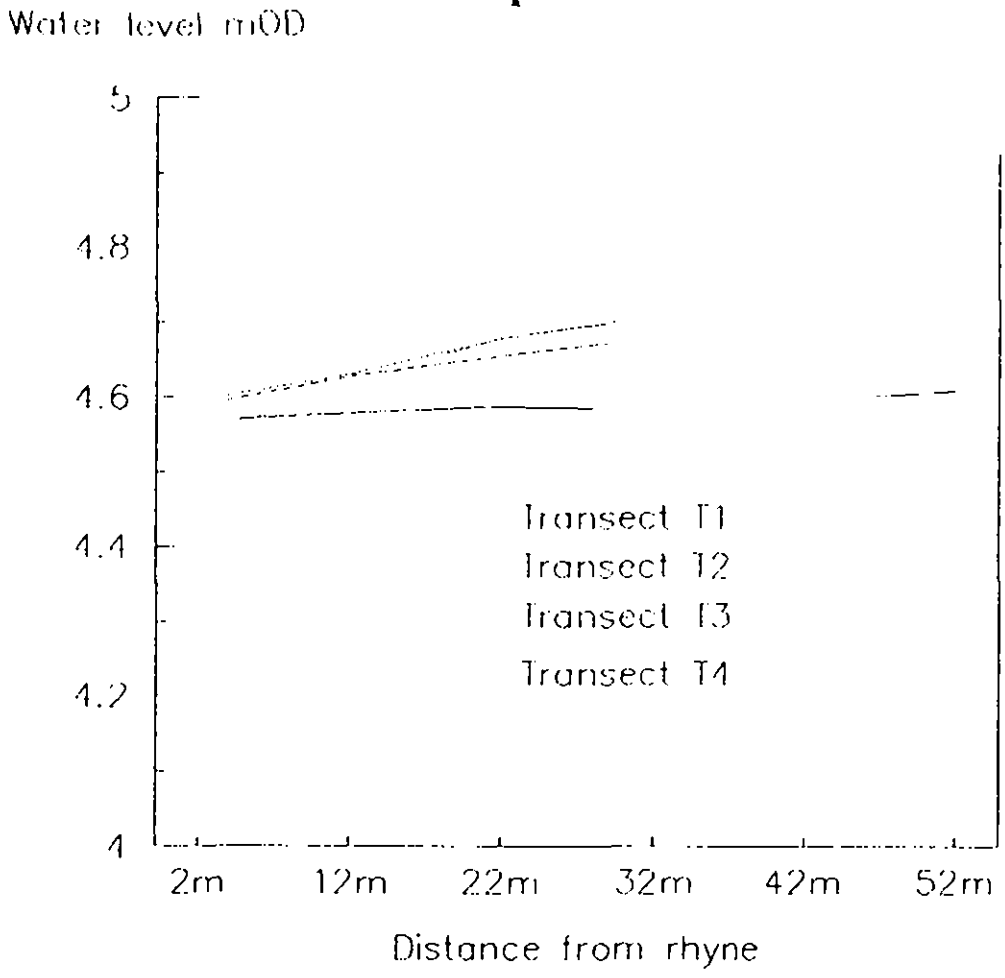
West Sedgemoor
1 October 1986



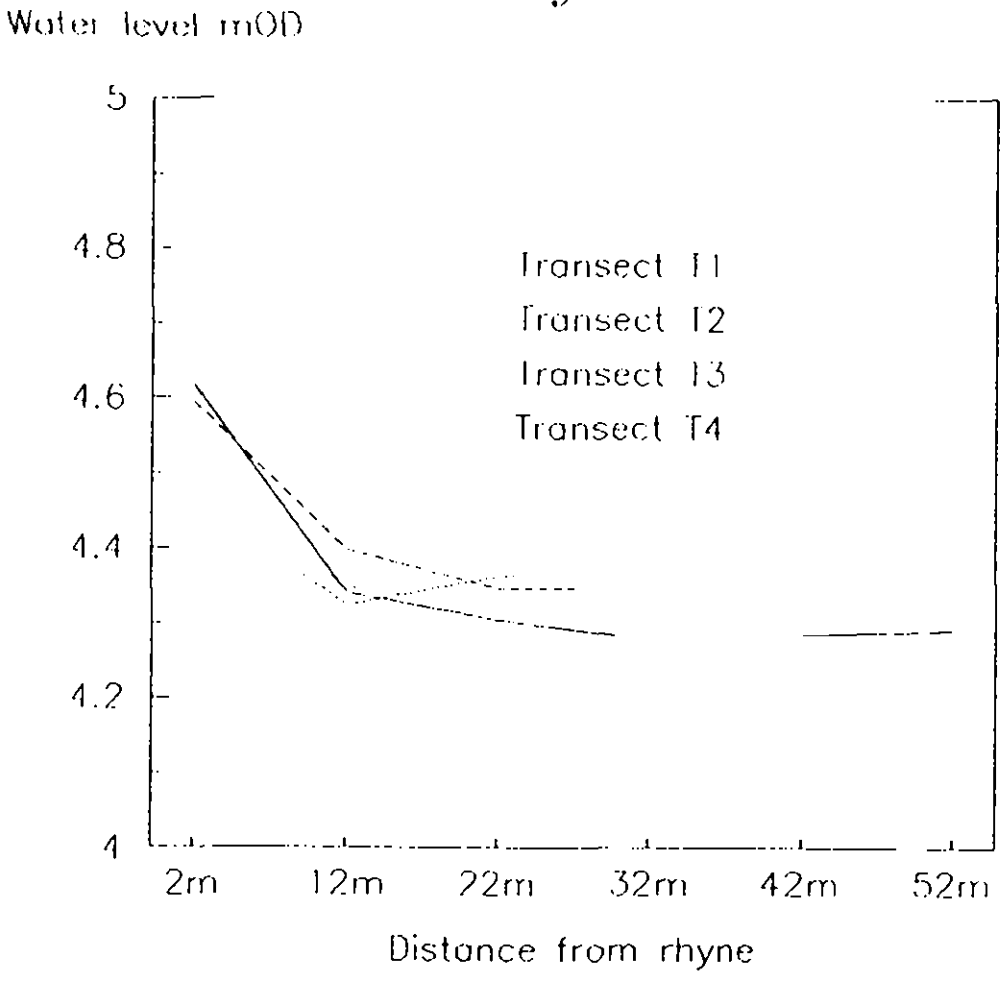
West Sedgemoor
18 February 1987



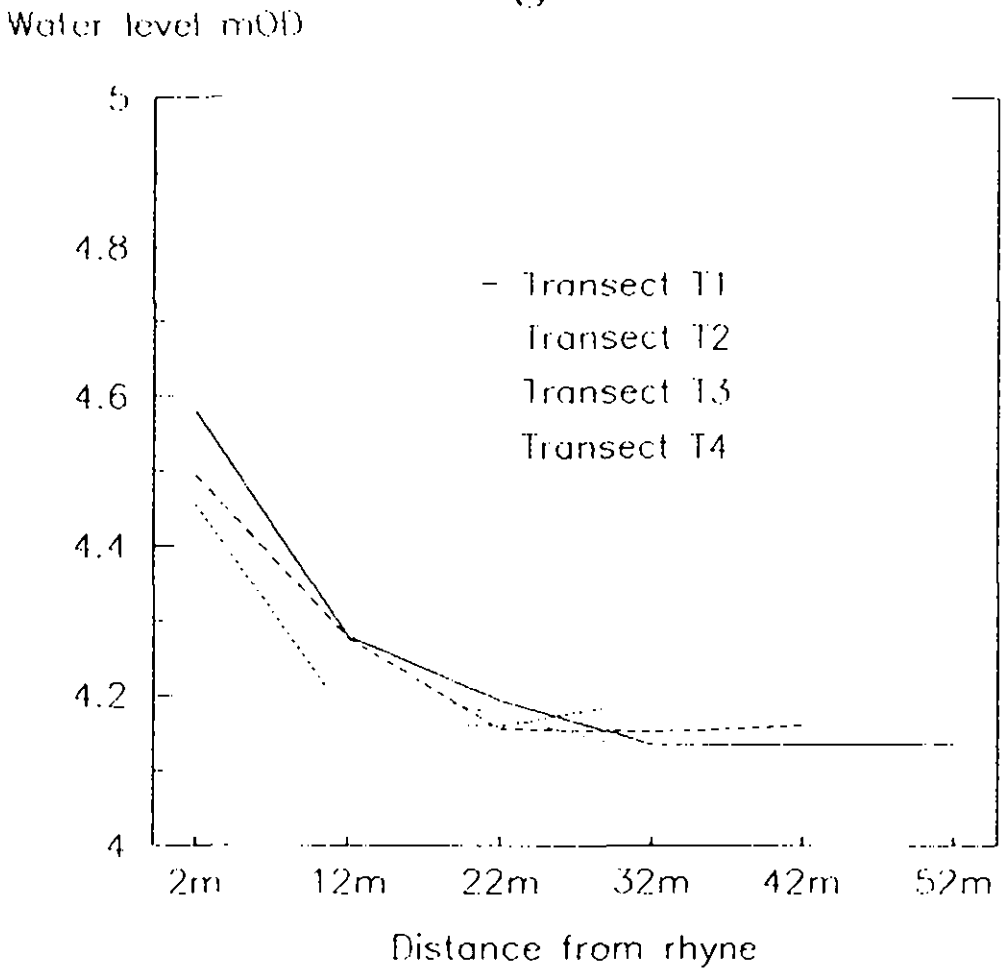
West Sedgemoor
29 April 1987



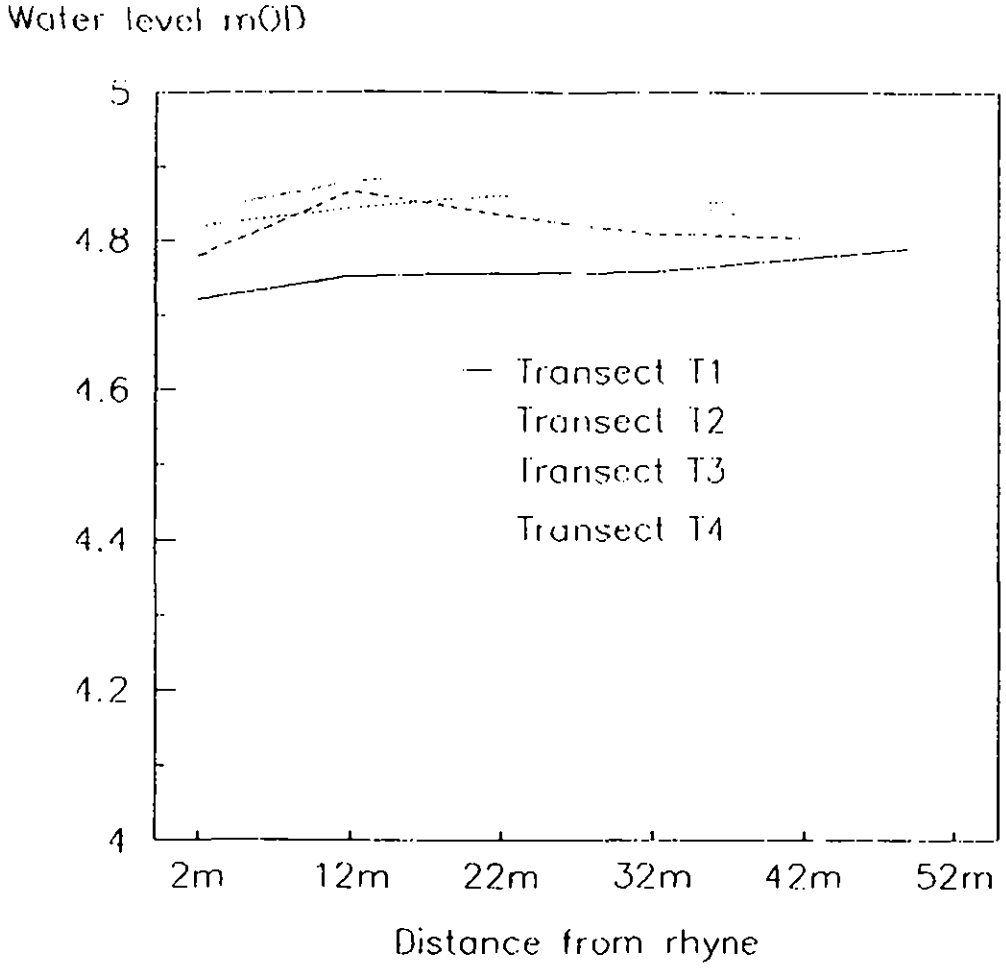
West Sedgemoor
8 July 1987



West Sedgemoor
26 August 1987



West Sedgemoor
18 November 1987



Levelling of datum posts and dipwell tops

Land level changes are an important element of the study and the previous report described information obtained from the Ordnance Survey and MAFF. The first survey of the datum posts and dipwells was carried out by WWA in August 1986 and they have recently sent IH details of a re-levelling excercise carried out in early October 1987. A summary of ground movement at the various sites over the 14 month period between August 1986 and October 1987 follows. Negative data refer to apparent rise in ground level.

Transect site	Dipwell average drop in level(mm)	Datum post average drop in level (mm)
T1	14.8	10
T2	28.8	14
T3	29.0	15.5 **
T4	20.2	27.5

** some ground rise near to rhyne

1) Dipwell transect T1 & Water level recorder staff 6

		Distance from rhyne
Datum post	11mm	2m
Dipwell	-1mm	2m
Dipwell	13mm	12m
Dipwell	19mm	22m
Dipwell	20mm	32m
Dipwell	23mm	52m
Datum post	9mm	52m

Water level recorder 6 staff dropped by 2mm

2) Dipwell transect T2 & Water level recorder staff 7

		Distance from rhyne
Datum post	5mm	2m
Dipwell	9mm	2m
Dipwell	40mm	12m
Dipwell	25mm	22m
Dipwell	32mm	32m
Dipwell	38mm	42m
Datum post	23mm	42m

Water level recorder 7 staff level of 5.000m shown on October 87 level exercise to be 5.103m!

3) Dipwell transect T3 & Water level recorder staff 2

		Distance from rhyne
Datum post	-9mm	2m
Dipwell	-3mm	2m
Dipwell	34mm	12m
Dipwell	46mm	22m
Dipwell	45mm	32m
Dipwell	23mm	42m
Datum post	40mm	42m

Water level recorder 2 staff level of 5.000m stated to be still correct.

4) Dipwell transect T4

		Distance from rhyne
Datum post	42mm	2m
Dipwell	21mm	2m
Dipwell	17mm	12m
Dipwell	16mm	22m
Dipwell	20mm	32m
Dipwell	27mm	42m
Datum post	13mm	42m

5) Water level recorders 1, 3, 4 & 5

Water level recorder 1 staff dropped 3mm

Water level recorder 3 staff - no data supplied to IH from Oct 87 survey

Water level recorder 4 staff dropped 11mm

Water level recorder 5 staff dropped 5mm

West Sedgemoor pumping station

Copies of the pumping station operator's log sheets were provided by WWA. These show the days and times that the two diesel pumps were operating, together with the water level on both the suction and delivery sides of the pumping station, which was recorded manually. A program was written to use this information in association with the head-discharge characteristic curve for the pumps, to generate average daily (pumped) flows for the pumping station. This had been done for the period 1 Nov 63 - 10 Nov 85 and during the period has been updated to 12 Jan 87, after which the new electric pumping station started to operate.

It was, originally, difficult to compute the amount of water pumped by the new electric pumping station. The variable speed pump was initially fitted with an 'hours run' meter and this alone was not sufficient to compute the volume of pumped runoff other than as a total number of hours occurring at unknown times within a known period and with no record of the head across the pumping station. WWA agreed to fit a flowmeter at the pumping station at their own expense (approximately £50, as much of the necessary electronics was already installed for other reasons). The flowmeter which will need to be read manually, was installed in September 1987 and WWA have indicated that the meter will be read daily except weekends. It follows that the pumping station data from January 1987 - September 1987 will be of relatively low quality.

Streamflow gauge at Bowldish farm

This natural section gauging station near Bowldish Farm, recording the flow from an area of 'highland' approximately 12.5 sq km at the south west end of the moor, began operating on 17 Febuary 87. IH has been supplied with data up to 20 August, together with a warning that minor changes may be made to the rating curve at a later date.

Database

During January 1987 a database was set up on the Institute's IBM mainframe to hold the water level and rainfall data being collected. The database is structured in blocks of one day at one site. Each day has assigned to it 100 locations each capable of storing 1 value. In a 24 hour period, data collected at a 15 minute interval will occupy 96 locations. The date, being the 'key' for a 24 hour period, is stored in one of the 4 remaining locations, the remaining three locations are available for flagging the data should the need arise. This approach allows very flexible data retrieval. Analysis programs have been written to interact directly with the database. Graphical quality control programs allow examination and correction of the data. Data from up to four sites can be compared simultaneously. It is possible to display three water level traces and the rainfall in order to assess the effect of the rainfall on the drain water levels and implicitly through the recorder traces, the pumping station. Example graphs illustrating rainfall and water level data for June 86 are attached.

Schools GCSE projects

With NCC permission, data from the water level recorders, dipwells and raingauge was passed to Somerset County Council's planning department in October 1987 for distribution to local schools to use in GCSE project work. A letter received on 4 November indicated that the data had been passed on to Taunton school, Kings college, Richard Huish college, Queens college and Wellington college. The letter also said that Somerset CC would be touch with NCC in due course.

HYDROLOGICAL STUDIES OF WEST SEDGEMOOR

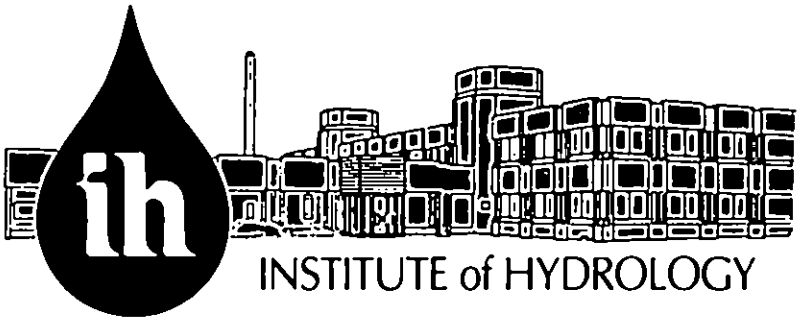
MARCH 1986 - JANUARY 1988

APPENDIX 1

SUMMARY OF INFLOWS, OUTFLOWS AND RESULTING WATER LEVELS WITHIN WEST SEDGEMOOR, JAN 86 - JUL 87.

				(LAST DAY OF MONTH AVERAGE WATER LEVELS)						
	(1)	(2)	(3)	WLR1	WLR2	WLR3	WLR4	WLR5	WLR6	WLR7
JAN 86	44.764	83.4	89.8	*	*	*	*	*	*	*
FEB 86	12.096	3.2	2.0	---	3.762	4.274	*	*	---	*
MAR 86	7.235	40.0	48.1	4.360	---	4.556	*	*	---	*
APR 86	16.550	70.3	67.1	4.620	4.144	4.526	*	*	---	*
MAY 86	11.036	73.0	76.2	4.436	---	4.621	*	*	---	*
JUN 86	3.660	31.9	32.2	---	---	4.573	*	*	---	*
JUL 86	0.310	31.9	33.6	4.613	4.580	---	*	*	4.799	*
AUG 86	4.154	31.6	38.8	---	4.502	4.652	*	*	4.765	*
SEP 86	1.500	30.7	33.2	4.650	---	4.650	*	*	4.627	*
OCT 86	2.511	57.5	58.7	4.583	---	4.670	*	*	4.673	*
NOV 86	23.430	66.2	91.3	4.373	---	4.565	4.495	4.509	4.565	4.40
DEC 86	33.294	79.3	93.5	4.413	---	4.634	---	4.513	4.565	4.40
JAN 87	#	14.2	12.9	---	---	4.381	4.426	4.305	4.426	4.23
FEB 87	#	39.2	46.2	---	---	4.648	4.481	4.487	4.488	4.38
MAR 87	#	34.7	42.2	3.869	---	4.312	3.967	4.202	4.373	---
APR 87	#	43.3	46.6	4.559	4.525	4.590	4.560	4.580	4.583	4.46
MAY 87	#	22.2	24.3	4.630	4.594	4.621	4.588	4.624	4.627	4.50
JUN 87	#	51.7	60.7	4.587	4.561	4.608	4.570	4.621	4.620	4.48
JUL 87	#	34.9	42.4	#	#	#	#	4.658	4.636	4.49

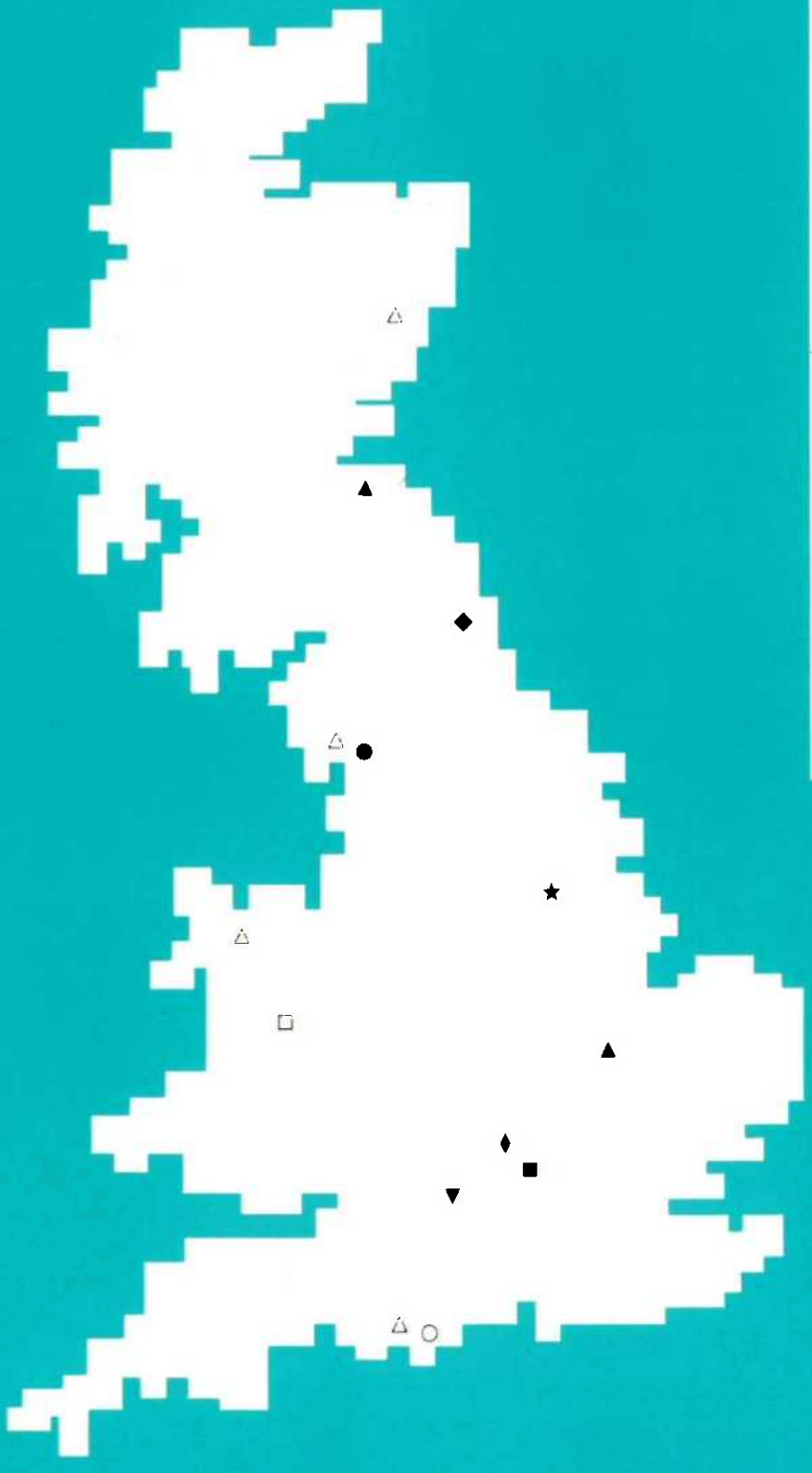
* = BEFORE SITE BECAME ACTIVE
--- = LOST DATA
\# = DATA NOT YET PROCESSED
(1) = MONTHLY VOLUME PUMPED IN CUMEC-DAYS
(2) = RAINFALL IN MM AT PUMPING STATION
(3) = RAINFALL IN MM AT FIVEHEAD



The **Institute of Hydrology** is a component establishment of the UK Natural Environment Research Council, grant-aided from Government by the Department of Education and Science. For over 20 years the Institute has been at the forefront of research exploration of hydrological systems within complete catchment areas and into the physical processes by which rain or snow is transformed into flow in rivers. Applied studies, undertaken both in the UK and overseas, ensures that research activities are closely related to practical needs and that newly developed methods and instruments are tested for a wide range of environmental conditions.

The Institute, based at Wallingford, employs 140 staff, some 100 of whom are graduates. Staff structure is multidisciplinary involving physicists, geographers, geologists, computer scientists, mathematicians, chemists, environmental scientists, soil scientists and botanists. Research departments include catchment research, remote sensing, instrumentation, data processing, mathematical modelling, hydrogeology, hydrochemistry, soil hydrology, evaporation flux studies, vegetation-atmospheric interactions, flood and low-flow predictions, catchment response and engineering hydrology.

The budget of the Institute comprises £4.5 million per year. About 50 percent relates to research programmes funded directly by the Natural Environment Research Council. Extensive commissioned research is also carried out on behalf of government departments (both UK and overseas), various international agencies, environmental organisations and private sector clients. The Institute is also responsible for nationally archived hydrological data and for publishing annually HYDROLOGICAL DATA: UNITED KINGDOM.



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