WATER BALANCE STUDY OF THIBA SECTION OF MWEA IRRIGATION SETTLEMENT //

BY

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THIS THESIS IS MY ORIGINAL WORK AND HAS NOT BEEN PRESENTED FOR A DEGREE IN ANY OTHER UNIVERSITY

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DEDICATED TO MY BELOVED PARENTS:

DAVID CHUAGA WA KŨBIŨ AND WANJIRŨ WA CHUAGA.

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ABSTRACTS

At present the Thiba and Nyamindi rivers are unable to meet the demands for the rice production. Therefore Water Balance Study was conducted in Thiba Section of Mwea Irrigation Scheme to seek more information regarding water utilization in the Scheme.

The main objectives were: to determine the water requirements at various stages of rice cultivation under present management; to determine seepage and percolation losses in unit feeders; to investigate the canal damage by water erosion, human beings and animals and to recommend ways and means of improving the current water management.

Each Unit had a constant-head orifice (CHO) at the outlet. Weirs were installed at the outlets of the Units. The inflow and outflow data were collected at least twice daily. Piezometers were installed in selected nurseries of the above Units at three levels. The weather data were collected twice a day. All readings were expressed in mm/day.

From this study it was found that rice growth and development stages consumed the most effective water - 44.8% of total effective water supplied to

Thiba Section, followed by water topping stage - 38.8%, and land preparation stage needed 16.4% of the total effective water. Of the total water supplied for the rice production in Thiba Section, river water constituted about 85.9% while rainfall water constituted 14.1%. The total irrigation water was utilised as follows:- 35.0% lost through evapotranspiration; 34.1% passed out of the fields as outflow; 7.9% was lost as deep percolation and 23.0% was stored in the soil.

The total estimated effective water requirements for 1979/80 season were 2667 ha-metres. The effective water requirements per hectare for the 1979/80 season was 2.34 ha-metres; effective water required per 0.405 ha holding (one-acre holding) for the same season was 0.95 ha-metres (9500 m^3); effective water required to produce 1 kg of paddy rice was 4.19 m^3 and effective water required to produce a 75 kg bag of paddy rice was 313.95 m^3. Owing to canal damage the main canal capacity is 83.4% greater than original capacity; the main canal gradient has increased from 1:3500 to 1:540. The side slopes are non-uniform. The shape of the canal cross-section has changed from trapezoidal to parabolic. Similar changes have taken place in the branch canals. The canal seepage losses are negligible once the soil is saturated. However, when the canals are dry and badly cracked, the seepage losses are 7.5 mm/hour for the first twelve hours. After twelve hours the seepage losses are almost zero.

From this study it was concluded that the irrigation water should be managed better than it was then; the water usage can be minimised if water topping stage can be reduced, the soils in the Units H1, H2, H3 and H20 did not have any drainage problems. Water table rises during the growing season and then falls below 150 cm during and after the harvesting stage. The water quality for both Irrigation and drain waters was good. Although horizontal flow was prevented in the experimental plots, such flow occurred from the field to the drain in practice.

To improve the present water management the following recommendations were made:-

1. The technical staff in-charge of water control needs training in water management.

Irrigation officers should have a sufficient knowledge of irrigation practices.

2. The tenants need to be educated in proper water utilization and management. They should be closely supervised to avoid misuse of water.

3. The existing water measuring structures need regular maintenance.

4. Additional water measuring structures should be installed in various canals and drains.

5. Water measuring scheme should be worked out as a part of water management in the settlement.

6. As the maximum water requirements are at transplanting and tillering stages, the possibility of building a storage dam should be investigated.

7. At the moment the rice growth depends on the availability of irrigation. The utilization of long rains needs more studies with an aim of having two crops per year.

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SYMBOLS AND ABBREVIATIONS

A	Cross-Sectional area of the canal
b	bottom or bed width of the canal
B	Top width of the canal
B.C.	Branch Canal
B.M.	Bench Mark
Bp	Blue piezometer
ca	calcium
c.e.c.	cation exchange capacity
CHO	constant head orifice
cm	centimeter
CR	capillary rise from high water table
d	canal depth
Dp	Deep percolation
Ec	Electrical conductivity
Eo	Pan evaporation
ESP	Exchange sodium percentage
E_T	Potential evapotranspiration
Ev	Evaporation
g	gram
H	Thiba Section
H1, H2, H3, etc.	Unit one, unit two, unit three, etc of Thiba Section
ha	Hectare
i	Hydraulic gradient
I	Inflow

k	potassium
Ls	Lateral Subsurface flow
m	metre
M.C.	Main canal
M.e.	milliequivalent
mg	magnesium
M.I.S.	Mwea Irrigation Settlement (or Mwea Irrigation Scheme)
mm	millimeter
n	Manning's roughness coefficient
N	Nitrogen
Na	Sodium
N.I.B.	National Irrigation Board
O	outflow
%	percentage
O.M.	Organic Matter
p	phosphorous
P	Wetted perimeter
pH	Log hydrogen ion concentration
ppm	parts per million
Qt	Current capacity of the canal
Qi	Initial design capacity of the canal
R	Rainfall
R	Hydraulic radius
R.L.	Reduced Level
S	Average gradient of the canal
SD	Surface drainage

Sf	Final water storage in the soil
si	Initial water storage in the soil
S.I.	Seepage Inflow
SRD	Scientific Research Division
STN	Station
V	Velocity
Wd	Water delivered to the field
WP	White piezometer
Wu	Water beneficially used in the field
Yp	Yellow piezometer
Z	Side slopes (in ratio)

CHAPTER 1

GENERAL INFORMATION

1.1 INTRODUCTION:

Mwea Irrigation Scheme (M.I.S.) is a rice Scheme located 96 km N.E. of Nairobi, near the foot hills of Mount Kenya, at an altitude of 1159 m above sea level, and latitudes of $0^{o}37'$ and $0^{o}45'$ South, longitudes $37^{o}17'$ and $37^{o}26'$ East. The Irrigation water is derived from the Thiba and Nyamindi rivers which rise in the high rainfall zone of the slopes of Mount Kenya.

The soils in the area consist of free draining reddish brown lateritic clay loam and impervious heavy (black cotton) clay. They are generally rather shallow and are underlaid by murram (ferricrete) and volcanic tuff.

Mwea Irrigation Scheme is divided into five sections - (See Fig. 6, P. 50) namely Tebere (1283 ha), Mwea (1213 ha), Thiba (1139 ha) - See Table 1, P. 2 , Wamumu (1094 ha) and Karaba (1034 ha). M.I.S. has good infrastructures.

TABLE 1: THIBA SECTION HOLDINGS

UNIT	NOS OF HOLDINGS	EXTRA FIELDS	TOTAL AREA ha.	UNIT	HOLDING	EXTRA FIELDS	TOTAL ha.
H1	176	3	72.47	H7	136	66	81.78
H2	220	6	91.50	H8	196	38	94.74
H3	260	7	108.10	H18	262	13	111.34
H4	204	17	89.47	H19	228	43	109.72
H5	360	23	155.06	H20	248	36	114.98
H6	236	35	109.72				

1.2 CLIMATE:

Climate (15) combined with latitude is a most important element in paddy production. The average mean temperature ranges from 20°C (July) to 23.3° (February). The average mean relative humidity varies from 52% (February) to 67% (May & July). The monthly mean evaporation (Class "A" Pan) ranges from 121 mm (July or 3.9 mm/day) to 224 mm (March or 7.2 mm/day). The mean monthly rainfall ranges from 16 mm (August and September to 251 mm (April), see Fig. 1, P. 4 Long rains occur during the months of March, April and May and short rains during the months of October, November and December. The mean wind speed varies from 3.36 kph (June) to 6.4 kph (February and September). The mean sunshine hours ranges from 3.7 hours/day (June) to 9 hours/day (February). A summary of Meteorological data for M.I.S. is in Appendix IV. A table showing the average rainfall for the years 1963-79 is given on page 5.

1.3 STATEMENT OF THE PROBLEM

Mwea Irrigation Scheme has been facing a variety of problems ranging from technical,

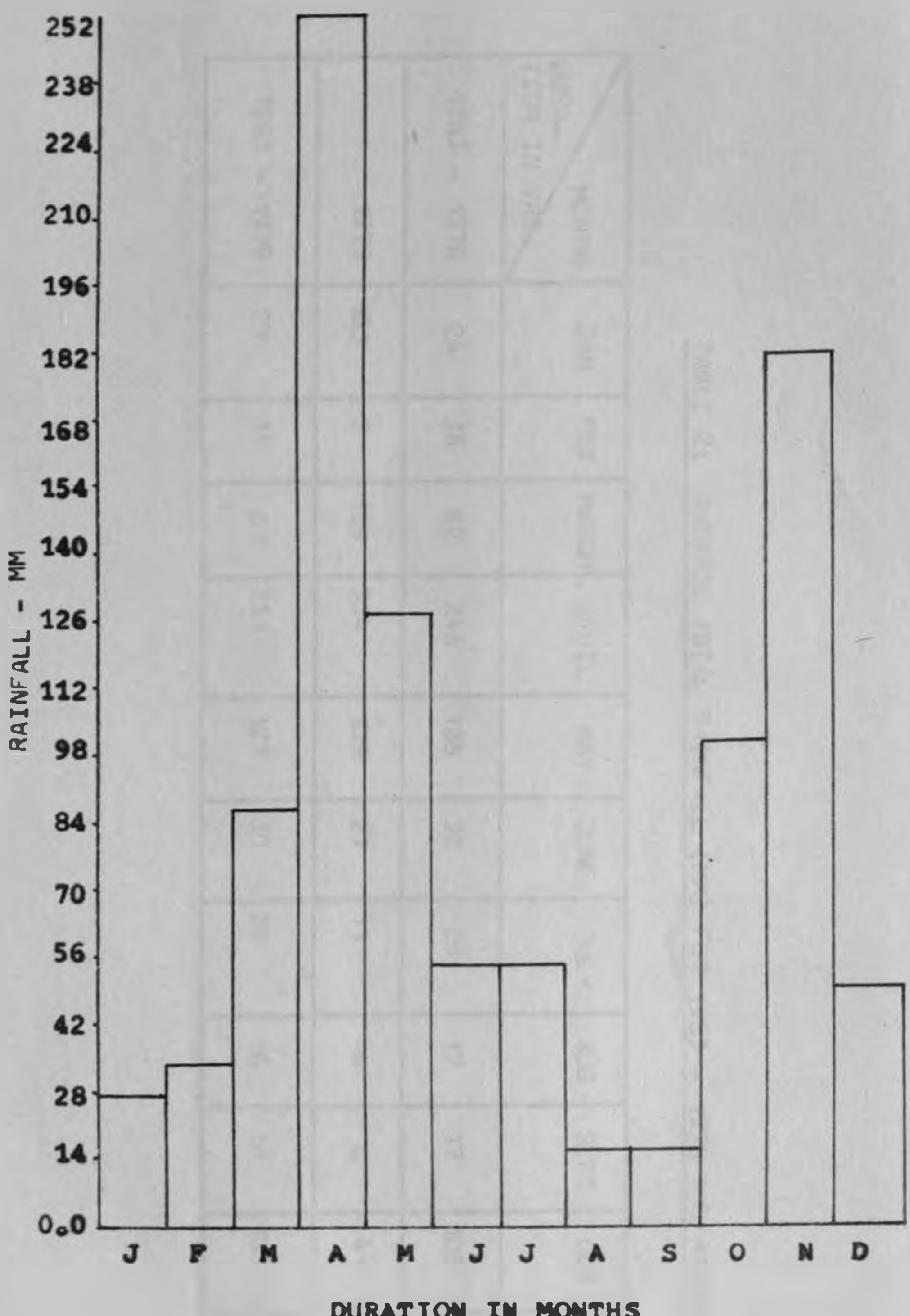


FIG. 1 AVERAGE TOTAL RAINFALL FOR YEARS 1963–1979

TABLE 2: AVERAGE TOTAL RAINFALL (MM) FOR 1963 - 1978 AND RAINFALL FOR 1979

MONTH / DURATION IN YRS.	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1963 - 1978	24	36	82	246	128	30	29	17	17	105	178	48
1979	103	5	159	334	109	27	13	4	4	41	221	58
1963 - 1979	29	34	87	251	127	30	28	16	16	101	181	49

concerning rice agronomy, water management to social and economic. The National Irrigation Board has initiated some study proposals for the major problems which have been identified in this scheme. One of the identified problems in M.I.S. is formulation of water resources development strategy as the details of the water requirements of the rice production are unknown.

Currently the gross water demands for the rice scheme overshadows all other demands on the Thiba and Nyamindi rivers. The farmers on the upper reaches of these rivers were consistently wishing to have supplemental irrigation, but the Water Apportionment Board cannot grant them water permits because of the high demands from the rice scheme. The causes of these high demands are not documented; whether these are due to scheme expansion or water mismanagement is not clear. The case being so, it was concluded that the study of the evaluation of water use at M.I.S. is vital if the Water Apportionment policy and development strategy can be based on sound planning data.

1.4 THESIS OBJECTIVES:

The objectives of the present study are based on those formulated by the NIB for water use study. These are:-

1. To determine the water requirements at various stages of rice cultivation under the present water management:-

   (a) to determine water losses through deep percolation

   (b) to determine evaporation losses

   (c) to determine evapotranspiration rate of the main rice varieties grown in Thiba Section

   (d) to determine water stored in the soil

   (e) to measure inflow and outflow for selected units.

2. To determine seepage and percolation losses in unit feeders and then determine conveyance and distribution efficiencies.

3. To investigate the canal damage by water erosion, human beings and animals.

4. To recommend ways and means of improving the current water management.

CHAPTER 2

RICE

2.1 PHYSIOLOGIC PHASES IN THE RICE GROWTH PROCESS

The entire life cycle of the rice plant may be divided into three main phases. These are:

1. Vegetative phase - (from seed germination to panicle initiation.

2. Reproductive phase - (from panicle initiation to flowering).

3. Ripening phase - (from flowering to full maturity).

These main phases, however, may be sub-divided into physiologically distinct stages or periods as discussed below:-

1. VEGETATIVE PHASE

This phase begins with seed germination which is signified by the emergence of radicle or coleoptile in the germinating embryo as shown in Fig. 2.

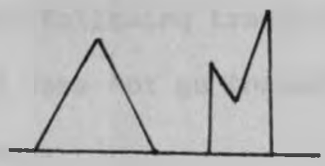


Fig. 2: Coleoptile (and tip of primary leaf).

During the vegetative stage, the plant undergoes the following stages:-

Seedling Stage:

This stage follows seed germination. At the seedling stage, the seedling develops seminal and lateral roots. The leaves grow until the fifth leaf develops (Fig. 3). During this stage, the seedling absorbs most of the endosperm.

Fig. 3. Seedling at 5-leaf stage.

Transplanting Stage

Transplanted seedlings undergo through this stage, which covers the period from uprooting of the seedling to full recovery following transplanting. Seed sown directly in the field does not go through the transplanting and recovery stage.

Tillering Stage

The tillering stage follows the seedling stage.

It starts with the appearance of first tillers from the axillary bud in one of the lowermost nodes. The increase in number of tillers continues until the maximum tillers (maximum tillering stage) is reached. Then some tillers die and the number of tillers declines and then levels off. The plants stop producing tillers after the tertiary tillers (third group of tillers) have been produced.

Component - Phases of the Vegetative Phase

The vegetative phase is the most variable of the phases of plant growth. This phase is markedly affected in certain varieties by the prevailing daylength and temperature and be subdivided further into two phases:-

(i) the basic vegetative or active vegetative phase,

(ii) photoperiod-sensitive phase or lag-vegetative phase.

The basic vegetative phase or active vegetative phase, is the minimum period of vegetative growth required by plant before it will initiate a panicle primordium. The usual variations of daylength have little or no effect on its duration. In temperature-sensitive varieties, temperature may either shorten or lengthen its duration.

The photoperiod-sensitive phase or lag vegetative is that portion of the vegetative phase in which flowering date is determined by the number of hours of daylight per day to which the plant is exposed. It is therefore, from the end of the basic vegetative phase to panicle initiation. Not all varieties have a photoperiod-sensitive phase. Early maturing and non-seasonal varieties usually have very short photoperiod-sensitive phase.

2. REPRODUCTIVE PHASE

Panicle Initiation Stage

The reproductive phase may begin before the maximum tiller number is reached, at about the time of the highest tillering activity or thereafter. This phase is marked by the initiation of the panicle primordium of microscopic dimension at the growing shoot.

Panicle initiation occurs approximately 70 to 75 days before the expected date of maturity of any variety. This period corresponds roughly to 60 to 70 days after seeding for non-seasonal varieties maturing in 130 days.

The date of initiation of the panicle from seeding in seasonal or photoperiod-sensitive varieties varies because panicle initiation depends on daylength to which the plant is subjected.

Internode Elongation and Booting Stage

The time of occurrence of internode elongation stage differs among varieties. With late maturing varieties, the accelerated elongation of the upper internodes may begin considerably earlier than the reproductive phase. With early maturing varieties, elongation may begin after panicle initiation.

As the young panicle develops, it becomes visible to the naked eye in a few days. The tiny panicle is a transparent structure measuring 1 to 2 mm long with a fizzy and spongy tip. This occurs about 55 days before the expected date of maturity of a variety and marks the beginning of the booting.

As panicle development continues, the spikelets become distinguishable. The increase in the size of the young panicle and its upward extension inside the flag leaf sheath causes the sheath to bulge. Culms must be dissected to observe these developments for panicles are still enclosed by leaf sheaths during this period.

Heading Stage

The booting stage is followed by the emergence of panicle tip (heading) out of the flag leaf sheath. Emergence continues until 90% of the panicles are out of the sheaths. Anthesis (blooming or flowering) begins with the protrusion of the first dehiscing anthers in the terminal spikelets on the panicle branches. Flowering occurs about 25 days after booting regardless of variety. Flowering continues successively until all spikelets in the panicles bloom. Pollination and fertilization then follow.

3. RIPENING PHASE

The ripening phase (from flowering to maturity) occupies a period of 25 to 35 days regardless of variety. The rice grain develops after pollination and fertilization. Grain development is a continuous process and the grain undergoes distinct changes before it fully matures.

Milk Stage

The contents of the caryopsis (the starch portion of the grain) are first watery but later turn milky in consistency.

Dough Stage

The milky caryopsis turns into soft dough and later turns into hard dough.

Maturation Stage

The individual grain is mature when the caryopsis is fully developed in size and is hard, clear, and free from greenish tint. The maturation stage is complete when more than 90% of grains in the panicles are fully ripened. Mature grains may have a greenish tint if harvested with moisture content of 26% or more.

As the grains ripen, the leaves become senescent, and turn yellowish in ascending order. The non-functioning leaves and culm tissues are termed dead straw. In some varieties, the culm and upper leaves may remain green even when the grains have ripened. The straw dies and the over-ripened grains shatter from the panicle. Cracking of the caryopsis within the lemma and palea may occur while the kernels are still attached to the panicle with a resulting loss in milling recovery and market grade.

In this study the author was interested in determining water use in different rice (Sindano variety) husbandry stages. The rice husbandry stages were divided as shown below:-

1. Land preparation (from flooding to end of rotavation).
2. Water topping (from end of rotavation to beginning of transplanting).

3. Rice growth and development (from transplanting to maturity).

4. Harvesting (from cutting to field bagging).

The duration of land preparation stage is governed by the area of the unit. The more the area the longer the duration of the land preparation stage, for a given strength of tractor team, (at the time of conducting the study a tractor team consisted of 6 tractors). Water topping stage is governed by the management factors (Number of tractors available, seeds and fertilizer distribution, water distribution, rice transport, rice drying etc). If some these management factors, are manipulated, the water topping can either be lengthened or shortened. The units in the first group have the longest water topping stage while those in the last group have the shortest water topping stage - (see tables 19, P. 98 and 20, P.102. The rice growth and development stage is a natural stage which ranges from 107 to 115 days (table 19, P.98). Sometimes owing to weather influence this stage can take about four months (122 days). The duration for harvesting stage is governed mainly by labour availability but mean duration is 38 days.

2.2 RICE HUSBANDRY PRACTISED IN MWEA: LAND PREPARATION

The mechanical land preparation is the common practice in the entire scheme. The scheme has a fleet of tractors to meet the annual requirements. Before the rotavation starts, the rice fields are flooded to soften the ground. Thereafter the fields are rotavated with the ground covered by water upto a depth of 10 cm to 15 cm. After rotavation the fields are still kept under water as a means of weed control till transplanting operation starts. Experience has shown that a tractor team of six tractors is the most practical working unit. Each of the four sections at Mwea is allocated a six tractor team, supervised by a tractor supervisor, which deals with its entire hectareage at an average rate since 1961 of 1.54 ha per day. Tractors move over the dykes by portable ramps.

After rotavation has been finished, the harrowing and manual weeding follow just a month or so before transplanting. The harrowing is done by oxen pulling a local tined harrow (tines fixed on a piece of wood). The harrowing is carried out while the fields are still under a water depth of 10 cm to 15 cm. When tined harrow does not do a good job, the tenants go over the fields manually, smoothening the areas where the mud is heaped and at the same time uproot the weeds.

<u>Nurseries Preparation</u>

After harvesting, before the ground hardens, the tenants dig the nursery plots with a "jembe" (hoe). The size of the nursery is 0.051 ha. When the fields are flooded so as to soften the ground, some water is allowed to enter the nursery plots. The ground is covered by water to a depth of 10 cm to 15 cm. The nursery plots are harrowed by tined harrows drawn by oxen. After this the final touches are done manually. Weeding is also done manually. The nursery plots are levelled to a zero grade. During the levelling operation the water is drained till a depth of about 5 cm is left on the surface. After levelling the water is added to a depth of about 15 cm; this water level is maintained till the seeds are broadcasted.

Sowing and Transplanting[1]

Mwea paddy is sown in nurseries and then transplanted. A disadvantage of transplanting may be that it requires more labour than broadcasting or drilling but given Kenya's unemployment problem this labour intensive approach is welcomed. Transplanting is excellently done by children. The local schools' holidays have been planned to coincide with the transplanting time. Transplanting has the advantages over drilling or broadcasting of generally producing a crop which develops faster, is more uniform in stand, matures

[1] Moris & Chamber P. 112-114

a little later, and produces a greater number of tillers because of more even spacing. Even spacing and better tillering also decrease weed growth and facilitate weed control through easier access to the field.

Each tenant has his or her own nursery to cater for his four 0.405 ha - holdings. If a tenant has extra fields, he/she establishes extra nurseries to cater for them. For ease of transplanting the nursery is sub-divided using sticks into four equal-sized beds, each surrounded by a narrow channel to facilitate water control. In the past, the scheme experimented with communal nurseries but this led to an impossible situation in which no tenant would accept an responsibility for whatever went wrong. Since the introduction of individual nurseries, a high standard has been obtained and also the control by the field staff is much more effective.

After the nurseries are prepared as mentioned earlier (NURSERIES PREPARATION), pregerminated seeds are then evenly broadcasted at a seed rate of about 18.2 kg per 0.405 ha. This apparently dense seed rate is necessary to provide adequate surplus of seedling for "gapping" where transplanted seedlings die off or birds cause havoc at night, as frequently happens in the scheme.

Nitrogen fertilizer (Sulphate of Ammonia) is applied at sowing at a rate of 40 kg of nitrogen fertilizer per nursery plot to ensure a good rooting ability at transplanting and a strong seedling. Half the rate is applied at the intial stages and the remaining when the seedlings are about 10 cm. tall. The water level in the nursery is increased in accordance with the growth of the seedling. The water depth ranges from 5 cm to 10 cm. The seedlings mature in the nursery for 25 days when they attain a height of about 15 cm. Leaving the seedlings too long in the nursery would complicate the growing process directly after transplanting and decrease heading ability.

The tenant removes all weeds from the fields prior to transplanting, and does some final levelling necessary. Water is drained off, leaving a film of water over the field just about 5 cm. The seedlings are then uprooted by pulling them out manually, and the roots carefully washed to clean all mud from the root system. The tips of the leaves are cut by hand twisting to make the seedlings short enough to minimise problems of transporting and transplanting. The spacing recommended at Mwea is 10 cm. x 10 cm. with one seedling per hole. This recommendation is rarely observed.

Transplanting is an arduous job which requires a great deal of attention and labour. Closer spacing than that recommended can cause severe intershading at a later stage and decrease production; wider spacing means poor land utilization. The seedlings should not be planted too deep as this restrict proper root development and retards plant growth.

Tenants generally engage casual labour to assist them with transplanting but as the work is done on a task basis, wide spacing by the casuals, to speed up their task, is often the result. Although a rope-line is not used to facilitate transplanting, visual spacing control works quite effectively and a fair degree of uniformity has been achieved although wide variations have been noted.

Fertilizers are applied at the time of transplanting to boost the initial growing phase. The rate of fertilizer application is 100 kg. per 0.405 ha, given in the form of sulphate of ammonia as a split application - 50 kg. at transplanting and the balance 28 days later. Phosphate is applied at transplanting at the rate specified by the technical staff when needed - normally every other year. Although nitrogen tends to increase the lodging effect at Mwea, this mainly occurs after heading and, as the crop is hand-harvested, it does not present the tenant with difficulty (it is often regarded as a welcome sign that the crop is heavy).

During transplanting and just after, the water depth in the fields should be kept from 0 to 10 cm, which can be reduced to encourage tillering. Although draining for a period of ten days is carried out between tillering and flowering in various countries, this practice is not followed at Mwea as it is felt that due to the nitrogen applications lodging would take place earlier if the fields were drained off during the period of growth.

Once the plant is established, water is added gradually as the plant grows. Finally the water is maintained at a depth ranging from 10 cm to 25 cm. Sometimes during the rains the depth increases to a maximum of 50.8 cm; the outlet of the field is opened to reduce it to the normal depth. It is recommended that the water be kept continuously flowing during the growing stage allowing a slight trickle of water over the inlet gate board and a similar flow over the outlet gate. This practice promotes a good erect stand as it supplies fresh aerated water but it does slightly increase the total water use. This recommendation is rarely observed by either tenants or technical staff.

After transplanting the only work the tenant has to do is to keep the water level at the correct depth, to weed and maintain the bunds, feeders and drain. Weed growth is generally severe, being mainly of sedges, grasses and algae, and it is vital that weeding is carried out at regular intervals during the first six weeks after transplanting. It was noted that there were a few tenants who are keen to observe all the recommendations. However, the technical staff are very vigilant and report to the irrigation officer in-charge, the tenants who do not follow the recommended practices for necessary action. Although experiments with herbicides have been carried out with good results, the tenant prefers hand weeding because labour is cheap (normally family labour) and abundantly available, whereas his cost per hectare would be significantly increased with chemical weed control. From a managerial viewpoint hand weeding is preferable to chemical weed-killing as the latter would raise problems of application.

2.3 AFTER HARVESTING

After harvesting is completed the paddy straw is evenly spread over the fields and burned. This retards a ratoon crop, regrowth of weeds during season and adds some potash and trace elements to the soil. The land is left in farrow till next season. Illegal grazing normally takes place during this time. The animals damage the canals and field dykes.

CHAPTER 3

SOIL AND WATER ANALYSIS

3.1 SOIL ANALYSIS

SOILS

The Mwea soils (15) can be divided into two main groups:

(a) black, montomorillonitic clay (grumustert) commonly known as "black cotton soil".

(b) reddish-brown lateritic clay loam, commonly described as "red soils".

The rice is grown in black cotton soil while cotton and other food stuff are grown in red soils. The three pits dug in Units H1, H2, and H20 and these profiles are described below. The results for soil analysis (samples collected from the above Units and analysized by the Department of Soil Science, University of Nairobi) are shown in table 3, P. 28.

PIT IN UNIT H1

Location: The pit was dug in central part of Unit H1.

Depth of pit: 122 cm.

Topography: gentle sloping plain

Parent Material: Thiba basalt

Vegetation/Land Use: rice growing

Soil classification: vertisol

Drainage: good surface drainage

PROFILE DESCRIPTION

0 - 23 cm	Dark brown clay; fine roots; moderate, medium, angular blocky structure; extremely hard when dry, very firm when moist, very sticky and plastic when wet; fine pores; gradual smooth boundary to:
23 - 46 cm	Black clay; moderate, medium to coarse prismatic structure ; extremely hard when dry, firm when moist, very sticky and plastic when wet; very fine to fine pores; a few, fine roots. Gradual smooth boundary to:
46 - 91 cm	Black clay; common fine to medium prominent yellowish red mottles; moderate medium prismatic structure; very hard when dry, very firm when moist, very sticky and plastic when wet. No roots. Gradual smooth boundary to:
91 - 122 cm	Grey, whitish clay; clay mixed with broken stones (murram-like); coarse structure. No roots.

PIT IN UNIT H2

Location: The pit was dug on central part of the access road leading to the research station.

Depth of pit: 122 cm.

Topography: gentle sloping plain.

Parent Material: Thiba basalt

Vegetation/Land use: rice growing

Soil classification: Vertisol.

Drainage: good surface drainage.

PROFILE DESCRIPTION:

0 - 23 cm Brown to black clay; strong medium, angular blocky structure; extremely hard when dry, very firm when moist; very sticky and plastic when wet, few fine pores; many fine roots. Gradual smooth boundary to:

23 - 46 cm Black clay; moderate coarse prismatic structure breaking to some moderate medium angular blocks; extremely hard when dry, very firm when moist, very sticky and plastic when fine; fine pores, cracks badly. Gradual smooth boundary to:

46 - 91 cm Black clay; few, fine, prominent yellowish red mottles; moderate, medium angular blcoky structure; extremely hard when dry, firm when moist, very sticky and plastic when wet; fine pores. No roots. Cracks badly.

Gradual smooth boundary to:

91 - 122 cm Grey clay mixed with broken, round stones (Murram-like). Coarse structure; No roots.

PIT IN UNIT H20

Location: The pit was dug on central part of the 2nd access road from main drain outlet.

Depth of pit: 122 cm.

Topography: gentle sloping plain.

Parent Material: Thiba basalt.

Vegetation/Land use: rice growing.

Soil classification: Vertisol.

Drainage: good surface drainage.

PROFILE DESCRIPTION

0 - 23 cm Very dark greyish brown clay; root channels and fine roots, coarse and granular structure, hard when dry; plastic when wet; cracks badly. Clear smooth lower boundary to:

23 - 46 cm Very dark grey clay; coarse blocky structure; hard and firm when moist; plastic and sticky when wet; cracks badly. Gradual smooth boundary to:

46 - 91 cm Black clay; moderate and strong blocky structure; extremely hard and very firm;

plastic and sticky when wet. No roots, cracks badly. Gradual smooth boundary to:

91 - 122 cm Dark grey clay mixed with broken round stones (murram-like); coarse loose structure. Non-plastic and non-sticky when wet. No roots; porous.

SOIL ANALYSIS

The soil samples from each horizon were collected from the pits in Units H1, H2 and H20. The pits were dug upto a metre depth, the murram horizon was found. The soil samples were analyzed by Department of Soil Science, University of Nairobi for organic matter (O.M.), nitrogen (N) phosphorus (P), cation exchange capacity (C.E.C.), exchange bases (Calcium (Ca), magnesium (Mg), Sodium (Na), potassium (K) and exchange sodium percentage (EXP). The summary of the results is shown in table 3. P. 28.

Table 3: SUMMARY FOR SOIL CHEMICAL ANALYSIS FOR THIBA SECTION SOIL (UNITS H1, H2 & H20)*

PIT NO.	DEPTH cm	PH 1:2 H O	% O.M.	% N	ppm P	C.E.C. m.e/100g	EXCHANGE BASES Ca	Mg	Na	K	ESP*	REMARKS
H1	0-23	6.9	2.47	0.17	0.3	60.0	40.8	14.4	0.9	0.2	1.5	Non-alkaline
	23-46	7.3	2.22	0.13	0.4	48.2	30.1	10.6	2.1	0.1	4.4	"
	46-91	7.9	1.62	0.11	0.8	11.0	5.8	3.6	3.4	0.0	30.9	alkaline
	91-122	7.3	0.82	0.13	1.9	20.8	13.5	4.8	1.9	0.1	9.1	Non-alkaline
H2	0-23	7.3	1.69	0.20	0.4	59.2	41.3	10.7	0.9	0.2	1.5	"
	23-46	7.3	1.34	0.11	1.4	60.0	44.5	16.5	2.0	0.1	3.3	"
	46-91	7.3	1.30	0.11	0.4	57.4	39.1	12.8	4.2	0.1	7.3	"
	91-122	7.1	0.86	0.08	4.0	50.0	32.7	10.9	5.4	0.1	10.0	"
H20	0-23	7.3	2.22	0.20	2.0	65.2	45.9	18.6	10.3	1.2	15.8	alkaline
	23-46	8.8	1.28	0.17	0.3	62.8	39.5	21.5	13.0	0.3	20.7	"
	91-122	8.1	0.52	0.10	0.5	52.2	30.0	12.7	10.9	0.1	20.9	"

* If ESP (Exchange Sodium Percentage)

>15 soil is alkaline. $ESP = \frac{Na\ 100}{C.E.C.}$ (1)

\+ PH 1-7 : Acidity

PH 7.0 : Neutral

PH 7-14 : Alkaline

1.2 means one part of soil and two parts of water.

From the above results it can be concluded that soils of Units H1 and H2 are non-alkaline and non-calcarous while the soil of Unit H20 are alkaline and calcarous. It can also be noticed that the hydraulic conductivity as shown in Table 4, P.34 of soil of Unit H20 is almost zero. Black cotton soils require good management practices for cultivation.

* Analyst: Mr. Clement Mugo, Department of Soil Science, University of Nairobi.

LABORATORY MEASUREMENT OF HYDRAULIC CONDUCTIVITY

Laboratory measurement of hydraulic conductivity can be made either on disturbed or undisturbed samples. In this study undisturbed samples of soils were used. Various techniques and equipment are available for obtaining relatively undisturbed samples of soil from the field. The tools shown in Fig. 4(i), P.32 were used to collect the undisturbed samples of soil. The core ring was fitted into the core sampler and was driven into the soil with the help of a sledge hammer. After the core sampler reached the desired depth, it was withdrawn and the core ring along with the soil filled in it was removed carefully from the core sampler. The core ring with the soil was wrapped with a muslin cloth after labelling it. Using this method, more samples of soil were obtained from the horizons 1, 2, 3 and 4 labelled accordingly. Root holes, cracks, rocks can greatly influence results of such samples of soil.

The samples of soil were taken to the laboratory where the muslin cloth was tied with rubber bands at the bottom of the core ring and another empty core ring was fitted with insulating tape on top of the same core ring. These samples were saturated with water for twenty four hours. Finally the water was added on the top of the core ring and maintained at a constant head of **h** by frequent additions of water. Steady flow through the soil was obtained. The water flowing through the soil was collected in a graduated cylinder for time, t - see Fig. 4(ii). P. 33

Darcy's law for flow of water in soils is applied for computing permeability after measuring volume of flow Q in unit time, t, across soil cross-sectional area A at right angles to flow, loss of hydraulic head, H, and flow length L (where H = h+L). Using symbols defined above and solving the Darcy's flow equation for the permeability, it follows that

$$K = \frac{QL}{AH(t)} \qquad (2)$$

Full results for the samples of soil collected in this study are shown in tables 4, 5, and 6, P. 34, 36 and 38 respectively.

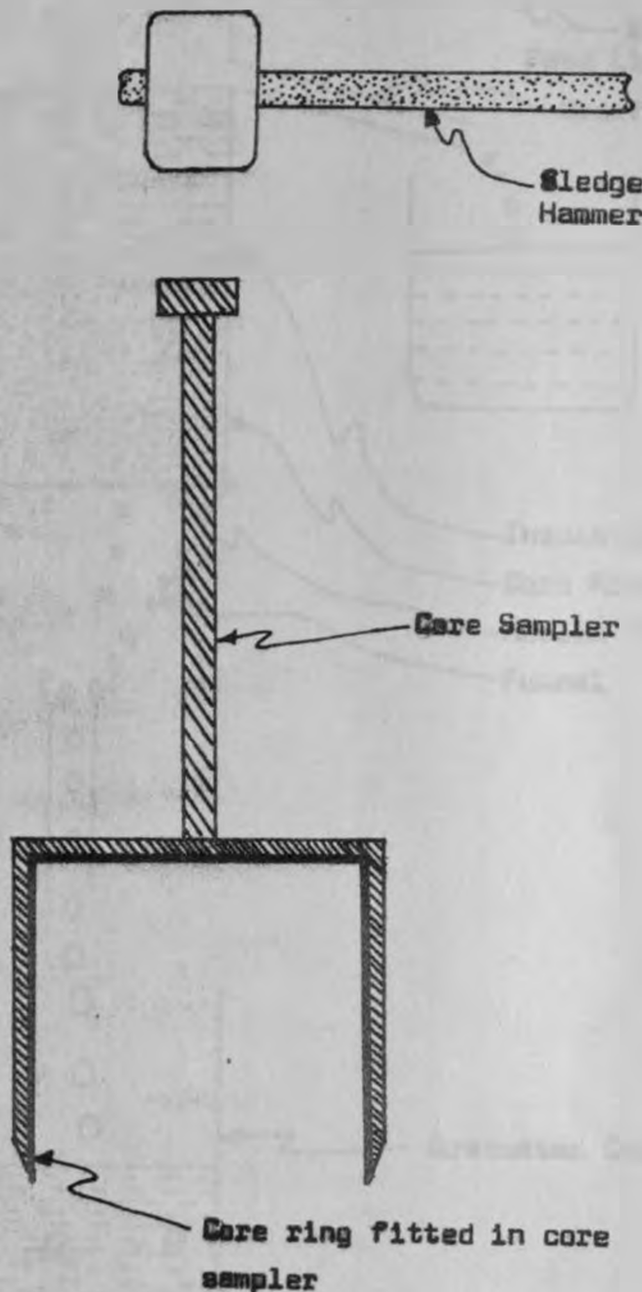


FIg. 4(1) SOIL SAMPLING TOOLS

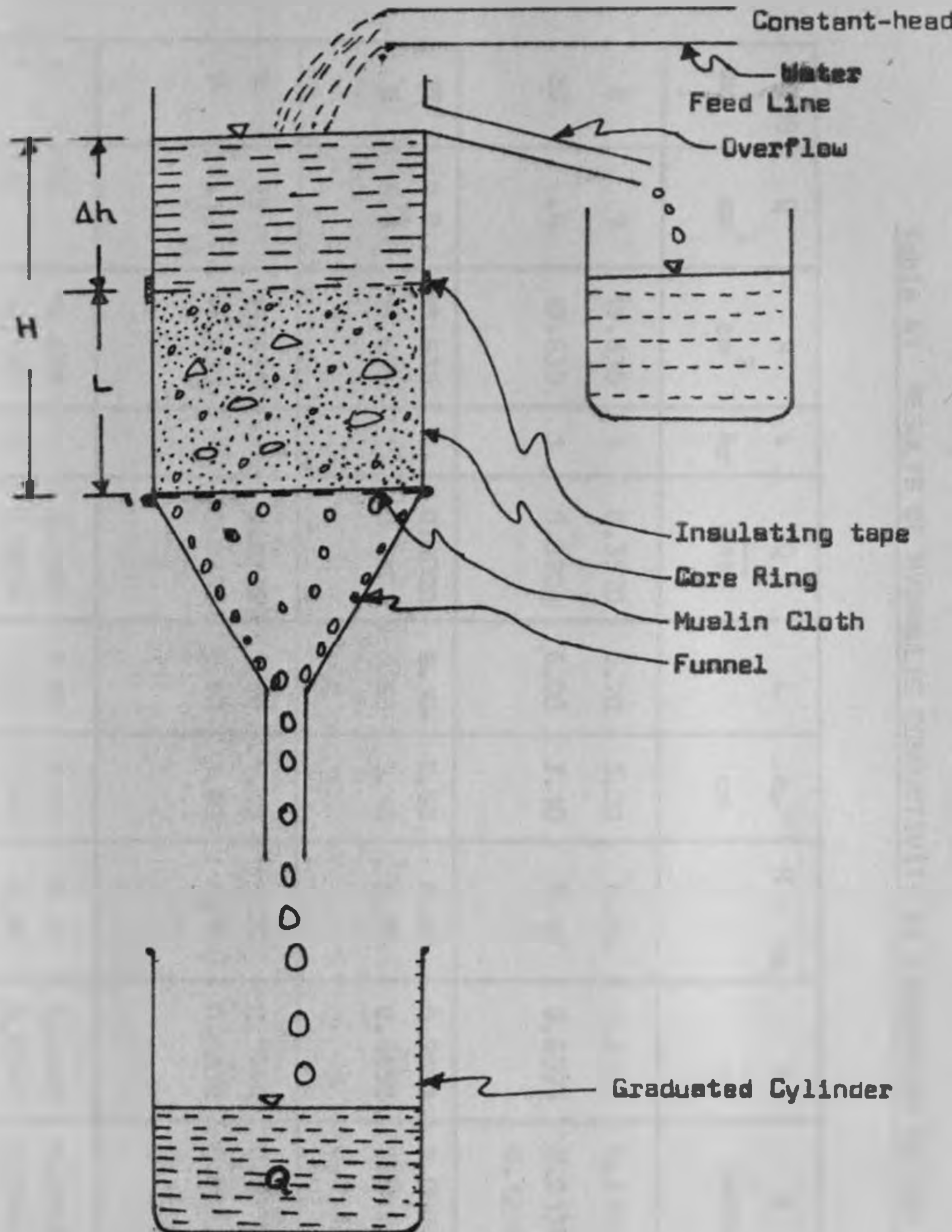


Fig. 4(11) CONSTANT-HEAD PERMEAMETER

Table 4: RESULTS OF HYDRAULIC CONDUCTIVITY BY LABORATORY METHOD FOR UNIT H1

RING No	Q cm^3	A cm^2	t hr	$\frac{Q}{At}$	L	h, cm	H = h+L	$\frac{L}{H}$	K cm/hr.	REMARKS
8	7	19.635	1	0.3570	5.70	3.00	8.70	0.6552	0.2336	HORIZON 1*
20	.4	19.635	1	0.0204	6.00	3.10	9.10	0.6593	0.0134	HORIZON 1
									0.1235	AVERAGE K
15	0.0	19.635	1	0.0000	6.10	2.50	8.60	0.7093	0.0000	HORIZON 2
5	16.5	19.635	1	0.8403	5.65	3.10	8.70	0.6457	0.5426	HORIZON 2
									0.2713	AVERAGE K
4	25	19.635	1	1.2732	4.90	4.10	9.00	0.5444	0.6932	HORIZON 3
7	0.1	19.635	1	0.0051	4.90	3.80	8.70	0.5632	0.0029	HORIZON 3
									0.3480	AVERAGE K
1	130	19.635	1	0.1104	5.20	3.00	8.20	0.6342	0.0700	HORIZON 4
3	110	19.635	1	0.0934	5.20	3.40	8.60	0.6047	0.0565	HORIZON 4
									0.0632	

• HORIZON 1: 0 - 23 cm.

HORIZON 2: 23 cm - 46 cm.

HORIZON 3: 46 cm - 91 cm.

HORIZON 4: 91 cm - 122 cm.

$$K = \frac{Q}{At}\frac{L}{H} \quad (2)$$

where

K = Hydraulic conductivity, cm/hr.

Q = Volume of water collected in cm^3.

A = Cross-sectional area of the core ring cm^2.

t = time taken to collect Q, hr.

L = Length of sample, cm

H = Δh + L where Δh = head of water on the surface in cm.

Table 5: RESULTS OF HYDRAULIC CONDUCTIVITY BY LABORATORY METHOD FOR UNIT H2

RING NO	Q c.c	A cm^2	t hr	$\frac{Q}{At}$	L cm	h cm	H = h+L	$\frac{L}{H}$	K cm/hr.	REMARKS
17	0.1	19.635	1	0.00009	6.00	2.60	8.60	0.6977	0.0001	HORIZON 1
23	4.2	19.635	1	0.00357	6.20	2.20	8.40	0.7381	0.0026	HORIZON 1
									0.0014	AVERAGE K
2	23	19.635	1	0.01952	6.20	2.80	9.00	0.6889	0.0135	HORIZON 2
12	58	19.635	1	0.04923	5.70	3.50	9.20	0.6196	0.0305	HORIZON 2
									0.0220	AVERAGE K
10	87	19.635	1	0.07385	5.60	3.60	9.20	0.6087	0.0450	HORIZON 3
19	30	19.635	1	0.02547	6.30	3.10	9.40	0.6702	0.0171	HORIZON 3
									0.0310	AVERAGE K
22	814	19.635	1	0.69094	5.30	3.40	8.70	0.6092	0.4209	HORIZON 4
24	0.0	19.635	1	0.00000	5.60	3.20	8.80	0.6364	0.0000	HORIZON 4
									0.2105	AVERAGE K

*HORIZON 1: 0-23 cm

HORIZON 2: 23cm - 46 cm

HORIZON 3: 46cm - 91 cm

HORIZON 4: 91cm - 122 cm

$$K = \frac{Q}{At} \frac{L}{H} \qquad (2)$$

Where K = Hydraulic Conductivity, cm/hr.

Q = Volume of water collected in c.c.

A = Cross-sectional area of the core ring, cm^2.

t = Time taken to collect Q, hr.

L = Length of sample, cm.

H = Δh+L where Δh= Head of water on the surface in cm.

Table 6: RESULTS OF HYDRAULIC CONDUCTIVITY BY LABORATORY METHOD FOR UNIT H20

RING NO	Q c.c	A cm^2	t hr	$\frac{Q}{At}$	L cm	h,	H = h+L	$\frac{L}{H}$	K cm/hr.	REMARKS
16	0.1	19.635	1	.0051	6.00	2.70	8.70	0.6897	0.0035	HORIZON 1
21	285	19.635	1	14.5150	5,70	2.90	8.60	0.6628		HORIZON 1
									4.81	AVERAGE K
9	0.3	19.635	1	0.0153	5.70	3.20	8.90	0.6405	0.0098	HORIZON 2
13	0.0	19.635	1	0.0000	6.20	2.50	8.70	0.7126	0.0000	HORIZON 2
									0.0049	AVERAGE K
14	0.3	19.635	1	0.0535	5.80	3.00	8.80	0.6591	0.0353	HORIZON 3
11	0.0	19.635	1	0.0000	5.60	3.10	8.70	0.6437	0.0000	HORIZON 3
									0.0177	AVERAGE K
6	0.30	19.635	1	0.0153	5.20	3.60	8.80	0.5909	0.0090	HORIZON 4
18	0.0	19.635	1	0.0000	6.00	3.70	9.70	0.6186	0.0000	HORIZON 4
									0.0045	AVERAGE K

*HORIZON 1: 0 - 23 cm

HORIZON 2: 23 cm - 46 cm

HORIZON 3: 46 cm - 91 cm

HORIZON 4: 91 cm - 122 cm

$$K = \frac{Q}{At} \frac{L}{H} \qquad (2)$$

Where K = Hydraulic Conductivity, cm/hr.

Q = Volume of water collected in c.c.

A = Cross-sectional area of the core ring cm^2.

t = Time taken to collect Q, hr.

L = Length of sample, cm.

H = $\Delta h + L$ where Δh = Head of water on the surface in cm.

Table 7: SUMMARY OF HYDRAULIC CONDUCTIVITY, (K) RESULTS

UNIT / HORIZON (depth, cm)	H1		H2		H20	
	K Cm/hr.	K Cm/day	K Cm/hr.	K Cm/day	K Cm/day	K Cm/day
1 (23 cm)	0.124	2.965	0.081	1.944	4.812	115.488
2 (23 cm)	0.271	6.504	1.319	31.651	0.0048	0.115
3 (46 cm)	0.348	8.352	1.861	44.654	0.018	0.432
4 (30 cm)	3.793	91.032	12.628	303.062	0.0045	0.108

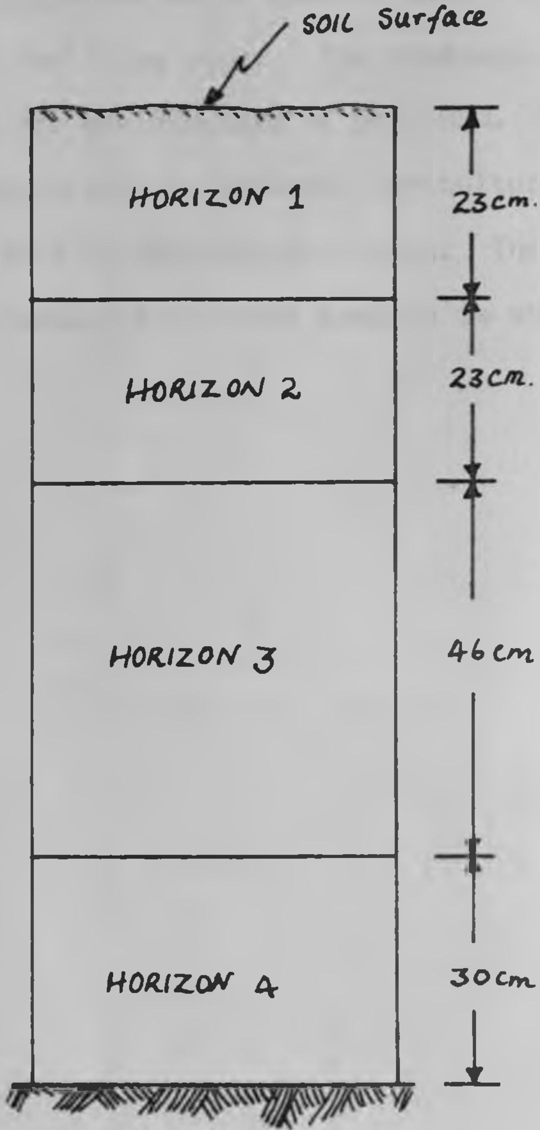


Fig. 5 SKETCH SHOWING HORIZONS

3.2 WATER ANALYSIS

The irrigation water samples were taken near the headworks of the Thiba river. The drainage water sample was taken at the drain outlet of unit H20. The said samples were analyzed by National Agricultural Laboratories, Ministry of Agriculture, Kenya. The summary for the chemical analysis of these samples is shown in table 8, P. 43.

Table 8: SUMMARY OF CHEMICAL ANALYSIS OF IRRIGATION AND DRAINAGE WATERS*

REF. Water Samples	RIVER WATER	DRAIN WATER	REMARKS
LAB. No. /80	11361	11362	
PH	7.8	8.4	
Conductivity micro mhos/cm	55	290	
Sodium me/litre	0.30	1.39	
Potassium me/litre	0.03	0.03	
Calcium me/litre	0.16	0.16	
Magnesium me/litre	0.16	1.06	
Carbonates me/litre	Nil	0.24	
Bicarbonates me/litre	0.30	1.36	
Chlorides me/litre	0.30	0.43	
Sulphate me/litre	Nil	0.25	
Nitrates me/litre			

Table 8: Continued

REF. Water Samples	RIVER WATER	DRAIN WATER	REMARKS
Fluorides me/litre			
Adjusted Sodium Adsorption Ratio+	0.75	1.80	
Na %	46	53	

* Water analysis was done by National Agricultural Laboratories, Ministry of Agriculture, Kenya.

\+ Adjusted Sodium Adsorption Ratio (Adj. SAR) =

$$\frac{Na}{\left(\frac{Ca + Mg}{2}\right)^{1/2}} \qquad (3)$$

SAR rating (100): $<$ 10 Low

10 - 18 Medium

18 - 26 High

$>$ 26 Very high

•

$$\text{Percent Sodium} = \frac{100\ Na}{Ca + Mg + Na + K} \qquad (4)$$

Table 9: STANDARDS FOR IRRIGATION WATERS

WATER CLASS	ELECTRICAL CONDUCTIVITY Micro-mho/cm*	SALT CONTENT		SODIUM %	BORON ppm
		TOTAL ppm	Tons per Acre-foot +		
1	0-1000	0-700	1	60	0.0-0.5
2	1000-3000	700-2000	1 - 3	60-75	0.5-2.0
3	Over 3000	Over 2000	Over 3	75	Over 2.0

* (55) P. 225 - 226

\+ 1 acre-foot = 43,560 ft^3

1 acre-foot is approximately 0.1234 ha-metre (or 1234 m^3)

THE QUALITY OF IRRIGATION AND DRAINAGE WATERS

From table 8, P. 43, the pH of irrigation water is 7.8 and that of drainage water is 8.4. Therefore, both waters are alkaline. The Electrical conductivity for irrigation water is 55 micromhos/cm and that of drainage water is 290 micromhos/cm; the sodium percentage for irrigation water is 46% and that of drain water is 53%; adjusted sodium adsorption ratio for irrigation water is 0.75 and that of drain water is 1.8 which is low. According to table 7, P. 40 the irrigation water and drain water are class 1. (See also table 9, P. 46).

Messers Van Gessel and Kangu (105) of Irrigation and Drainage Unit, Ministry of Agriculture have carried out detailed measurements of the EC-Value (electrical conductivity) of both irrigation water and drain water in Thiba Section and other Sections. They found that the EC-Value for irrigation water was very constant and in the order of 50 - 70 micro-mhos/cm. Drainage water had higher EC-values ranging from 100 to 450 micro-mhos/cm which, they concluded was still excellent for irrigation. They also observed that drainage water, if being re-used, was in general mixed with irrigation water and therefore, they concluded that no salinity problems would occur.

CHAPTER 4

THEORY OF WATER BALANCE

4.1 DEFINITION OF WATER BALANCE

A water balance is essentially a system of accounting for the volume of water held within a defined catchment area. In its simplest form, it can be written as follows:

$$Q_i = Q_o + \Delta S \qquad (5)$$

where:

Q_i = Water added to the catchment area.

Q_o = Water removed from the catchment area.

$S_f - S_i = \Delta S$ = the increase or decrease in the storage of water within the catchment area.

S_i = initial storage and S_f = final storage

The water balance is usually expressed dynamically, as:-

$$Q_i, t = Q_o, t + S_{f(t)} - S_{i(t-1)} \qquad (6)$$

Where t refers to the time interval.

In the case of this study, the inflow and outflow components are:-

(a) INFLOW COMPONENT

(1) R, Precipitation

(2) I, Irrigation water inflow

(3) S.I. Seepage inflow

(4) CR, Capillary rise from high water table

(b) OUTFLOW COMPONENT

(1) E_T, Evapotranspiration

(2) DP, Deep Percolation

(3) SD, Surface Drainage

(4) LS, Lateral subsurface flow

The complete equation can be written as follows:

$$R + I + SI + CR + S_{i(t-j)} = E_T + DP + SD + LS + S_{f(t)} \qquad (7)$$

Careful identification of these term requires the specification of the catchment area cover which the water balance study is to be conducted. In this study, the catchment area includes units H1, H2, H3, & H20 of the Thiba Section. These units are rice producing portions of Mwea Irrigation Scheme and are operated like any other units of the scheme. The units, where the studies were conducted are shown in the Fig. 6, P. 50.

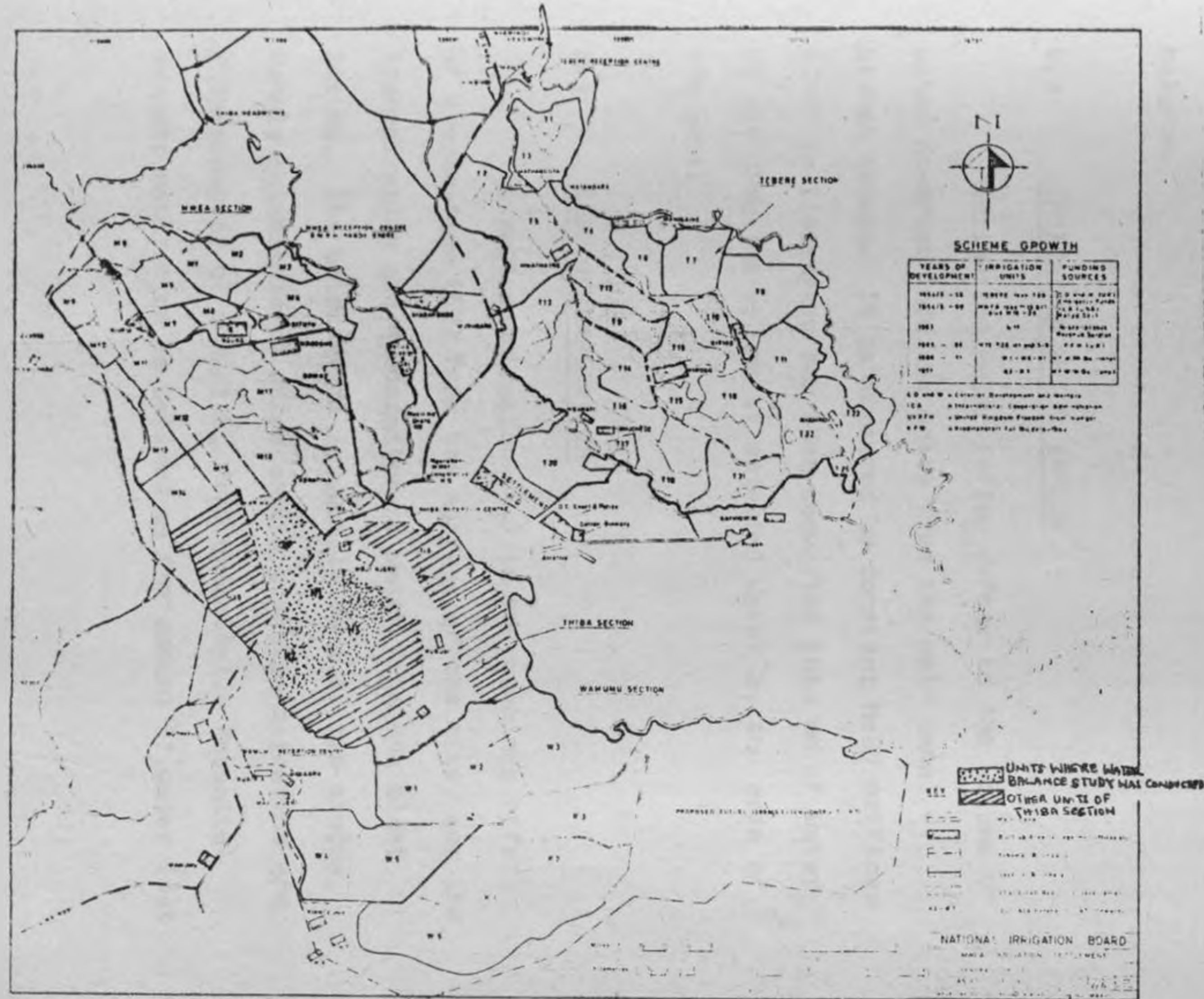


Fig. 6 The Mwea Irrigation Settlement: Layout and Growth

4.2 PRECIPITATION

All measurable precipitation is included in the term, R. Light rains, which may be intercepted the plant and never reach the soil, nevertheless contribute to the water in the soil-plant system. Rainfall effectivity is not a significant issue in computing the water balance.

4.3 IRRIGATION WATER INFLOW

Irrigation water inflow refers to the volume of water diverted into the units from the main canal or branch canals. It is measured by constant head orifices (CHO) in litres/sec and then converted into mm of water by dividing the volume of entering water by the area of the unit.

4.4 EVAPOTRANSPIRATION

Evapotranspiration (E_T) is the combined effect of evaporation (EV) from the surface of the site, and the transpiration and evaporation of water from the plant leaves. Its calculation is usually done in two stages, namely establishment of potential evapotranspiration and determination of actual E_T from potential. Potential evapotranspiration is defined as the amount of water lost as evaporation and transpiration by a short green crop which is of uniform height, never short of water, and which covers the ground completely. Potential E_T has come to mean the maximum possible E_T for a wide range of crops and is, therefore a crop and climatic parameter. Its calculation can be made from climatological data - radiation, wind speed, evaporation, temperature, and relative humidity. Outstanding engineers and scientists have formulated several methods of determining potential evapotranspiration employing climatological data. Pruitt among others has shown correlated with potential E_T. The ratio potential E_T /Evaporation as obtained by him is approximately 0.84 using a class A Pan. Other methods employed in determining potential E_T are Thornthwaite method, (55) Lowry -Johnson method Blaney - Criddle Method and Penman method. Penman has made the most complete theoretical approach, showing that consumptive use is inseparably connected to incoming solar energy. The common methods for determining actual E_T from potential are lysimeter and tank experiments.

The factors reported to affect the ET/EV ratio are: stage of crop growth, moisture content of the root-zone available for plant uptake, and the level of evaporation. The rice fields of Mwea Irrigation settlement are flooded with water and E_T during the earliest days of the rice crop is almost wholly evaporation from the free water in the paddy. As the rice crop develops, transpiration becomes relatively more important than evaporation, but, studies by Van de Goor and Ziglstra have shown that the ratio of E_T/EV remains largely independent of the stage of growth of the crop prior to heading.

4.5 DEEP PERCOLATION

Seepage losses through the bunds and field inlets and outlets are ignored because the water lost through seepage goes into the road drain where it either evaporates or goes outside the unit as surface drainage. Percolation refers to downward movement of water through the soil toward the water table while seepage applies to lateral water movement through the soil borders of the catchment area, (Unit). Seepage and percolation losses are very difficult to be measured accurately. Only deep percolation water is considered a loss from the catchment area; this contributes generally to ground water, while the seepage water usually collects in drains as stated above. In some units the seepage water is not a loss as surface drainage is re-used in downstream units.

In some cases a clear differentiation is not possible between the seepage losses and deep percolation losses because sometimes the deep percolation water re-appears somewhere downstream and sometimes the seepage water disappears into the soil as deep percolation water. The two most important factors affecting the rate of percolation are soil properties and the depth of the water table. Heavy clay soils greatly retard downward water movement and well puddled soils impede it still further. In some cases where the water is near the surface, there might be no percolation at all. Percolation rates are most often measured by bottomless tanks surrounding an experimental plot. In this study a similar approach was employed and Darcy's Equation was used to determine the percolation rate. The Darcy's equation is written as follows:

$$Q = KiA \qquad (8)$$

where:

Q = the volume of water flowing per unit time through a given cross-sectional are ($l^3 t^{-1}$)

K = hydraulic conductivity (lt^{-1})

i = hydraulic gradient (dimensionless)

A = cross-section of flow area (l^2)

The said approach will be described fully in methodology section

4.6 SURFACE DRAINAGE

This term refers to the excess supplies of water leaving the catchment area; the surface drainage can be re-used in the downstream units or it can go back to the river or get lost as deep percolation or evaporate outside the catchment area. Surface drainage in the wet season includes runoff from excessive rainfall which would otherwise cause damage to the crop by inundation. When the road and collector drains are overtopped and thus some surface drainage water is lost outside the catchment area.

4.7 STORAGE

When the fields are flooded during the land preparation, the water level is maintained at least 5 cm from the soil surface till the rice crop is ripe. This means some water goes into the storage term. Before flooding the water stored is very low, then stored water increases after flooding and during the growing season and when the fields are drained after the rice crop is ripe, the water stored decreases rapidly, Fig. 7, P. 56.

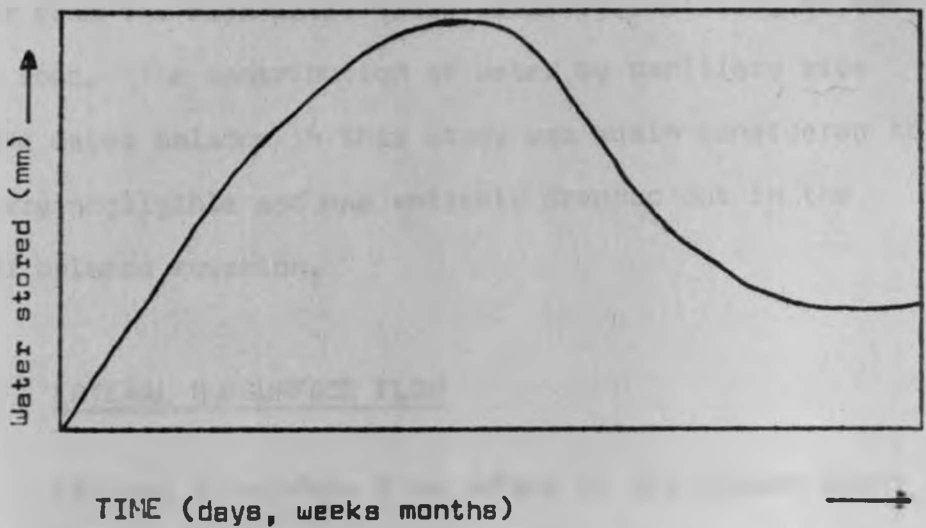


Fig. 7 Water stored V_s TIME

4.8 SEEPAGE INFLOW

Seepage inflow refers to the amount of water that seep into the fields from the bunds of adjacent fields, banks or dykes of drains, distributing canals, nearby rivers or any other source. The contribution of seepage inflow to the water balance in this study was considered to be very negligible and therefore, was completely ignored.

4.9 CAPILLARY RISE FROM HIGH WATER TABLE

High water table in a semi-arid area like Mwea Irrigation Scheme may due to irrigation water, subsurface flow from the upland, drains, distributing canals, nearby rivers, storage reservoirs or any other source. The water from the high water table rises by capillary to the root zone. The contribution of water by capillary rise to the water balance in this study was again considered to be very negligible and was entirely dropped out in the water balance equation.

4.10 LATERAL SUBSURFACE FLOW

Lateral subsurface flow refers to the ground water flow through the soil laterally from the adjacent fields, drains, distributing canals, nearby rivers, storage reservoirs or any other source. The contribution of the lateral subsurface flow to the water balance in this study was again considered to be very negligible and was ignored completely.

CHAPTER 5

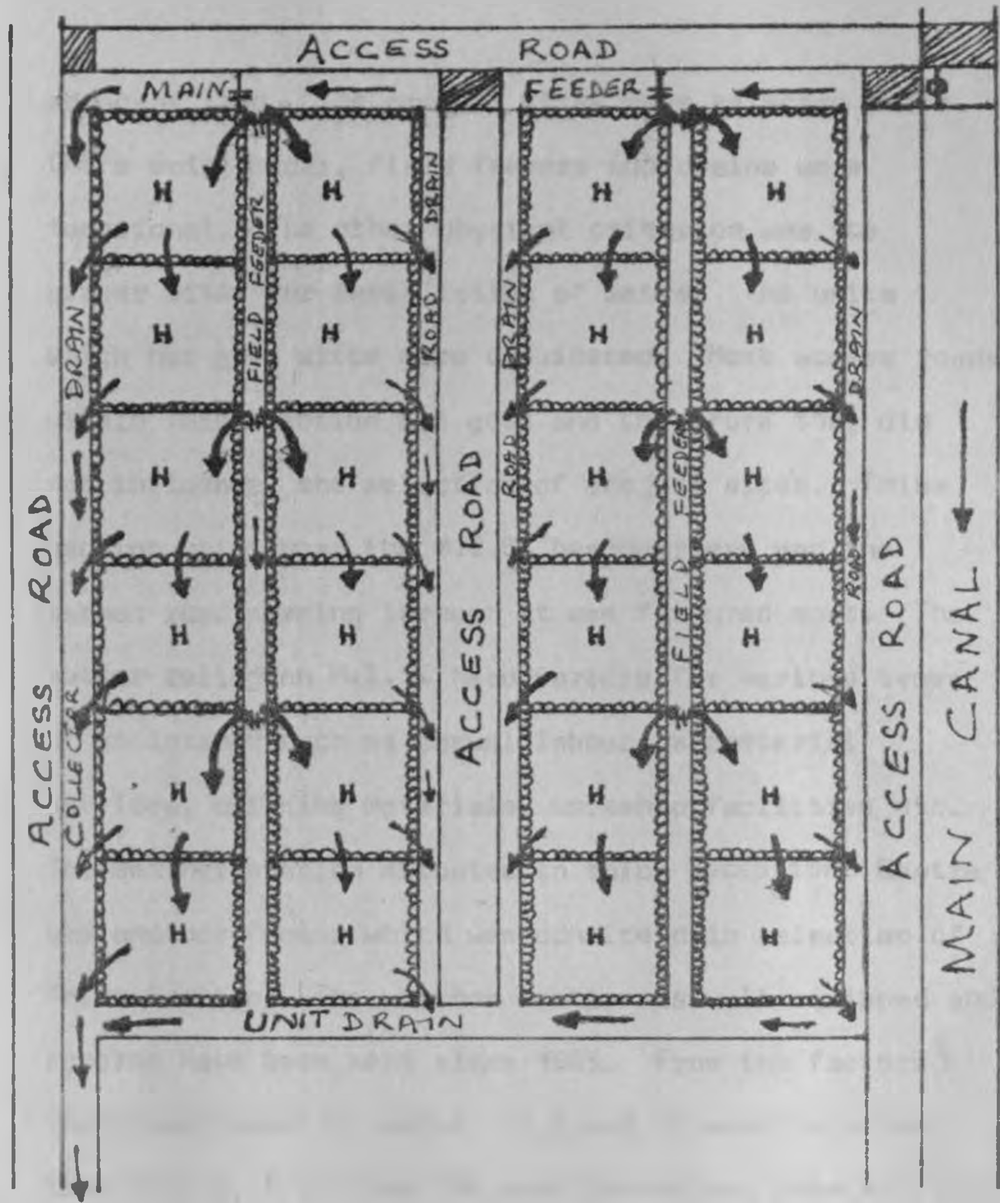
METHODOLOGY AND MEASUREMENTS

5.1 SELECTION OF PROJECT SITES

The amount of the funds and the machinery of releasing the said funds did partly influence the selection of the project sites, especially the number of the project sites covered in this study. The amount of the funds allocated to this study were just enough for the number of sites selected.

The major physical criteria required of a site was that it was well bounded. So the units which are bounded wwre selected. In a typical field layout of a unit (see Fig. 8, P.51) water leaves the main canal through a constant head orifice (CHO). The water is then conveyed by the main feeder. Thereafter, the water from the main feeder is diverted into the field feeders by means of checks and finally is applied to the fields or holdings. The water moves from one holding to the other through bund check. Each holding has its own outlet to allow water to flow into the road drain. The water from the road drains flows into the main drain which finally empties into the collector drain.

In some units the feeders and drains were not functioning properly. Water was seeping into the



KEY:
- Constant Head Orifice
- Dyke
- Direction of water flow
- Flashboard check
- Culvert
- H 0.45 ha Holding

Fig 8: Typical Field Layout of one Unit

adjacent land. The project sites were selected whose CHO's main feeder, field feeders and drains were functional. The other physical criterion was the proper sites for installation of weirs. The units which had good sites were considered. Most access roads within Thiba Section are good and therefore they did not influence the selection of project sites. Thiba section being near the M.I.S. headquarters and the tarmac road passing through it was favoured most. The author relied on M.I.S. headquarters for various types of assistance such as casual labour, secreterial services, building materials, workshop facilities etc. The weather station situated in thiba Reception Centre was another factor which was considerd in selection of Thiba Section. The weather station is well equipped and records have been kept since 1963. From the factors described above the units 1,2,3 and 20 were Selected (see Fig. 6, P. 50) as the most convenient possibilities for further study.

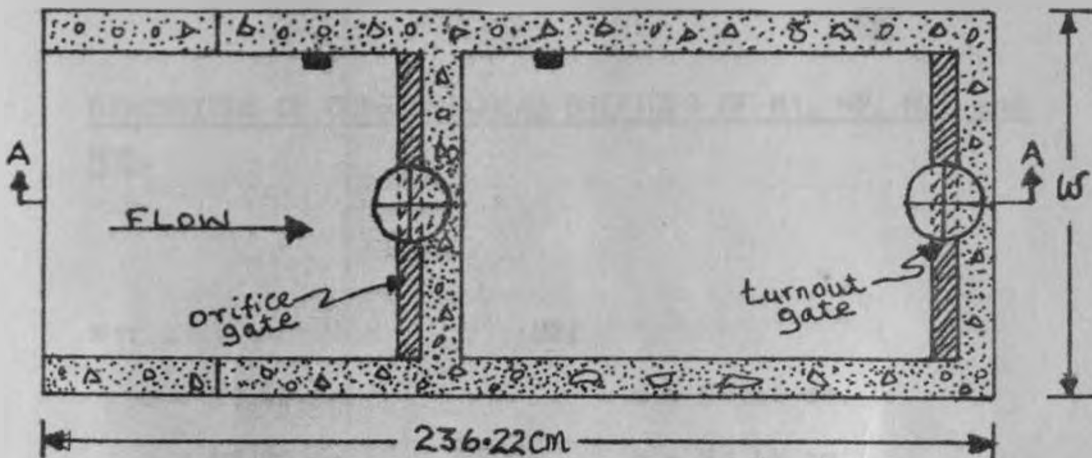
5.2 EQUIPMENT AND SUPPLIES

The inlets of units H20, H1, H2 and H3 were equipped with constant - head orifices, (Fig.9 P.64. These CHO's were installed at the time of construction of units. Unit H1 has two inlets; one with a CHO and the other with sluice gate. A rectangular weir was installed in the canal receiving water through the sluice gate - Fig. 10, P. 66. At the outlets of units H1 and H3 rectangular weirs were installed (Figs. 11, P. 67 and 12, P. 68); the rectangular weir for unit H1 outlet was installed by the author while that one of unit H3 was installed by Irrigation and Drainage Unit (IDU). At the outlet of H2 (See Fig. 13, P.69 and Photo 1, P.62) a rectangular weir was installed by the author. Later on it was thought that the rectangular weir could not hand the drainage water during the short rains, so the IDU installed a cipolletti weir next to the rectangular weir - See Fig. 14, P.72 . At Unit H20 outlet there was a cipolletti weir and automatic recorder installed by the NIB Head-quarters some time in 1964 - (See Fig. 15, P.70).

The weirs were constructed by the technicians of Department of Agricultural Engineering, University of Nairobi according to the specifications of the USBR Manual [(100)p. 7 - 42] under the supervision of the author. They were made of mild steel sheet metal reinforced by 50 mm x 50 mm angle irons and painted to eliminate rust. These weirs were installed under the supervision of the author according to the instructions in the USBR Manual. Installation of polythene sheets in experimental plots for determination of evapotranspiration, E_T was carried out under the supervision of

PHOTO 1: Rectangular Weir Located at the Outlet of H2

PHOTO 2: Trench of the Experiment Plot



TOP VIEW

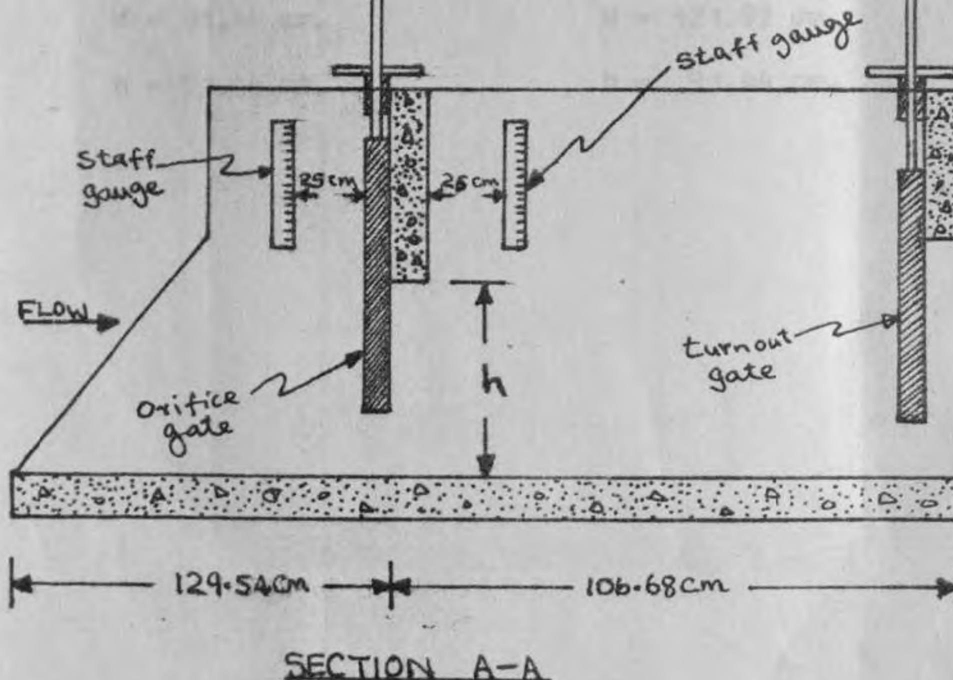


Fig. 9 Schematic View of a Typical Single-barrel Constant-head Orifice Found in M.I.S.

DIMENSIONS OF CONSTANT-HEAD ORIFICES OF H1, H2, H3, and H20.

H1:

W = 91.44 cm.

h = 76.20 cm.

H2:

W = 91.44 cm.

h = 91.44 cm.

H3:

W = 91.44 cm.

h = 91.44 cm.

H20:

W = 121.92 cm.

h = 91.44 cm.

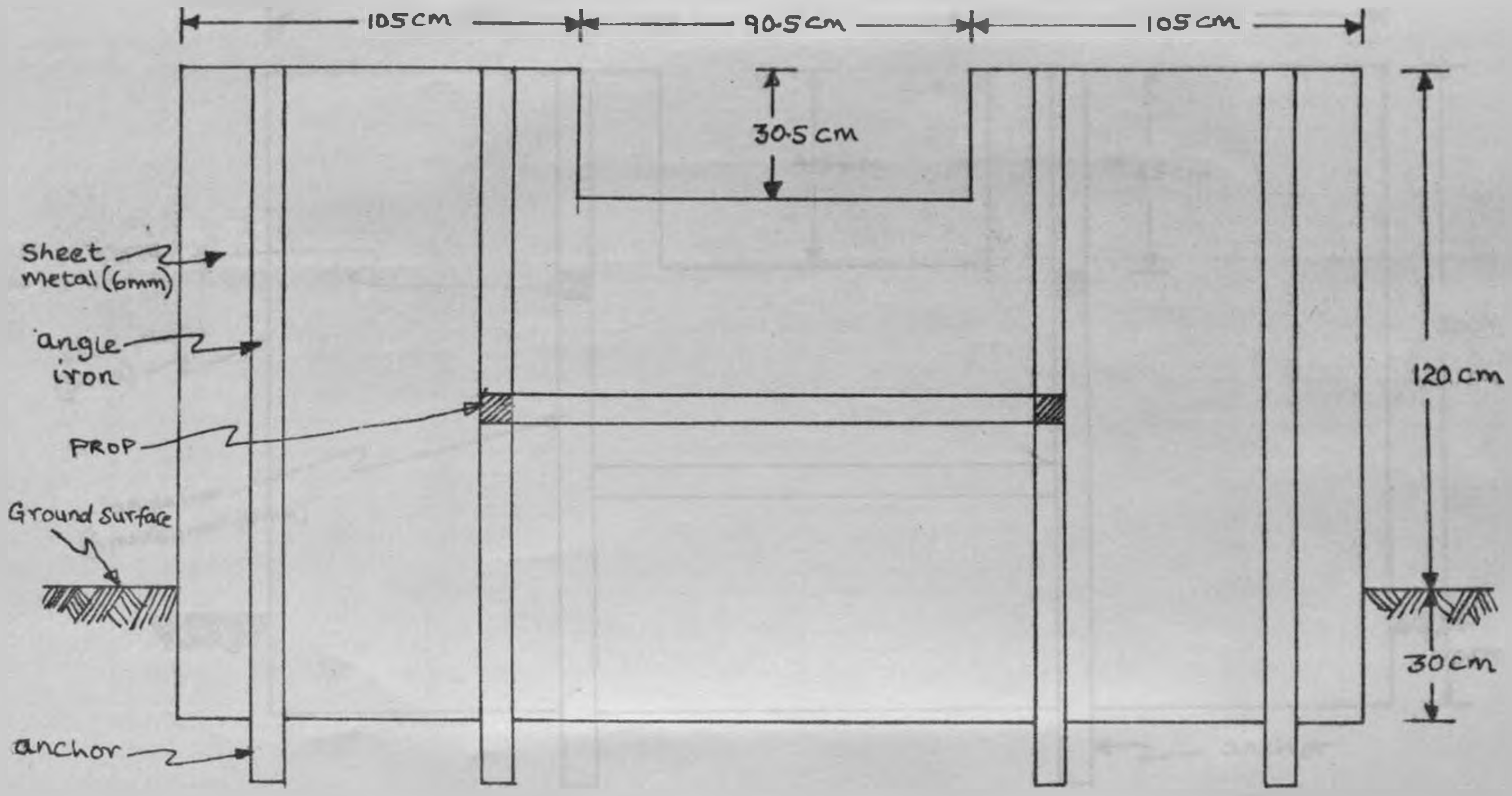


Fig. 10 Rectangular Weir at the Inlet of Unit H1

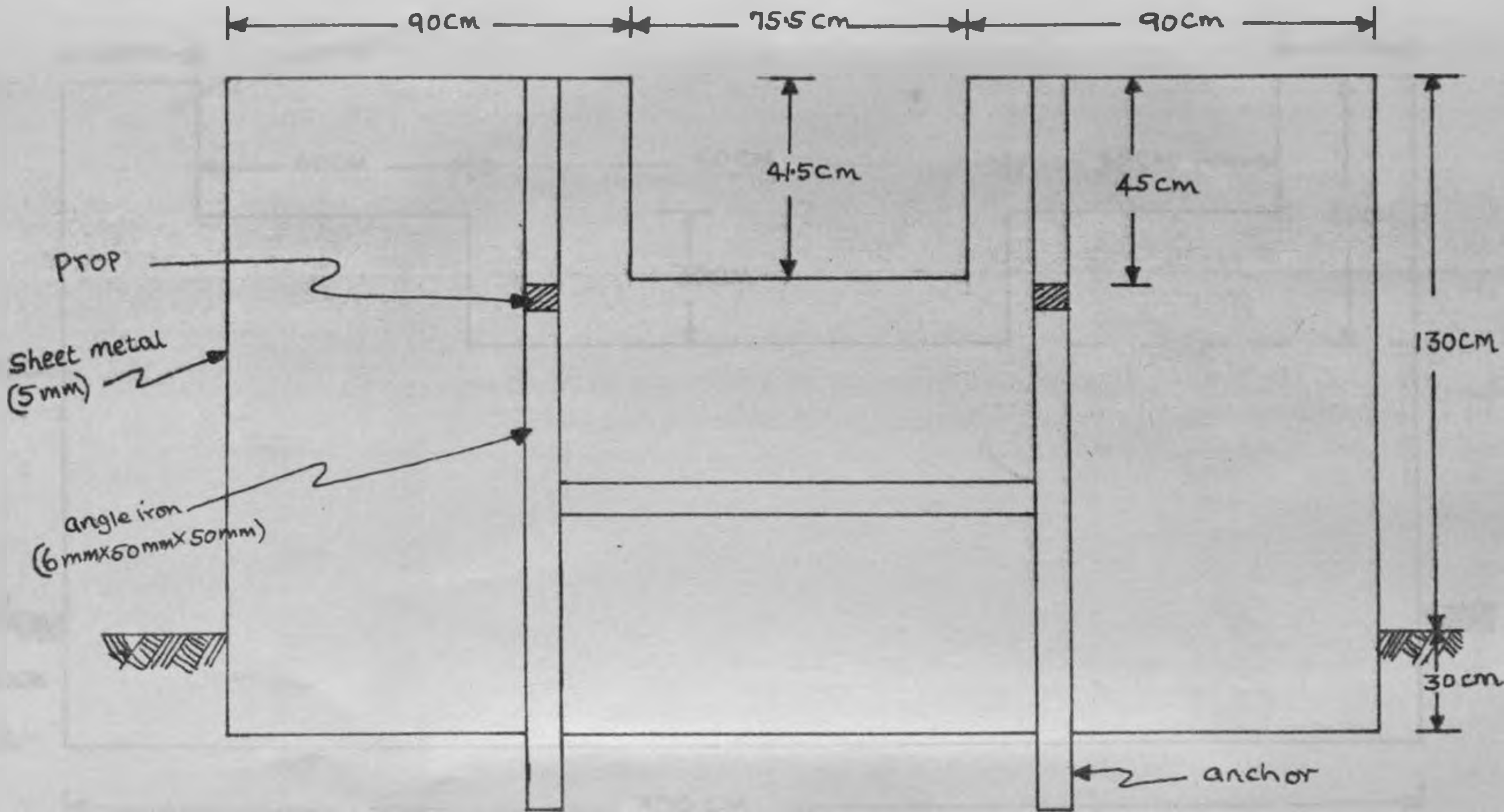


Fig. 11 Rectangular Weir at the Outlet of Unit H1

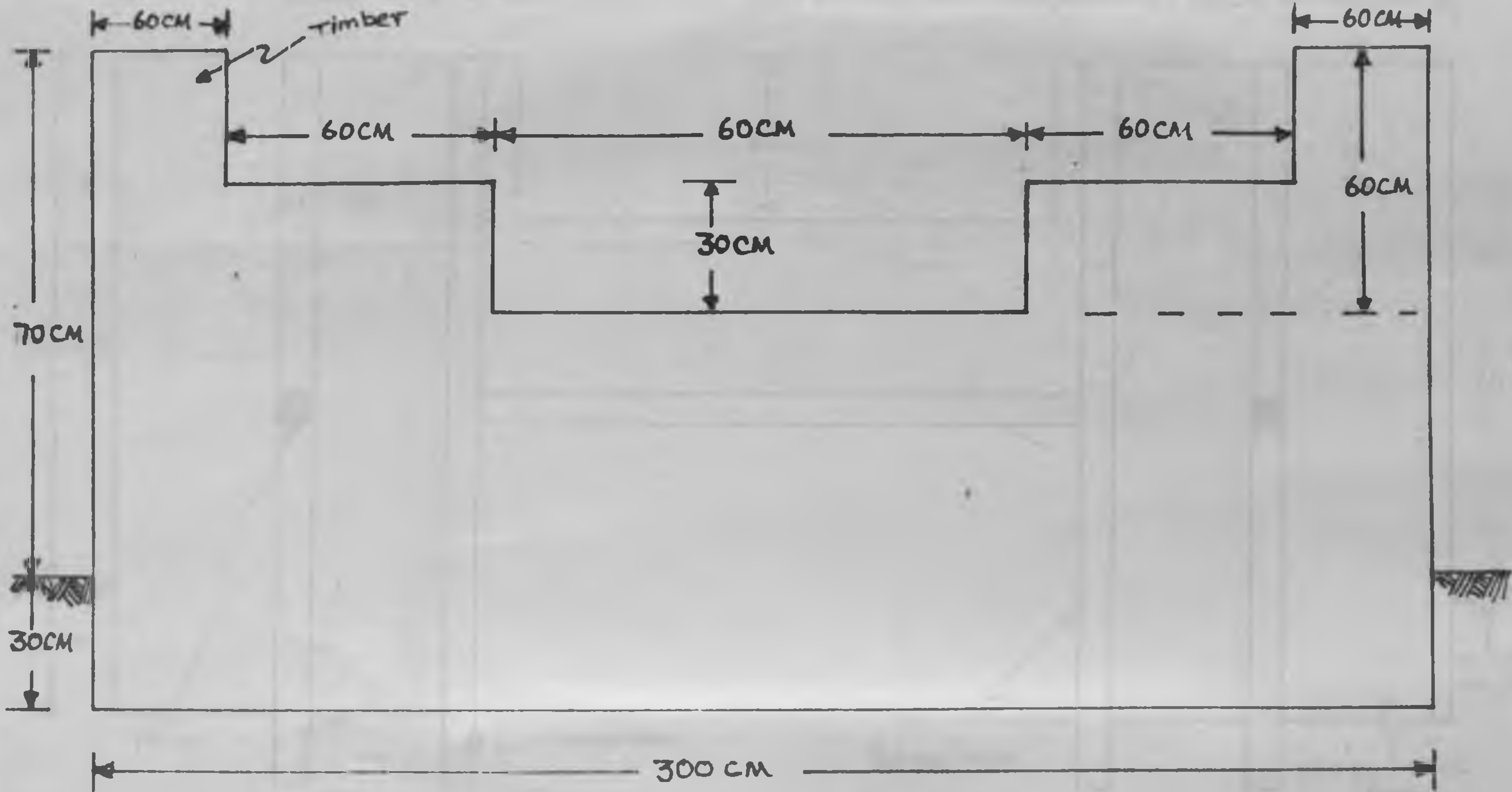


Fig. 12 Rectangular Weir at the Outlet of Unit M3 (It also measured outflow from Unit H1)

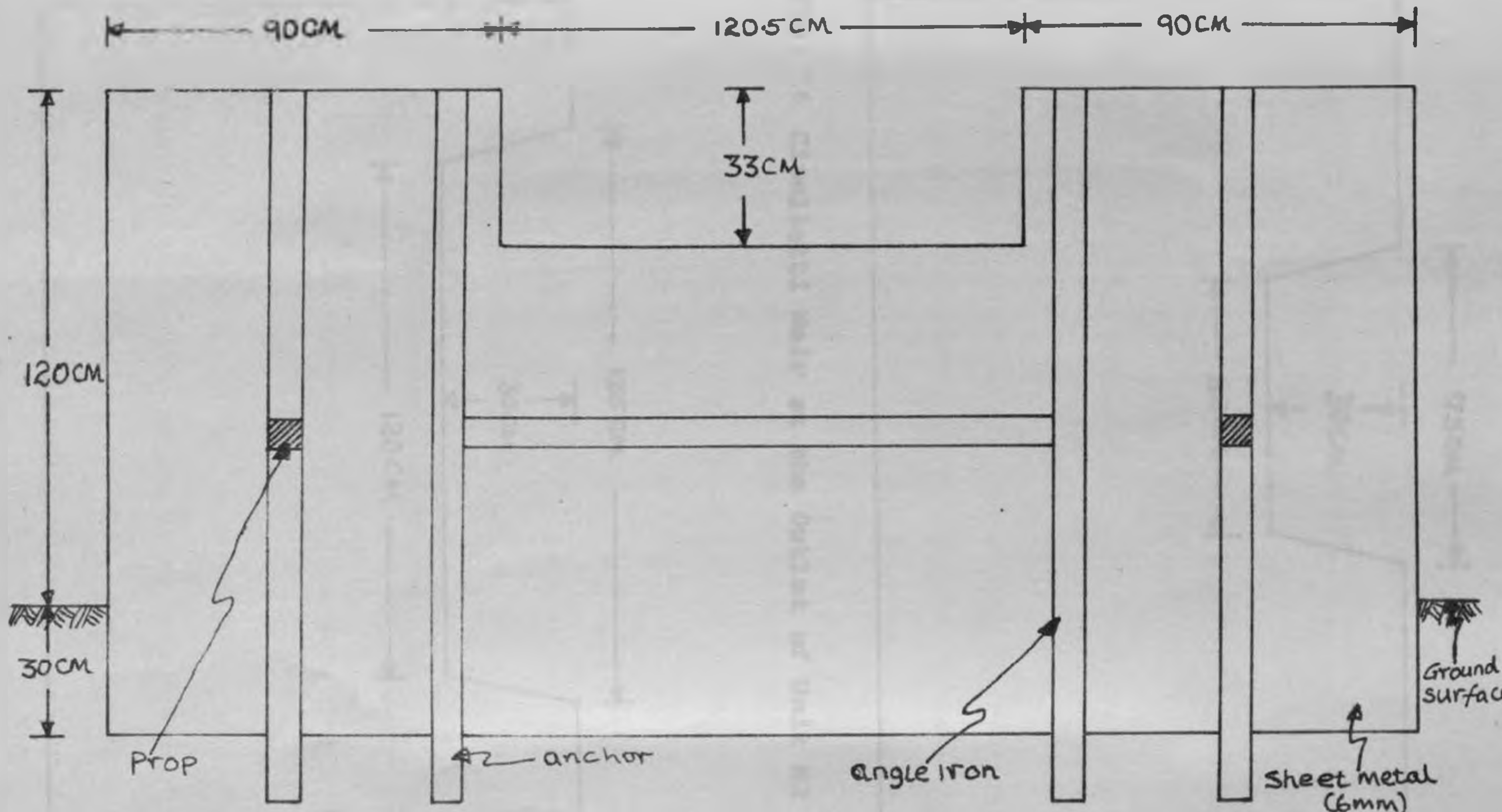


Fig. 13 Rectangular Weir at the Outlet of Unit H2

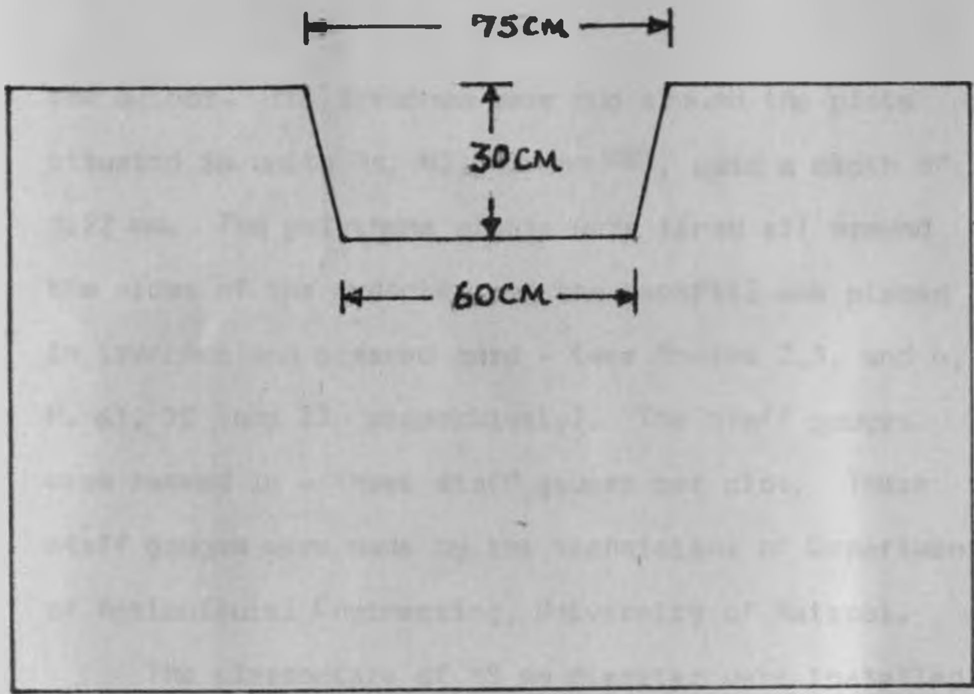


Fig. 14 Cipolletti Weir at the Outlet of Unit M2

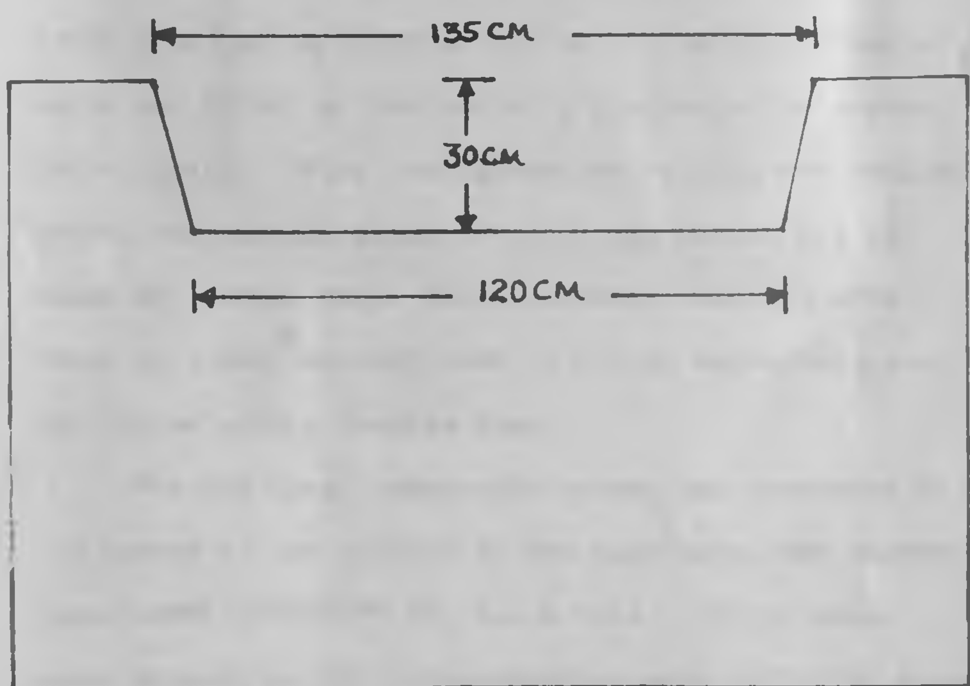


Fig. 15 Cipolletti Weir at the Outlet of Unit M20

the author. The trenches were dug around the plots situated in units H1, H2, H3 and H20, upto a depth of 1.22 mm. The polythene sheets were lined all around the sides of the trenches and the backfill was placed in trenches and pressed hard - (see Photos 2,3, and 4, P. 63, 72 and 73 respectively). The staff gauges were rammed in - three staff gauges per plot. These staff gauges were made by the technicians of Department of Agricultural Engineering, University of Nairobi.

The piezometers of 15 mm diameter were installed by ramming them into the ground by a sledge hammer - See Fig. 16, P.74 and 17, P.75. The first pair of piezometers was driven into the ground to a depth of 20 cm; the second pair upto a depth of 100 cm; and the third pair upto a depth of 120 cm. A conical piece of metal was fitted at the end of a piezometer to prevent mud clogging. After the piezometer reached the desired depth, the conical piece of metal was driven out by means of a metal rod. The piezometer readings were taken by a bell sounder made by M.I.S. machinist, and was fitted with a 3-metre tape.

For the canal damage the survey was conducted by the author in one section of the main canal and branch canal -see Appendices VI, VII & VIII. In the main canal elevations for cross-sections were collected every 200 metres, and in branch canal every 100 metres. Canal

PHOTO 3: Polythene Sheet Lined Around the Trench

PHOTO 4: **Backfill** Being Placed Around the Polythene Sheet

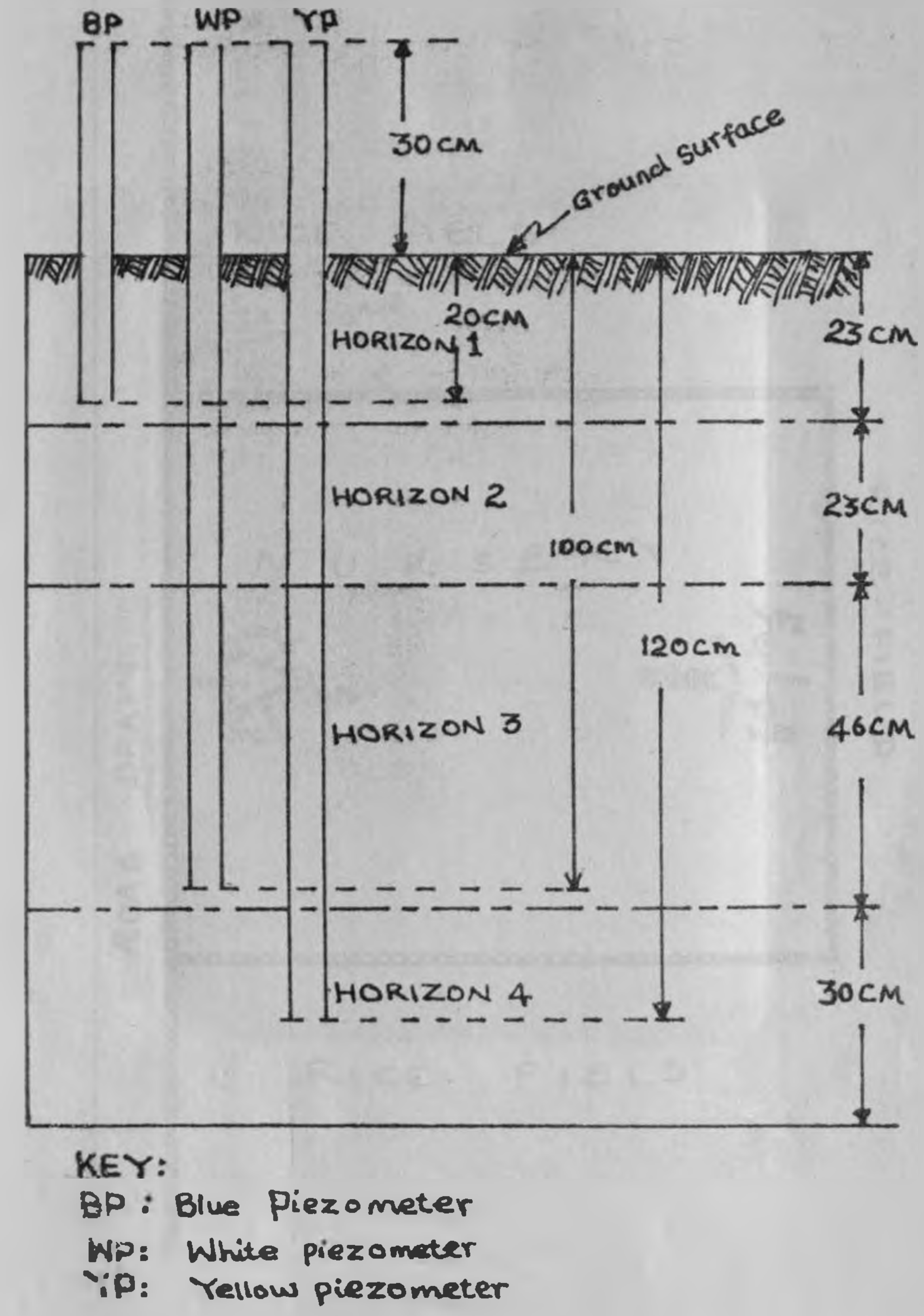


Fig. 16 Location of Piezometer Battery in the Soil

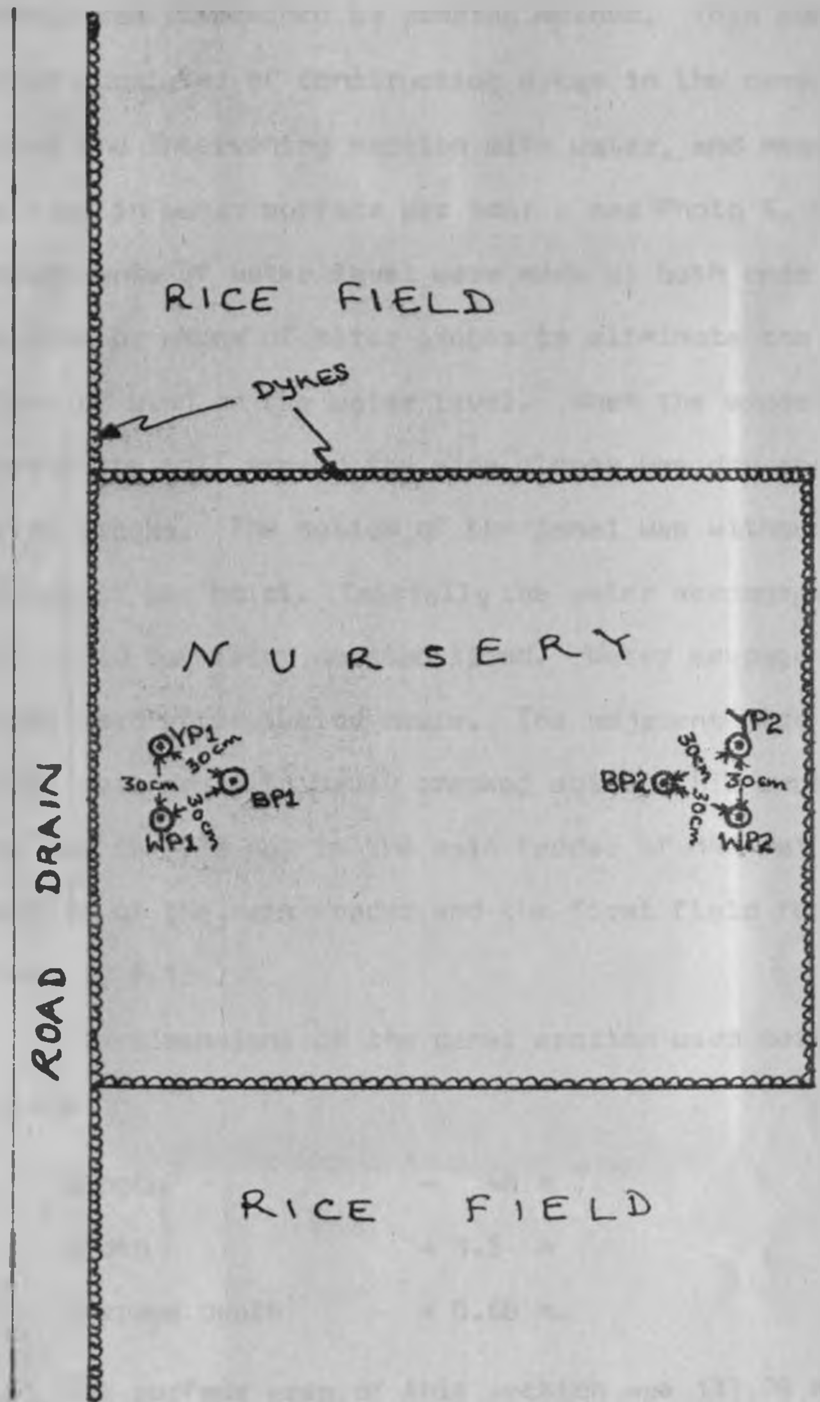


Fig. 17 Location of Piezometers in the Experimental Plots (Nurseries)

seepage was determined by ponding method. This ponding method consisted of constructing dykes in the canal, filled the intervening section with water, and measured the drop in water surface per hour - see Photo 6, P. 78 . Measurements of water level were made at both ends of the pond by means of meter gauges to eliminate the effect of wind on the water level. When the experiment started the soil around the side slopes was dry and having cracks. The bottom of the canal was without cracks; it was moist. Initially the water seepage was very rapid but later on stabilized. Water seepage was almost zero after twelve hours. The adjacent rice fields were dry with badly cracked soil. This experiment was carried out in the main feeder of H4 - at the junction of the main feeder and the first field feeder (Photo 6, P.78).

The dimensions of the canal section used were as follows:

Length	= 48 m
Width	= 1.5 m
Average depth	= 0.68 m.

The surface area of this section was 137.28 m^2. This experiment was conducted for 12 hours, and a water drop of 9.5 cm. was observed. The water drop per hour, therefore, was 0.75 cm./hour (7.5 mm/hour). The canal

PHOTO 5: Backfill after Being Placed in Trench

PHOTO 6: Intervening Section of the Canal Filled with Water (Canal Seepage Experiment)

seepage losses within 12 hours were 13.042 m^3 of water. It was observed that after 12 hours of seepage losses were negligible owing to the characteristics of the black cotton soil.

5.3 MEASUREMENTS OF WATER

Interest and co-operation in the experimental plots were surprisingly strong among the tenants involved, and the author and the tenants concerned held regular discussions how to co-ordinate their farming activities and water measurement programme. The co-ordination was excellent. In fact the author received excellent assistance from the Thiba Section field staff and the tenants involved.

Daily recording of the data was the task of the author throughout this study at each site. Inflow-outflow data were taken three times a day - (morning, mid-day and evening) and piezometer and experimental plot data were recorded once a day at random. As mentioned earlier the inflow and water distribution in the holdings were regulated by the water guards according to the normal use and practices of the current water management. The author did not interfere at all in regulation of inflow and water distribution in the fields. The tenants manipulated the water in their holdings as they found fit for each farming activity.

This applies too in the case of experimental plots as well.

The water management practices of experimental plots were recorded daily once the staff gauges were read. Water uses in the holdings were also recorded daily. If the water was either entering or leaving the experimental plots the staff gauges were not read. The staff gauges were read only when water level was stable. The water depth in experimental plots was increasing owing to water addition intentionally by the tenants or unintentionally if the polythene sheet fell off and if there is rainfall. Any water losses in experimental plot were either due to evapotranspiration or deep percolation.

The weirs installed by the author (H1 & H2) had enough head and fall as specified in USBR Manual and there was no leakage on either corners of the weirs embedded in the soil. The cipolletti and rectangular weirs installed by the Irrigation and Drainage Unit (H1 & H3) had also adequate head and fall. However, the cipolletti weir installed by NIB had no free fall at certain times. So a staff gauge was installed at downstream to measure the water height for correction of submergence. The readings obtained from the weirs were fairly accurate for all practical purposes. However, there was an error introduced in weir readings.

The sides of CHO's were leaking when fully closed. This leakage was not recorded as inflow but part of it was recorded as outflow. Despite these leakages in CHO's, the CHO readings were also fairly accurate for all practical purposes. Irrigation and Drainage Unit research team found the CHO error not appreciable. Similary the piezometer and experimental plot staff gauge readings were fairly accurate.

The weather readings were recorded daily by M.I.S. technical staff according to the instructions of Kenya Meteorological Department. As mentioned earlier weather station is located centrally in Thiba Section. The figures obtained from weather station are representative of the entire project area. The inflow-outflow and weather information are found in appendices I & IV respectively.

CHAPTER 6

ANALYSIS AND FINDINGS: WATER BALANCE

6.1 DATA TREATMENT

The difference in head at the outlet and outlet gauges of constant head orifices (CHO) and heads on the weirs read and recorded daily. Using CHO formual, weir formulas and conversion formula (12) (see Appendix V), the inflow and outflow rates were calculated in mm/day (Appendix I). Rainfall and evaporation data were taken from the records of Thiba Meteorological Station. The Meteorological technician from Mwea Irrigation Settlement collected meteorological information twice daily from the weather stations located in different section of the settlement. Employing these climatic data (i.e. wind, speed, relative humidity, mean temperature and actual sunshine hours/day - Appendix IV) from Thiba meteorological station, the evapotranspiration was computed using the Penman Method (Appendix XI) in mm/day. Total inflow, rainfall, evapotranspiration, deep percolation losses, outflow and effective water per month for each unit (i.e. Units, H1, H2, H3 and H20 are shown in tables 10, 20, 21 and 23, P. 87, 102, 105 and 113 respectively. The summary of the components of water balance for the above units is tabulated in table 28, P. 122. The average daily inflow-out rates for the said units are shown in table 11 and the E_T/E_o ratio for 1979 and for 1963-1979 are in tables 12, P. 90 and 13, P. 91 respectively. The average daily deep percolation losses for the above units are shown in table 14, P. 92.

The data from Appendix XI employed in the calculation of evapotranspiration rates are: Values of T , extra terrestrial radiation, mean daily duration of maximum possible sunshine hours for different months and latitude, values of weighting factor for the effect of radiation on ET different temperatures and altitudes, saturated vapour pressure, slope of saturated vapour pressure curve of air at absolute temperature (T_a in ^oF) and percentage daylight hours.

The Darcy equation was used to compute the deep percolation rates employing the data from tables 4, 5, 6, P. 34, 36, and 38 respectively and Appendices IX and X. Hydraulic conductivity (K) cm/hr. was obtained from tables 4, 5 and 6 P. 34, 36 and 38 respectively. Depths of ponded water in experimental plots were obtained from Appendix IV. The hydraulic gradient was computed from Appendix X data. The laboratory method was used to determine the hydraulic conductivities of the soil samples. Initial soil water storage, capillary rise from high water table, lateral subsurface flow and seepage inflow were assumed to be negligible and therefore, the EFFECTIVE WATER was defined as INFLOW plus PRECIPITATION less the OUTFLOW.

6.2 RESULTS

UNIT: H1: In Unit H1 (tables 10, P. 87 and 28, P. 122) total inflow was composed of 84% (1881 mm) of irrigation water and 16% (352 mm) of rain water. It can be seen that 38% (848 mm) of it is lost through evapotranspiration (E_T, Penman) 16% (352 mm) as deep percolation; 39% (864 mm) goes as outflow from the field (surface drainage); and 7.6% (170 mm) is stored in the soil. The effective water is maximum during flooding and rotavation stages, it decreases a bit during water topping, nursery preparations and ox-harrowing stages and then it increases during transplanting and reaching near peak during the tillering stage. After this, effective water decreases considerably during flowering stage and approaching zero during the harvesting stage, Fig. 18 P. 99.

The total hectarage for unit H1 is 89.9 (table 29, P.123). The average daily inflow, outflow, evapotranspiration, deep percolation rates are 12.09, 5.13, 4.35 and 1.80 mm/day respectively - (Tables 11, 12 and 14 P.89, 90 and 92 respectively. Land preparations (flooding + rotavation) took eighteen (18) days instead of sixteen (16) days planned in the cropping programme for 1979/80 season (tables 15, P. 93 and 16, P. 94). The water topping stage took 35 days instead of 43 days planned in the cropping programme for 1979/80 season. Rice growth and development stage took 107 days instead of 122 days planned in the said programme. Harvesting stage took 40 days against 38 days contained in the 1979/80 cropping programme.

Land preparation, water topping and rice growth and development stages required 21, 7.35, and 6.61 mm of water per day respectively - table 17, P. 92. Total effective water required from land preparation stage to rice growth and development is 1342.13 mm (table 17, P. 96); 28.16 (378 mm) of this used for land preparation; 19.17 % (257 mm) used for water topping and 52.66 % (706.80) used for rice growth and development (table 17, P. 96). Using the 1979/80 cropping programme[1] total effective water reouirements would have been 1832.44 mm. (table 19) 17.31% (317.12 mm) for land preparation, 25.44% (466.12 mm) for water topping and 57.26% (1049.20 mm) for rice growth and development. The total actual effective water used per hectare per 1979/80 season (181 days) was 1370 mm/season (1979/80 cropping programme total effective water estimates were calculated from tables 16, P. 94 and 19, P. 98 - e.g. H4. Water reouirements for land preparation stage = 17 days (table 16, P. 94) x 19.82 mm/day (table 19, P. 98) = 336.94 mm.

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[1] A CROPPING PROGRAMME is a scheme of work composed of sequence of the farming activities to the accomplished during any given season. It is prepared by the Scheme Management as a guide and approximates as to when any particular farming activity is to be started and completed in different sections of the scheme - (see Appendix XII).

Table 10: SUMMARY OF WATER BALANCE FOR UNIT H1 AND WATER-USE EFFICIENCY

MONTH	(I) INFLOW mm/Mo.	(R) RAINFALL mm/Mo.	E_T (PENMAN) mm/Mo.	DEEP (DP) PERCOLATION LOSSES mm/Mo.	(O) OUTFLOW mm/Mo.	EFFECTIVE WATER (I+R)-O mm/Mo.	E_u %	FARMING ACTIVITIES^{xx}
JUNE 1979	-	-	-	-	-	-	-	
JULY 1979	482^{x}	5.0^{x}	64.0^{x}	72^{++}	109^{x}	378	77.62	1, 2
AUGUST 1979	408	4	124	67	186	226	54.85	2, 4, 5(a), 6, 7 & 8
SEPTEMBER 1979	343	4	159	41	112	235	67.72	9
OCTOBER 1979	331	41	161	38	54	318	85.48	10, 11, 12, 13 & 14
NOVEMBER 1979	227	221	123	25	279	169	37.72	15, 16 & 17
DECEMBER 1979	91	58	136	9	124	25	16.78	18, 19, 20, 21, 22 & 23
JANUARY 1979	0.00	19	81^{+}	100^{+}	0.00	19	-	23 & 24
TOTAL FOR THE SEASON	1882	352	848	352	864	1370		

Table 10: Cont'd

Eu = Water-Use efficiency, the proportion of water beneficially used on farm or field.

$$Eu = 100 \frac{Wu}{Wd} \qquad (9)$$

xx = See Appendix I for farming activity descriptions

++ = Estimated, total for 18 days

\+ = Total for 20 days

x = Total for 18 days, Flooding started on 14 July, 1979

Table 11: AVERAGE DAILY INFLOW-OUTFLOW RATES FOR UNITS H1, H2, H3 & H20

	H1		H2		H3		H20	
MONTH	INFLOW mm/day	OUTFLOW mm/day	INFLOW mm/day	OUTFLOW mm/day	INFLOW mm/day	OUTFLOW mm/day	INFLOW mm/day	OUTFLOW mm/day
JULY 1979	26.76	6.03	26.20	5.79	14.48	4.89	26.76	3.33
AUGUST 1979	13.17	6.00	16.80	6.88	11.60	7.68	23.80	4.72
SEPTEMBER 1979	11.44	3.73	17.63	5.35	13.50	2.28	22.98	4.02
OCTOBER 1979	10.67	1.74	11.40	2.71	10.99	2.60	20.08	3.31
NOVEMBER 1979	7.55	9.29	5.46	7.85	3.83	7.36	11.75	8.61
DECEMBER 1979	2.93	4.00	2.41	2.37	0.00	2.01	0.00	1.73
JANUARY* 1980	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AVERAGE	12.09	5.13	13.32	5.16	9.07	4.47	17.56	4.29

*January excluded

Table 12: AVERAGE EVAPOTRANSPIRATION (E_T) AND EVAPORATION (E_o) FOR THE RICE SEASONS (for 1979 DATA)

MONTH	E_T mm/day	E_o mm/day	E_T/E_o
July, 1979	3.38	3.81	0.89
August, 1979	4.01	4.57	0.88
September, 1979	5.30	6.83	0.78
October, 1979	5.28	6.66	0.78
November, 1979	4.10	5.13	0.80
December, 1979	4.38	5.65	0.78
January, 1980	4.07	5.25	0.77
AVERAGE	4.35	5.41	0.81

Table 13: AVERAGE DAILY EVAPOTRANSPIRATION* (E_T) AND EVAPORATION* CLASS "A" PAN (E_o)

MONTH	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
AVERAGE DAILY EVAPOTRANSPI-RATION, E_T mm/day (PENMAN METHOD	4.07	5.68	5.72	4.94	4.26	3.61	3.27	3.68	4.93	5.41	4.65	4.96
AVERAGE DAILY EVAPORATION, E_o mm/day (CLASS "A" PAN)	6.26	7.50	7.23	5.90	4.74	4.20	3.90	4.77	6.20	6.84	5.27	5.71
E_T/E_o	0.65	0.76	0.79	0.84	0.90	0.86	0.84	0.77	0.80	0.79	0.88	0.87

*The E_T figures are calculated from meteorological data from Thiba Reception Centre (90 37 112) recorded from 1963 - 1979 and Eo figure are from the said centre.

Table 14: AVERAGE DAILY DEEP PERCOLATION LOSSES FOR UNITS H1, H2, H3 & H20

MONTH	H1	H2	H3	H20
	DEEP PERCOLATION LOSSES, mm/day	DEEP PERCOLATION LOSSES, mm/day	DEEP PERCOLATION LOSSES, mm/day	DEEP PERCOLATION LOSSES, mm/day
July, 1979	x	x	0.27	0.00
August, 1979	2.15	1.80	0.04	0.00
September, 1979	1.37	1.17	0.12	0.00
October, 1979	1.21	1.02	0.14	0.00
November, 1979	0.82	0.66	0.90	0.00
December, 1979	0.28	0.52	0.60	0.00
January, 1980	4.99	1.90	1.31	0.00
Average	1.80	1.18	0.48	0.00

x Not recorded as piezometers were not installed.

Table 15: RICE HUSBANDRY STAGES BASED ON FIELD OBSERVATIONS FOR 1979/80 SEASON (THIBA SECTION)

RICE HUSBAN- DRY STA- GES / UNIT	LAND PREPARATION (NO. OF DAYS	WATER TOPPING (NO. OF DAYS)	RICE GROWTH & DEVELOPMENT (NO. OF DAYS)	HARVESTING (NO. OF DAYS)	REMARKS
H1	18	35	107	40	Group order: 4 Ha = 72.470
H2	15	32	113	37	Group order: 4 Ha = 91.498
H3	20	48	115	38	Group order: 2 Ha = 108.097
H20	25	39	111	38	Group order: 3 Ha = 114.980

Table 16: HUSBANDRY STAGES BASED ON CROPPING PROGRAMME FOR 1979/80 SEASON (THIBA SECTION)

RICE HUSBANDRY STAGES / UNIT	LAND[x] PREPARARION (NO. OF DAYS)	WATER TOPPING (NO. OF DAYS)	RICE GROWTH & DEVELOPMENT (NO. OF DAYS)	HARVESTING (NO. OF DAYS)	REMARKS
H4	17	152	122	38[+]	Group order: 1 Ha = 89.474
H5	25	132	122	38	Group order: 1 Ha = 155.061
H6	20	114	122	38	Group order: 1 Ha = 109.717
H19	20	97	122	38	Group order: 1. Ha = 109.717
H7	17	91	122	38	Group order: 2 Ha = 81.781
H18	20	76	122	38	Group order: 2 Ha = 111.336
H3	20	61	122	38	Group order: 2 Ha = 108.097

Table 16: Cont'd

H20	20	53	122	38[+]	Group order: 3 Ha = 114.980
H8	18	40	122	38	Group order: 3 Ha = 94.737
H1	16	43	122	38	Group order: 4 Ha = 72.470
H2	18	31	122	38	Group order: 4 Ha = 91.498

[x]Average flooding period = 7 days; Cropping rotavation period as indicated in the programme for 1979/80 season.

[+]Average harvesting period.

Table 17: EFFECTIVE WATER REQUIREMENTS FOR DIFFERENT RICE HUSBANDRY STAGES BASED ON FIELD MEASUREMENTS, UNIT H1

RICE HUSBANDRY STAGE	NO. OF DAYS/STAGE	mm/stage	%	mm/day	DATES	REMARKS
LAND PREPARATION	18	378.00	28.16	21	July 14 - 31 1979	
WATER TOPPING	35	257.33	19.17	7.35	Aug. 1 - 4 Sept. 1979	
RICE GROWTH & DEVELOPMENT	107	706.80	52.66	6.61	5 Sept. - 20 Dec. 1979	
HARVESTING	40	-	-	-	21 Dec. 1979 19 Jan. 1980	Water not required

Table 18: EFFECTIVE WATER REQUIREMENTS FOR DIFFERENT RICE HUSBANDRY STAGES BASED ON FIELD MEASUREMENTS, UNIT H2

RICE HUSBANDRY STAGE	NO. OF DAYS/STAGE	mm/stage	%	mm/day	DATES	REMARKS
LAND PREPARATION	15	335.73	22.99	22.38	19 July - 2 Aug. 1979	
WATER TOPPING	32	274.58	18.80	8.58	3 Aug. - 3 Sept. 1979	
RICE GROWTH & DEVELOPMENT	113	850.27	58.22	7.53	4 Sept. - 25 ' 1979	
HARVESTING	37	-	-	-	20 Dec. 1979 - 2 Feb. 1980	Water not required

Table 19: SUMMARY OF DETERMINED EFFECTIVE WATER REQUIREMENTS FOR DIFFERENT RICE HUSBANDRY STAGES

RICE HUSBANDRY STAGES	EFFECTIVE WATER REQUIREMENTS, mm/day					
	H1	H2	H3	H20	TOTAL	AVERAGE
LAND PREPARATION	21.00	22.38	6.75	29.15	79.28	19.82
WATER TOPPING	7.35	5.58	7.90	19.53	43.36	10.84
RICE GROWTH & DEVELOPMENT	6.61	7.53	7.07	13.18	34.39	8.60
HARVESTING	x	x	x	x	x	x

x Water not required.

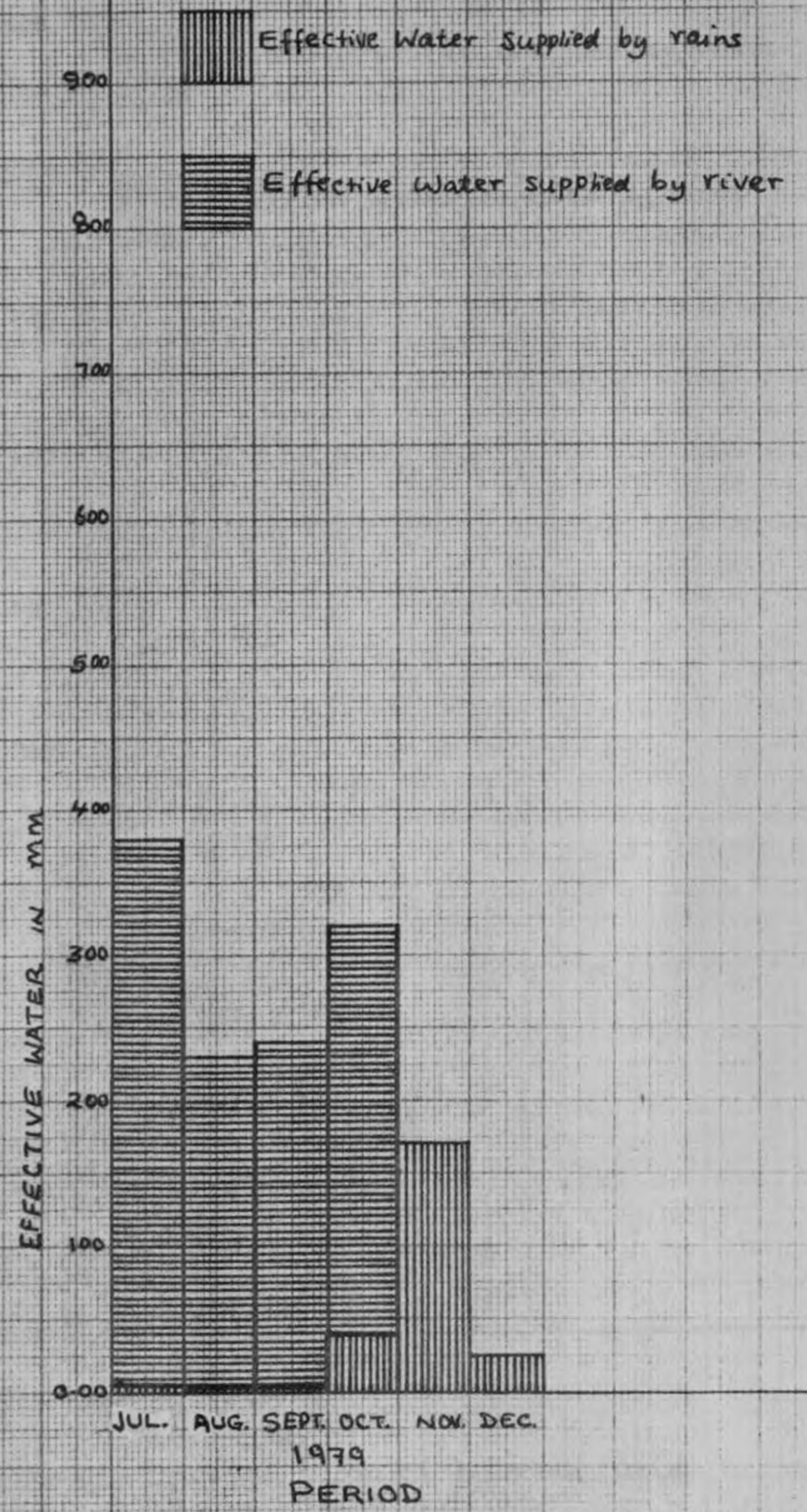

Fig. 18 Effective water supplied by rain and irrigation for UNIT H1

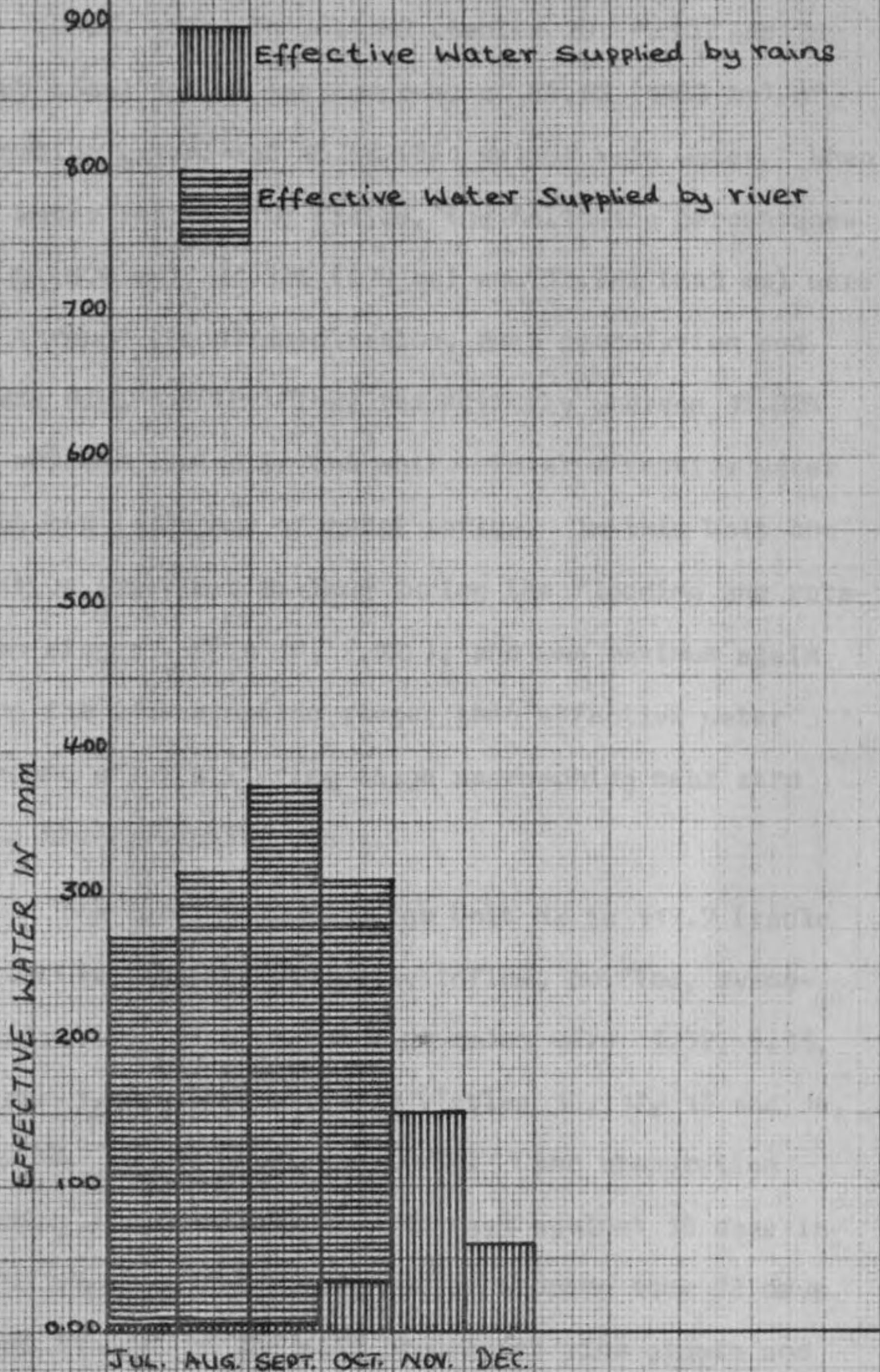

Fig. 19 Effective Water Supplied by rain and irrigation for UNIT H2

6.2 RESULTS -------- CONT'D

UNIT: H2: In Unit H2 (tables 20, P. 102 and 28 P. 122) total inflow was composed of 84.6% (1983 mm) of irrigation water, and 15.4% (361 mm) of rain water. When this water reaches the fields, the following percentages 37.50% (879 mm), 11.52% (270 mm) and 35.96% (843 mm) were lost through evapotranspiration, deep percolation and surface drainage (outflow) respectively whereas 15.02% (352 mm) was stored in the soil. Total effective water was 64.04% (1501 mm) of total inflow. In this Unit the effective water was maximum during the flooding and rotavation stages - (Fig 19, P.100), and was maximum again during the transplanting stage; then effective water decreased after tillering stage approaching near zero during the harvesting stage.

The total hectareage for Unit H2 is 117.7 (table 15, P . 93). The average daily inflow, outflow, evapotranspiration, deep percolation rates were 13.32, 5.16, 4.35 and 1.18 mm respectively (Tables 11, 12, 13 and 14, P. 89, 90, 91 and 92 respectively. Land preparation (flooding + rotavation) took 15 days against 18 days in 1979/80 cropping programme. Water topping took 32 days against 31 days in the said programme; rice growth and development took 113 instead of 122 days in the programme in question (see Tables 15, P. 93 and 16 P. 94).

Table 20: SUMMARY OF WATER BALANCE FOR UNIT H2 AND WATER-USE EFFICIENCY

MONTH	(I) INFLOW mm/Mo.	(R) RAIN-FALL mm/Mo.	E_T (PENMAN) mm/Mo.	DEEP (DP) PERCOLA-TION LOSSES mm/Mo.	(O) OUT-FLOW mm/Mo.	EFFECTIVE WATER (I+R)-O mm/Mo.	E_u %	FARMING ACTIVI-TIES +
JUNE 1979	-	-	-	-	-	-	-	-
JULY 1979	341^x	4^x	50^x	52^{++}	75^x	270	78.25	1 & 2
AUGUST 1979	521	4	124	56	213	312	59.43	2, 3, 4, 5(a), 5 (b), 6, 7, & 8
SEPTEMBER 1979	529	4	159	35	161	372	69.79	9
OCTOBER 1979	353	41	161	32	84	310	78.68	10, 11, 12, 13 & 14
NOVEMBER 1979	164	221	123	20	236	149	38.70	15, 16, 17 & 18
DECEMBER 1979	75	58	136	16	74	59	44.36	19, 20, 21, 22 & 23
JANUARY 1980	0.00	29	126	59	0.00	29	-	23 & 24
TOTAL FOR THE SEASON	1983	361	879	270	843	1501	-	

+See Appendix I for Farming activity descriptions. ×Total for 13 days ++ Estimated, total for 13 days.

Land preparation, water topping and rice growth & development stages required 22.38, 8.58 and 7.53 mm of water per day respectively (table 18, P. 97). The total effective water required for the first three rice husbandry stages (land preparation, water topping and rice growth & development) was 1460.58 mm (table 18, P.97). Total effective water was used as follows: 22.38% (335.73 mm) for land preparation, 8.58% (274.58 mm for water topping and 58.22% (850.27 mm) for rice growth & development (table 22). If 1979/80 cropping programme (table 25, P. 115 is examined it can be seen total effective water which would have been used by this Unit is 1742.00 mm. This would have been used as follows: 20.48% (356.76 mm) for land preparation, 19.29% (336.04 mm) for water topping and 60.23% (1049.20 mm) for rice growth & development. The effective water used for land preparation was higher by 1.90% while that of water topping was lower by 10.71% as per 1979/80 cropping programme. Rice growth & development water requirement was 2.01% lower than 1979/80 estimates.

6.2 RESULTS --------- CONT'D

UNIT H3: In Unit H3 (table 21, P.105 and 28, P.122) total inflow consisted of 84.83% (1922 mm) of river water and 15.37% (349 mm) rain water. Once this water reached the fields: 40.51% (920 mm), 4.67% (106 mm) and 41.35% (939 mm) were lost through evapotranspiration, deep percolation and surface drainage (outflow) respectively. 13.47% (306 mm) was stored in the soil. Total effective water was 58.65% (1322 mm) of the total inflow. The effective water was maximum during the flooding and rotavation stages - (Fig.19. P.100) followed by a bit decrease and then it increased again reaching maximum during the transplanting and tillering stages and thereafter it decreased approaching near zero during the harvesting stage.

The totalhectareage for Unit H3 is 134.1 (table 29, P.123). The average daily inflow, outflow, evapotranspiration and deep percolation were 9.07, 4.47, 4.35 and 0.48 mm respectively (Tables 16, 17 and 18, P. 94, 96 96 , and 97 respectively. Land preparation stage took 20 days, same period as planned in 1979/80 cropping programme; water topping took 48 days against 61 days planned in the said programme; and rice growth & development took 115 days instead of 122 days in the programme in question - (tables 15 and 16, P. 93 and 94 respectively).

Table 21: SUMMARY OF WATER BALANCE FOR UNIT H3 AND WATER-USE EFFICIENCY

MONTH	(I) INFLOW mm/Mo.	(R) RAINFALL mm/Mo.	E_T (PENMAN) mm/Mo.	DEEP (DP) PERCOLATION LOSSES mm/Mo.	(O) OUTFLOW mm/Mo.	EFFECTIVE WATER (I+R)-O mm/Mo.	E_u %	FARMING ACTIVITIES[1]
JUNE 1979	252^{x}	0.00^{x}	75^{x}	30^{++}	117^{x}	135	53.57	1 & 2
JULY 1979	449	13	105	9	152	310	67.10	3, 4, 5(a), 5(b), 6 & 7
AUGUST 1979	360	4	124	1	238	126	34.62	8 & 9
SEPTEMBER 1979	405	4	159	4	68	341	83.37	9, 10, 11, 12 & 13
OCTOBER 1979	341	41	161	4	81	301	78.80	13, 14, 15 & 16
NOVEMBER 1979	115	221	123	27	221	115	34.23	16, 17, 18, 19, 20, 21 & 22
DECEMBER 1979	0.00	58	136	19	62	4	-	23
JANUARY 1980	0.00	8.0^{+}	37^{+}	12	0.00	8	-	24
TOTAL FOR THE SEASON	1922	349	920	106	939	1332		

^{x}Total for 20 days

^{x}Total for 9 days

[1] See Appendix I(a) for Farming Activity descriptions

$^{++}$Estimated, total for 20 days

Land preparation, water topping and rice growth & development stages consumed 6.75, 7.90 and 7.07 mm of water per day respectively (table 22, P, 112). The total effective water required for the first three rice husbandry stages (land preparation, water topping and rice growth & development) was 1326.71 mm (table 22, P. 112). The total effective water was used as follows: 10.18 (135 mm) for land preparation), 28.57% (379.10 mm) for water topping and 61.25% (815.61 mm) for rice growth & development (table 22, P. 112). Using 1979/80 cropping programme total effective water requirements would have been 2106.84; 18.81% (396.40 mm) for land preparation 31.39% (661.24 mm) for water topping and 49.80% (1049.20 mm) for rice growth & development (tables 22, P, 112 and 25, P. 115). The effective water used for land preparation was lower by 8.63% while that of water topping was still lower by 2.82% as per 1979/80 cropping programme. Rice growth & development water requirement was 11.45% higher than 1979/80 cropping programme estimate. It should be noted that total effective water requirement used during 1979/80 season is lower than that of 1979/80 cropping programme estimates by 780.13 mm.

UNIT H20: Total inflow of Unit H20 (tables 23, P. 113 and 28, P. 122) consisted of 90.41% (3401 mm) of the river water and 9.59% (361 mm) of rain water. When this water reached the fields; 24.05 (905 mm), 0.00% (0.00 mm) and 20.94% (788 mm) were lost through evapotranspiration, deep percolation and surface drainage (outflow) respectively. 55.01% (2070 mm) was stored in the soil. Total effective water was 79.06% of the total inflow. Like other units, the effective water was maximum during the flooding and rotavation stages; then it decreased thereafter gradually from the water topping stage to ripening stage and decreased abruptly during the harvesting stage approaching near zero at the end of the harvesting stage (Fig. 20 P. 108).

The average daily inflow, outflow evapotranspiration and deep percolation were 17.56, 4.29, 4.35 and 0.00 mm respectively - (tables 11, 12 and 14, P. 89 , 90 , and 92 respectively. Land preparation stage took 25 days estimated in 1979/80 cropping programme; water topping took 39 days against 61 days in the said cropping programme and rice growth & development took 111 days instead of 122 days planned in the 1979/80 cropping programme - (tables 15 and 16, P. 93 , and 94 respectively).

Land preparation, water topping and rice growth & development stages consumed 19.15, 19.53 and 13.18 mm of water per day respectively (table 24, P. 114). The total effective water consumed by the first three rice husbandry stages (land preparation, water topping and rice growth & development) was 2953.45 mm. This unit

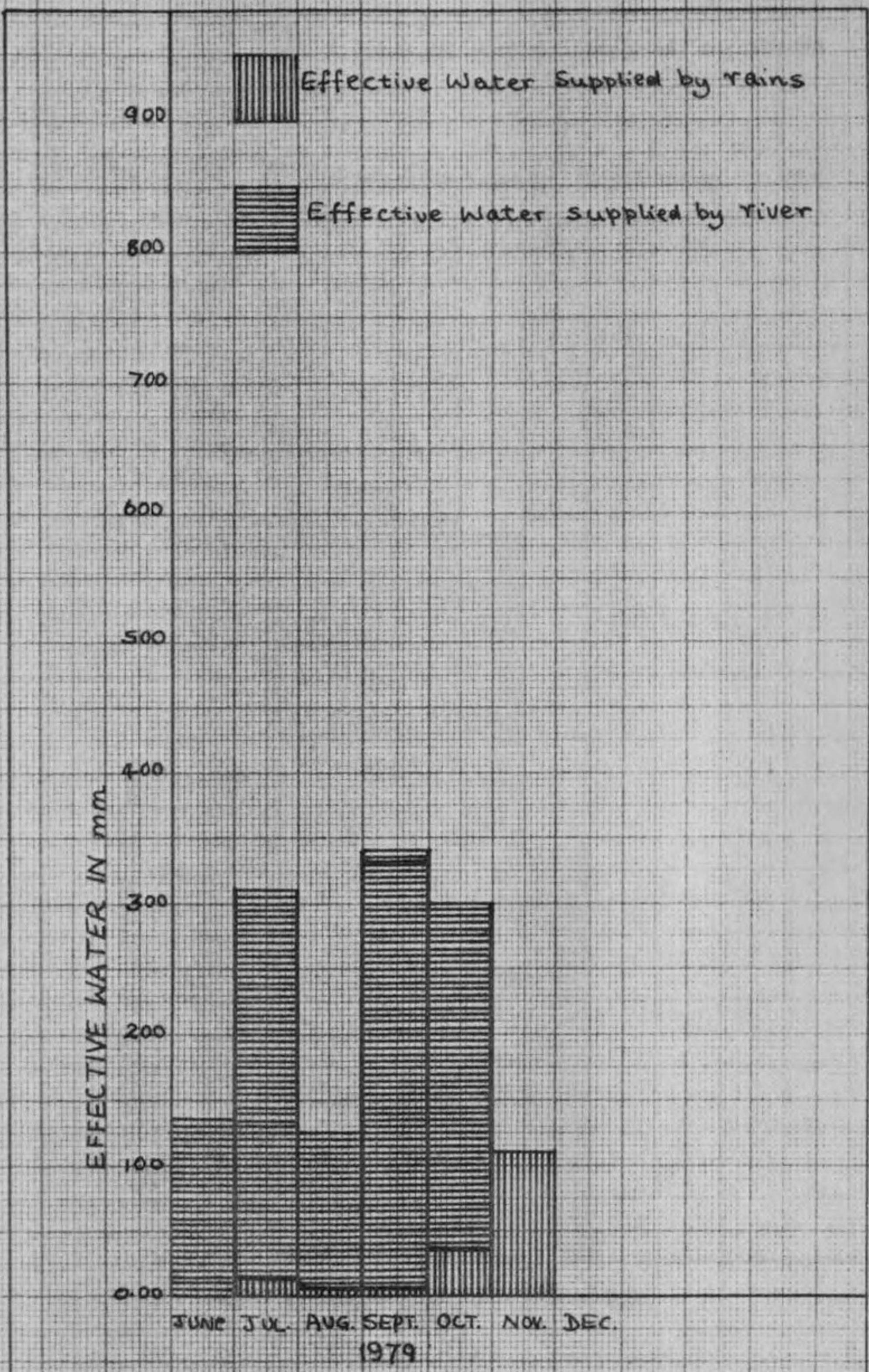

Fig. 20 Effective Water Supplied by rain and irrigation for UNIT H3

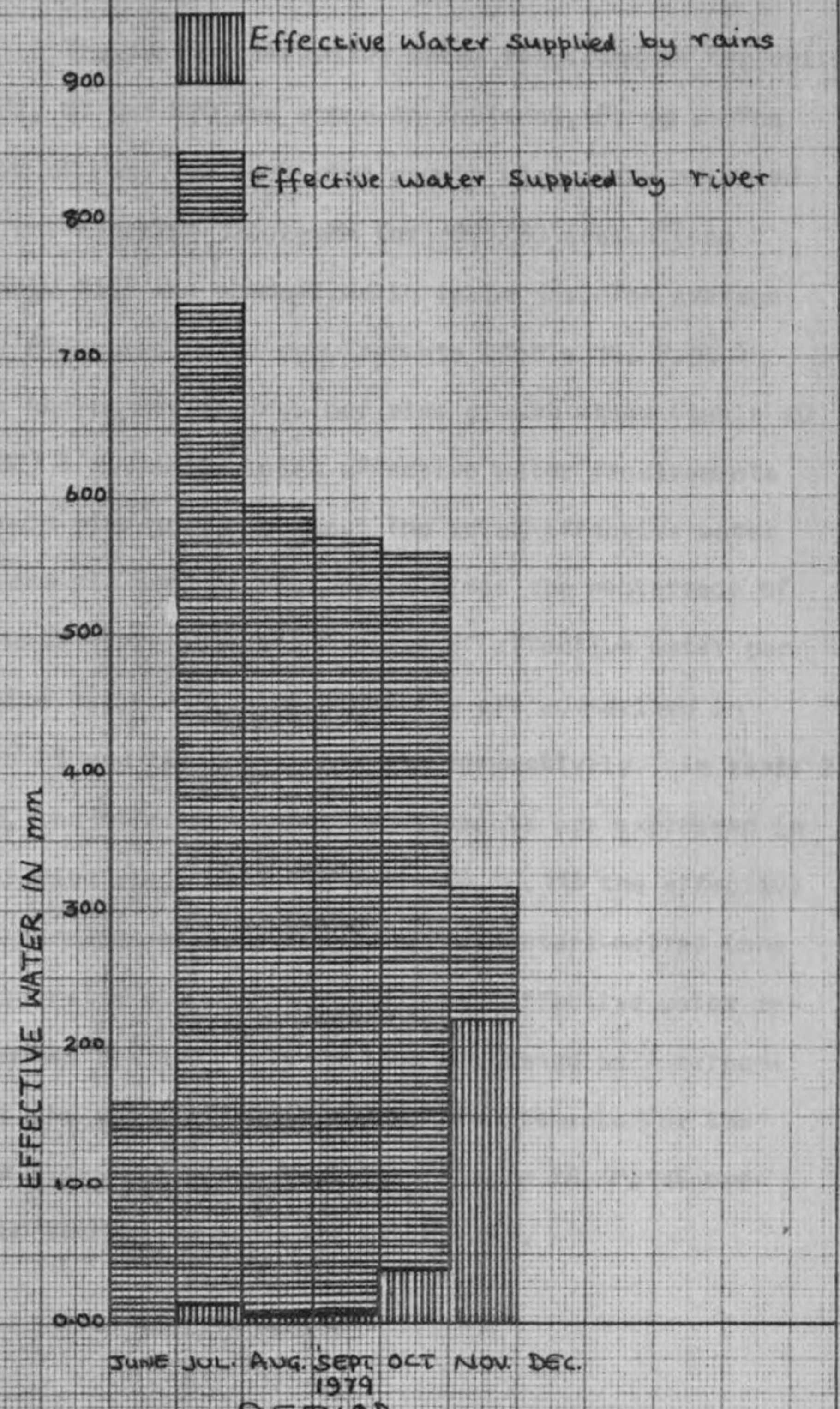

Fig. 21 Effective water supplied by rain and irrigation for UNIT H20

The average effective water requirements for units H1, H2, H3 and H20 are shown in table 19, P. 98 . The number of days for each rice growth stage were obtained from the cropping programme for 1979/80 season (see Appendix XII) and summarized in table 16. The average daily effective water requirements (table 16, P.94) times the number of days per rice growth stage (table 20 P. 102)) gives the total effective water requirements for each rice growth stage. The total effective water requirements per one rice cycle times the hectareage of each unit gives the total volume of effective water per one rice cycle. All these details are summarized in tables 25 and 26, P. 115, and 116 respectively. In table 25, P. 115, the effective water requirements are expressed in mm per rice stage while in table 26, P. 116 the effective water requirements are expressed in hactare-metres (one hactare-metre = 10,000 m^3) and total effective water requirements for each unit is also expressed as a percenage of the total effective water requirements for the entire Thiba Section. Details of table 26, P. 116 are further summarized in table 27, P. 117.

has hectareage of 132 (table 29, P.123). The actual effective water requirement per hectare per 1979/80 season was 22.37 mm. The total effective water was used as follows: 24.67% (728.74 mm) for land preparation, 25.79% (761.56 mm) for water topping and 49.54% (1463.15 mm) for rice growth and development (table 24, P. 114). Total effective water requirements based on 1979/80 cropping programme would have been 2020.12 mm. The breakdown would have been 19.62% (396.40 mm) for land preparation, 28.44; (574.52 mm) for water topping and 51.94% (1049.20 mm) for rice growth & development (table 25, P. 115). Total effective water used in this unit was higher than 1979/80 cropping programme figure by 933.33 mm. The effective water consumed by land preparation was higher than estimated in 1979/80 cropping programme by 332.34 mm, while the effective water topping was still higher by 187.04 mm and rice growth and development stage used 413.95 mm more than estimated in the said programme.

6.3 ESTIMATION OF THE EFFECTIVE WATER REQUIREMENTS FOR THIBA SECTION DURING 1979/80 SEASON

From this water balance study the total effective water requirements for each growth stage was determined as summarised in tables 10, 17, 18, 20, 21, 22, 23 and 24, P. 87,96 ,97,102,105,112,113 and 114 respectively.

Table 22: EFFECTIVE WATER REQUIREMENTS FOR DIFFERENT RICE HUSBANDRY STAGES ON FIELD MEASUREMENTS, UNIT H3

RICE HUSBANDRY STAGE	NO. OF DAYS PER STAGE	mm/stage	%	mm/day	DATES	REMARKS
LAND PREPARATION	20	135.00	10.18	6.75	11 June - 30 June 1979	
WATER TOPPING	48	379.10	28.57	7.90	1 July - 17 Aug. 1979	
RICE GROWTH & DEVELOPMENT	115	812.61	61.25	7.07	18 Aug. - 10th Dec. 1979	
HARVESTING	38	-	-	-	10 Dec. 1979 - 17 Jan. 1980	

MONTH	(I) INFLOW mm/Mo.	(R) RAINFALL mm/Mo.	E_T (PENMAN) mm/Mo.	DEEP (DP) PERCOLATION LOSSES mm/Mo.	(O) OUTFLOW mm/Mo.	EFFECTIVE WATER (I+R)-O mm/Mo.	Eu %	FARMING ACTIVITIES ++
JUNE 1979	169 x	0.00 x	11 x	0.00 x	3 x	166	98.22	1 & 2
JULY 1979	830	13	105	0.00	103	740	87.78	3, 4, 5(a), 5(b), 6, 7 & 8
AUGUST 1979	738	4	124	0.00	146	596	80.43	9
SEMPTEMBER 1979	689	4	159	0.00	121	572	82.54	9, 10, 11 & 12
OCTOBER 1979	623	41	161	0.00	103	561	84.48	13, 14, 15 & 16
NOVEMBER 1979	353	221	123	0.00	258	316	55.05	16, 17, 18, 19, 20, 21 & 22
DECEMBER 1979	0.00	58	136	0.00	54	4	-	23
JANUARY 1980	0.00 +	20 +	86 +	0.00	0.00	20	-	24
TOTAL FOR THE SEASON	3402	361	905	0.00	788	2975		

++See Appendix I for farming activity descriptions x Total for 4 days + Total for 21 days

Table 24: EFFECTIVE WATER REQUIREMENTS FOR DIFFERENT RICE HUSBANDRY STAGES BASED ON FIELD MEASUREMENTS, UNIT H2O

RICE HUSBANDRY	NO. OF DAYS PER STAGE	mm/stage	%	mm/day	DATES	REMARKS
LAND PREPARATION	25	728.74	24.67	29.15	June 27 - July 22 1979	
WATER TOPPING	39	761.56	25.79	19.58	July 22 - Aug. 30 1979	
RICE GROWTH & DEVELOPMENT	111	1463.15	49.54	18.18	Aug. 31 - Dec. 19 1979	
HARVESTING	38	-	-	-	Dec. 20 1979 - Jan. 26 1980	Water not required

TABLE 25: ESTIMATED EFFECTIVE WATER REQUIREMENTS FOR THIBA SECTION BASED ON CROPPING PROGRAMME FOR 1979/80 SEASON AND FIELD DATA (FROM TABLES 21,22,23,24 AND 19)

RICE HUSBANDRY STAGES	H4		H5		H6		H19		H7		H18		REMARKS
	D/S**	EWR/S***	D/S	EWR/S	D/S	EWR/S	D/S	EWR/S	D/S	EWR/S	D/S	EWR/S	
LAND PREPARATION	17	336.94	25	495.50	20	396.40	20	396.40	17	336.94	20	396.40	
WATER TOPPING	152	1647.68	132	1430.88	114	1235.76	97	1051.48	91	986.44	76	823.84	
RICE GROWTH & DEVELOPMENT	122	1049.20	122	1049.20	122	1049.20	122	1049.20	122	1049.20	122	1049.20	
TOTAL	291	3033.82	279	2975.58	256	2681.36	239	2497.08	230	2372.58	218	2269.44	

RICE HUSBANDRY STAGES	H3		H20		H8		H1		H2				REMARKS
	D/S	EWR/S	D/S	EWR/S	D/S	EWR/S	D/S	EWR/S	D/S	EWR/S			
LAND PREPARATION	20	396.40	20	396.40	18	356.76	16	317.12	18	356.76			
WATER TOPPING	61	661.24	53	574.52	40	433.60	43	466.12	31	336.04			
RICE GROWTH & DEVELOPMENT	122	1049.20	122	1049.20	122	1049.20	122	1049.20	122	1049.20			
TOTAL	203	2106.84	195	2020.12	180	1839.56	181	1832.44	171	1742.00			

** D/S= DAYS/STAGE *** EWR/S= EFFECTIVE WATER REQUIREMENTS PER STAGE

EFFECTIVE WATER REQUIREMENTS PER STAGE= DAYS PER STAGE X AVERAGE EFFECTIVE WATER PER DAY (SEE TABLE 25)

TABLE 26: ESTIMATED EFFECTIVE WATER REQUIREMENTS FOR THIBA SECTION BASED ON CROPPING PROGRAMME FOR 1979/80 SEASON AND FIELD DATA

RICE HUSBANDRY STAGES	H4		H5		H6		H19		H7				SUB-TOTAL PER RICE HUSBANDRY STAGE, Ha-M****
	D/S	EWR/S (Ha-M/S)	D/S	EWR/S (Ha-M/S)	D/S	EWR/S (Ha-M/S)	D/S	EWR/S (Ha-M/S)	D/S	EWR/S (Ha-M/S)			
LAND PREPARATION	17	30.147	25	76.83374	20	43.492	20	43.492	17	27.555			221.519
WATER - TOPPING	152	147.425	132	221.874	114	135.584	97	115.365	91	80.672			700.920
RICE GROWTH & DEVELOPMENT	122	93.876	122	162.690	122	115.115	122	115.115	122	85.805			572.601
TOTAL	291	271.448	279	461.397	256	294.191	239	273.972	230	194.032			1495.040
% EWR		10.176		17.297		11.029		10.271		7.274			
RICE HUSBANDRY STAGES	H18		H3		H20		H8		H1		M2		SUB-TOTAL PER RICE HUSBANDRY STAGE, Ha-M
	D/S	EWR/S (Ha-M/S)	D/S	EWR/S (Ha-M/S)	D/S	EWR/S (Ha-M/S)	D/S	EWR/S (Ha-M/S)	D/S	EWR/S (Ha-M/S)	D/S	EWR/S (Ha-M/S)	
LAND PREPARATION	20	37.453	20	42.850	20	45.578	18	33.798	16	22.982	18	32.643	215.304
WATER TOPPING	76	91.723	61	71.478	53	66.058	40	41.078	43	33.780	31	30.742	334.859
RICE GROWTH & DEVELOPMENT	122	116.814	122	113.415	122	120.637	122	99.398	122	76.036	122	96.000	622.300
TOTAL	218	245.990	203	227.743	195	232.273	180	174.274	181	132.798	171	159.385	1172.463
% EWR		9.222		8.538		8.708		6.533		[illegible]		[illegible]	

**** [redacted] SEE TABLE:27) = 2667.503 EWR= EFFECTIVE WATER REQUIREMENTS

Table 27: GRAND-TOTAL ESTIMATED EFFECTIVE WATER REQUIREMENTS FOR DIFFERENT RICE HUSBANDRY STAGES FOR 1979/80 SEASON

RICE HUSBANDRY STAGE	TOTAL ESTIMATED EFFECTIVE WATER Ha - m	% OF EFFECTIVE WATER	REMARKS
LAND PREPARATION	436.82	16.38	grand-total for all units in Thiba Section
WATER TOPPING	1035.78	38.83	grand-total for all units in Thiba Section.
RICE GROWTH & DEVELOPMENT	1194.90	44.80	grand-total for all units im Thiba Section.
GRAND TOTAL FOR 1979/80	2667.50		

6.4 WATER-USE EFFICIENCY

Water-use efficiency is defined as the proportion of water beneficially used on farm or field. It is expressed as follows:-

$$E_u = 100 \frac{Wu}{Wd} \quad (9)$$

where:

Wu = Water beneficially used in the field.

Wd = Water delivered to the field.

In this study Wu is taken to be the effective water and Wd is taken to be total inflow (river water plus the rain water). In Units H1, H2 & H3, Eu was highest during the tillering stage while in H20 it was highest during the flooding time. In other units (H1, H2 and H3) the Eu is generally high and low during the ripening stage (tables 10, 21 and 23, P. 87, 105, and 113 respectively.

6.5 CALCULATIONS OF VARIOUS PERCENTAGES OF WATER BALANCE COMPONENTS

The water balance equation can be rewritten as follows:-

$$Si+I+R+SI+CR = O+DP+E_T+LS+SF \quad (10)$$

Since Si, SI, CR and LS are negligible, the equation 10 therefore can now be written as follows:-

$$I+R = O+DP+E_T+S_f \quad (11)$$

The water balance components in equation (11) can be expressed as percentages of total water supplied to each unit as shown below:-

1. <u>UNIT H1 (See table 10. P. 87)</u>

Total water supplied to Unit H1 within one rice cycle = 2234 mm.

I = 1882 mm; 1% = (1882/2234) x 100 = 84%

R = 352 mm; R% = (352/2234) x 100 = 16%

O = 864 mm; O% = (864/2234) x 100 = 38.6% = 39%

DP losses = 352 mm; DP losses.

% = (352/2234) x 100 = 15.76% = 16%

E_T = 848 mm; E_T = (848/2234) x 100 = 37.96% = 38

Sf = 170 mm; Sf% = (170/2234) x 100 = 7.6% = 8%

Effective water = 1370 mm; Effective water

% = (1370/2234) x 100 = 61.32% = 61%

2. <u>UNIT H2 (See table 20, P.102)</u>

Total water supplied to Unit H2 within one rice cycle = 2344 mm.

I = 1983 mm; I% = (1983/2234) x 100 = 84.6% = 85%

R = 361 mm; R% = (361/2344) x 100 = 15.4% = 15%

O = 843 mm; O% = (843/2344) x 100 = 35.96% = 36%

DP losses = 270 mm; DP losses -

% = (270/2234) x 100. = 11.52 = 12%

E_T= 879 mm;E_T.% = (879/2234) x 100 = 37.5% = 38%

Sf = 352 mm; Sf% = (352/2234) x 100 = 15.02% = 15

Effective water = 1501 mm; Effective water % =

(1501/2344) x 100 = 64.04% = 64%

3. UNIT H3 (See table 21. P. 105)

Total water supplied to Unit H3 within one rice cyle = 2271 mm.

I = 1922 mm; I% = (1922/2271) x 100 = 84.63% = 85

R = 349 mm; R% = (349/2271) x 100 = 15.37% = 15

O = 939 mm; O% = (939/2271) x 100 = 41.35% = 41%

DP losses = 106 mm; DP losses -

% = (106/2271) x 100 = 4.67% = 5%

E_T = 920 mm; E % = (920/2271) x 100 = 40.51% = 41

Sf = 306 mm; Sf% = (306/2271) x 100 = 13.47% = 14

Effective water = 1332 mm; Effective - water % =

(1332/2271) x 100 = 58.65% = 59%.

4. UNIT H20 (See table 23. P. 113)

Total water supplied to Unit H20 within one rice cycle = 3763 mm.

I = 3402 mm; I% = 3402/3763) x 100 = 90.41% = 90%

R = 361 mm; R% = (361/33763) x 100 = 9.59% = 10%

O = 788 mm; O% = (788/3763) x 100 = 20.94% = 21%

DP losses = 0.00 mm; DP losses -

% = (0.00/3763) x 100 = 0.00

E_T = 905 mm; E % = (903/3763) x 100 = 24.05% = 24%

Sf = 2070 mm; Sf % = (2070/3763) x 100 = 55.01%

= 55%

Effective water = 2975 mm; Effective water % =

(2975/3763) x 100 = 79.06% = 79%

TABLE: 28 SUMMARY OF COMPONENTS OF WATER BALANCE FOR UNITS: H1, H2, H3 AND H20

UNIT	I		R		E_T		DP		O		S_f		EFFECTIVE WATER	
	mm	%	mm	%	mm	%	mm	%	mm	%	mm	%	mm	%
H1	1882	84.00	352	16.00	848	37.96	352	15.76	864	38.68	170	7.60	1370	61.32
H2	1983	84.60	361	15.40	879	37.50	270	11.52	843	35.86	352	15.02	1501	64.04
H3	1922	84.63	349	15.37	920	40.51	106	4.67	939	41.35	306	13.47	1332	58.65
H20	3402	90.41	361	9.59	905	24.05	0.00	0.00	788	20.94	2070	55.01	2975	79.06
AVERAGE	2297	85.91	355.75	14.09	888	35.01	182	7.99	858.50	34.23	724.50	25.28	1794	65.77

Table 29: <u>GROSS AND NETT AREAS - THIBA SECTION</u>

UNIT	NETT AREA ha	ROADS ha	BUNDS/DRAINS/ CANALS ha	TOTAL ha
H1	76.8	6.0	7.1	89.9
H2	104.6	2.0	10.3	117.7
H3	114.6	9.0	10.5	134.1
H20	116.4	5.0	10.6	132.0

6.6 THE SUMMARY OF THE MAIN FINDINGS

The main findings from this study can be summarized as follows:-

1. Total estimated effective water requirements for 1979/80 season = 2668 ha-metres.

2. Total estimated effective water requirements for land preparation stage during 1979/80 season = 437 Ha-M (16.4%) of total effective water requirements).

3. Total estimated effective water requirements for water topping stage during 1979/80 season = 1036 Ha-M (38.8%) of total effective water requirements).

4. Total estimated effective water requirements for rice growth and development stage during 1979/80 = 1194.90 Ha-M (44.8% of total effective water requirements).

5. Effective water requirements per ha for 1979/80 season = 2.34 Ha-M per ha.

6. Effective water required per holding of 0.405 ha (for 1979/80 season) = 0.95 Ha-M (9500 m^3).

7. Effective water required to produce 1 kg of paddy rice = 4.19 m^3.

8. Effective water required to produce a 75 kg-bag of paddy rice = 314 m^3.

CHAPTER 7

ANALYSIS AND FINDINGS: CANAL INVESTIGATIONS

DATA TREATMENT

Some points of known elevation along the canal were selected and the horizontal distances between them were determined. With this information the gradients in decimal points were calculated - (table, 32, P. 130, 33, P.131 and Appendix VI). For the main canal five distances were selected and average gradient was calculated. The original design specifications were obtained from R. Chambers and J. Moris P. 81 - 98. Using the survey data of the main canal the selected cross-sections were drawn to the scale and thereafter wetted perimeter (P), cross-sectional area (A), hydraulic radius (R), canal depth (d) and top width(B) were determined. The roughness coefficient, n of 0.15 was chosen to represent very weedy canal (Israelsen P. 81). Using the Manning's formula $(Q = \frac{1}{n} R^{\frac{2}{3}} S^{\frac{1}{2}} A)$ the original design capacity and current capacities were calculated (table 30, P.127). The same procedure was followed in determination of original and current capacities of the branch canal as well as the current specifications of the selected cross-sections (tables 34, P.133, 35, P.134 and Appendix VIII).

Table 30: THIBA SECTION MAIN CANAL (FROM PERMANENT [redacted] OFF-TAKE OF BRANCH CANAL FEEDING UNITS H2, H3, H4, & H5 TO OFF-TAKE OF UNIT H20) ORIGINAL AND CURRENT SPECIFICATIONS OF DIFFERENT STATIONS.

STN	WETTED PERIMETER P m	CROSS-SECTIONAL AREA A m^2	HYDRAULIC RADIUS R m	CANAL DEPTH d m	TOP WIDTH B m	AVERAGE GRADIENT S	DESIGN CAPACITY Qf m^3/sec	ROUGHNESS COEFFICIENT n*	CURRENT CAPACITY Qi m^3/sec
0 + 00	13.20	10.80	1.42	2.30	13.80	.0012	2.83	.15	5.55
2 + 00	12.43	13.84	1.11	1.90	10.00	-do-	-do-	-do-	3.46
18 + 00	11.72	14.00	1.19	2.10	10.40	-do-	-do-	-do-	4.52
20 + 00	10.07	11.00	1.09	1.80	10.40	-do-	-do-	-do-	3.35
22 + 00	11.70	12.00	1.03	2.10	9.60	-do-	-do-	-do-	3.52
24 + 00	12.54	14.40	1.15	2.10	13.20	-do-	-do-	-do-	4.54
26 + 00	11.99	13.00	1.09	2.20	10.40	-do-	-do-	-do-	3.96
28 + 00	16.56	14.00	0.85	2.50	11.60	-do-	-do-	-do-	3.61
30 + 00	15.73	20.00	1.27	2.90	12.80	-do-	-do-	-do-	6.74
32 + 00	13.97	16.00	1.15	2.70	10.80	-do-	-do-	-do-	5.05
34 + 00	14.30	19.00	1.33	2.60	11.60	-do-	-do-	-do-	6.61

Table 38: THIBA SECTION MAIN CANAL ....contd.

STN	P	A	R	d	B	S	Qi	n	Qf
36 + 00	13.31	15.00	1.13	2.50	12.00	-do-	-do-	-do-	4.68
38 + 00	13.26	18.00	1.36	2.50	13.20	-do-	-do-	-do-	6.35
40 + 00	13.75	17.00	1.24	2.50	10.40	-do-	-do-	-do-	5.64
42 + 00	15.29	20.00	1.31	2.80	13.60	-do-	-do-	-do-	6.88
44 + 00	14.63	16.00	1.09	2.60	12.00	-do-	-do-	-do-	4.87
46 + 00	14.41	17.00	1.18	2.70	12.80	-do-	-do-	-do-	5.46
48 + 00	14.30	19.00	1.33	2.40	15.20	-do-	-do-	-do-	6.61
AVERAGE	13.51	16.00	1.18	2.40	18.88	0.0012	2.83	0.15	5.19

P. 81 Israelsen * Origin design, n 0.033 chosen was for canal with earth bottom and rubble sides. In this study canals were observed to be very weedy, so n adjusted to = 0.15.

Table 31: MAIN CANAL (FROM OFF-TAKE OF BRANCH CANAL SUPPLYING WATER TO UNITS H2, H3, H4, AND H5 TO OFF-TAKE OF UNIT H20) ORIGINAL AND CURRENT SPECIFICATIONS ORIGINAL DESIGN SPECIFICATIONS

Initial capacity, Qi	2.83 m^3/sec.
Average Gradient, S	0.00028571
Top width, B	6.87 m.
Canal depth, d	1.27 m.
Side slopes, Z	1½ to 1.
Roughness Coefficient, n	0.033
Resulting Velocity, V	0.48 mps.
Cross-sectional area, A	6.32 m^2.
Wetted Perimeter, P	7.64 m.
Hydraulic Radius, R	0.83 m.
Shape of canal cross-section:	Trapezoidal

AVERAGE CURRENT SPECIFICATIONS

Current capacity, Qf	5.19 m^3/Sec.
Average Gradient, S	0.0012
Top width, B	18.88 m.
Canal depth, d	2.40 m.
Side slopes, Z	non-uniform
Roughness coefficient, n	0.15
Resulting Velocity, V	0.32 mps
Cross-sectional area, A	16.00 m^2
Wetted perimeter, P	13.51 m.
Hydraulic Radius, R	1.18
Shape of canal cross-section	: parabolic

Table 32: THE AVERAGE GRADIENT OF THE MAIN CANAL (FROM THE OFF-TAKE OF BRANCH CANAL FEEDING UNITS H2, H3, H4 AND H5 TO OFF-TAKE OF UNIT H20).

STATIONS (Points)	HORIZONTAL DISTANCE (M)	ELEVATION DIFFERENCE (M)	GRADIENT
26 + 00 & 18 + 00	800	0.86	0.0011
34 + 00 & 26 + 00	800	0.4	0.0005
38 + 00 & 34 + 00	400	1.06	0.0027
46 + 00 & 38 + 00	800	0.46	0.0006

Average gradient = 0.0049/4 = 0.0012

Table 33: THE AVERAGE GRADIENT OF BRANCH CANAL (FROM OFF-TAKE OF UNITS HI, TO NEAR THE ACCESS ROAD TO THIBA AND WAMUMU RECEPTION CENTRES).

STATIONS (Points)	HORIZONTAL DISTANCE	DIFFERENCE IN ELEVATION	GRADIENT
5 + 00 & 7 + 00	200	0.14	0.0007
6 + 00 & 8 + 00	200	0.13	0.0007
8 + 00 &10 + 00	200	0.07	0.0004
7 + 00 & 9 + 00	200	0.13	0.0007
0 + 00 & 2 + 00	200	0.14	0.0006

Average gradient = 0.00061

7.2 RESULTS: MAIN CANAL

The original design specifications and average current specifications are shown in table 30, P.127. The following are the main findings of the main canal:

1. Capacity has increased by 83.39%
2. Gradient has increased from 0.00028571 to 0.001856.
3. Top width has increased by 174.82%.
4. Canal depth has increased by 88.98%.
5. Side slopes have changed from uniform to non-uniform.
6. Roughness coefficient, n has been adjusted from 0.033 to 0.15 owing to very heavy growth of water-loving plants.
7. Resulting velocity has increased by 32.5%.
8. Cross-sectional area has increased by 153.16%.
9. Wetted perimeter has increased by 76.83%.
10. Hydraulic radius has increased by 42.17%.
11. Shape of the canal cross-section has changed from trapezoidal to parabolic.

Table 34: BRANCH CANAL (FROM OFF-TAKE OF UNIT H1 TO NEAR THE ACCESS ROAD TO THIBA AND WAMUMU RECEPTION CENTRES) ORIGINAL AND CURRENT SPECIFICATIONS

(a) ORIGINAL DESIGN SPECIFICATIONS

Initial capacity, Qi	1.42 m^3/sec.
Average Gradient	0.0004
Top width, B	4.39 m.
Canal depth, d	0.853 m.
Side slopes, Z	1½ to 1.
Roughness Coefficient, n	0.025
Resulting Velocity, V	0.534 mps.
Cross-sectional area, A	2.65 m^2.
Wetted perimeter, P	4.91 m.
Hydraulic Radius, R	0.54 m.

Shape of canal cross-section: Trapezoidal

(b) AVERAGE CURRENT SPECIFICATIONS

Current capacity, Qf	0.41 m^3/sec.
Average Gradient, S	0.00061
Top width, B	5.91 m.
Canal depth, d	1.27 m.
Side slopes, Z	non-uniform.
Roughness Coefficient, n	0.15
Resulting Velocity, V	0.11 mps.
Cross-sectional area, A	3.79 m^2
Wetted perimeter, P	7.26 m.
Hydraulic Radius, R	0.52

Shape of canal cross-section: parabolic.

Table 35: BRANCH CANAL - (FEEDING UNITS H1, H6, H7, & H8) CURRENT SPECIFICATIONS OF DIFFERENT STATIONS:

STN	P	A	R	d	B	S	Qi	n	Qf
0. + 00	6.23	4.32	0.693	1.20	5.80	0.00061	1.415	0.15	0.56
1. + 00	7.14	3.22	0.465	1.20	5.80	-do-	-do-	-do-	0.32
2 + 00	10.40	5.00	0.480	1.60	6.80	-do-	-do-	-do-	0.50
3 + 00	8.29	5.44	0.656	1.50	8.40	-do-	-do-	-do-	0.68
4 + 00	9.18	4.96	0.540	1.60	6.00	-do-	-do-	-do-	0.54
5 + 00	7.73	5.00	0.650	1.50	6.40	-do-	-do-	-do-	0.62
6 + 00	7.45	3.32	0.450	1.30	6.20	-do-	-do-	-do-	0.32
7 + 00	5.82	2.80	0.480	1.10	4.80	-do-	-do-	-do-	0.28
8 + 00	5.60	2.40	0.430	1.00	5.00	-do-	-do-	-do-	0.23
9 + 00	6.86	3.20	0.47	1.05	5.40	-do-	-do-	-do-	0.32
10 + 00	5.15	2.08	0.40	0.90	4.40	-do-	-do-	-do-	0.19
AVERAGE	7.26	3.79	0.519	1.268	5.91	0.00061	1.415	0.15	0.41

7.3 RESULTS: BRANCH CANAL

The original design specifications and average current specifications are shown in table 34, P.133. The following are the main findings of the branch canal:

1. Capacity has decreased by 101.00%.
2. Gradient has increased from 0.0004 to 0.00061.
3. Top width has increased by 34.62%.
4. Canal depth has increased by 48.89%.
5. Side slopes have changed from uniform to non-uniform.
6. Roughness Coefficient, n has been adjusted from 0.025 to 0.15 owing to heavy growth of water-loving plants.
7. Resulting velocity has increased by 79.40%.
8. Cross-sectional area has increased by 43.02%.
9. Wetted perimeter has increased by 47.86%.
10. Hydraulic radius has decreased by 3.7%.
11. Shape of canal cross-section has changed from trapezoidal to parabolic.

CHAPTER 8

DISCUSSIONS AND CONCLUSIONS

8.1 DIRECTIONS OF WATER FLOW IN THE SOIL

Ground water moves from a point of high hydraulic head to one of low hydraulic head; therefore, the flow of ground water can be charted if the various hydraulic heads are known. A piezometer is a tool that is used to determine the hydraulic head at a point in the soil profile, it is valuable in detecting artesian pressures and differences in pressure between various strata. The piezometer is a small-diameter pipe driven into the subsoil so that there is no leakage around the pipe and all entrance of water into the pipe is through the open bottom. The piezometer indicates only hydraulic head of ground water at the specific point in the soil where the lower end or opening of the tube is located. Batteries of piezometers of different lengths can be used to detect the vertical movement of ground water, and piezometers spaced at horizontal intervals can be used to detect horizontal seepage or movement.

This technique is especially useful in studying ground-water movement adjacent to canals, drains and reservoirs. The following figures show the ground-water flow at different hydraulic heads:

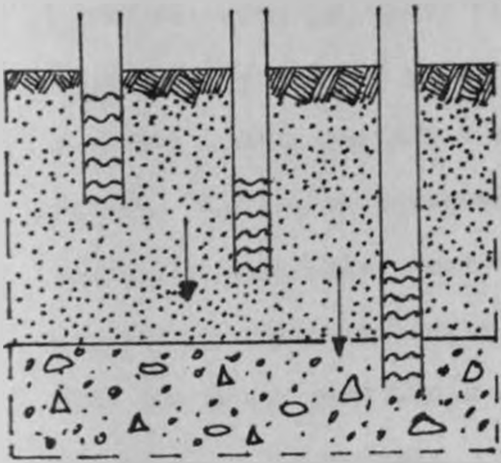

Fig. 22 (i) The piezometers indicate that the groundwater is going down and that there is some natural drainage

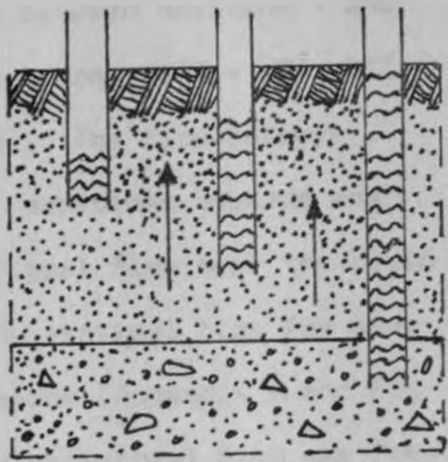

Fig. 22 (ii) The piezometers indicate a hydrostatic pressure or that there is water coming up from a deeper strata

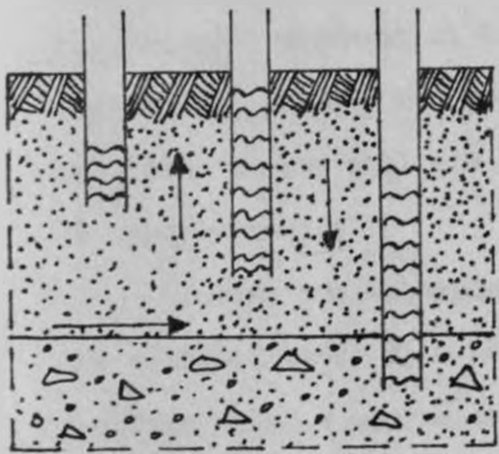

Fig. 22 (iii) The piezometers indicate a hydrostatic pressure in a stratum and that water is being forced up and down from the stratum

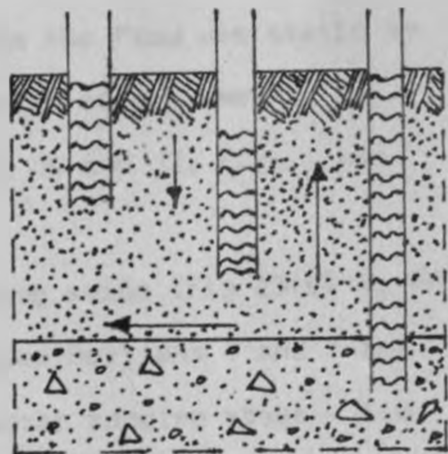

Fig. 22 (iv) The piezometers indicate that ground water is moving into a stratum and going out of the area

8.1 DIRECTIONS OF WATER FLOW IN THE SOIL

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UNIT HI

In HI during water topping stage (fig 23(a) P.141 the vertical water flow between horizons 1 and 3 and horizons 1 and 4 was downwards (BPI - WPI, BPI - YPI, BP2 - WP2, and BP2 - YP2). The flow between horions 3 and 4 was erratic - sometimes upwards and sometimes downwards. But vertical flow near the drain was mainly downwards while the vertical flow far away from the drain was mainly upwards (Appendix X and Fig 23, P.141. In horizons 1 the horizontal flow was from the field towards the area near drain (BP2 - BPI) while in horizon 3 the horizontal flow was from the area near drain towards the field (WP2 - WPI) and so in horizon 4 although at times the flow was static or reversed direction; for location of piezometer batteries in the soil see Fig 16 and 17, P. 74, and 75 respectively.

During the transplanting stage (Fig 23(b) P. 141 the vertical water flow between horizons 1 and 3 and horizons 1 and 4 was as in water topping stage - i.e. downwards. The vertical flow in horizons 3 and 4 near the drain was downwards while away from the drain it was mainly upwards although at times downwards flow was observed (Appendix X), month of September, 1979). In horizon 1 the horizontal flow now was from the area near the drain to the field (BPI to BP2) while in horizons 3 the horizontal flow was opposite (WP2 to WPI); and in horizon 4 the horizontal flow was from the area near the drain to the field (YPI to YP2).

The vertical flow in horizons 1 and 3 and horizons 1 and 4 during tillering stage (Fig 23(c) P.141 was the same as in the previous stages - downwards. In horizon 3 and 4 the flow near the drain was rather erratic - sometimes upwards, sometimes static and sometimes downwards, while far away from the drain the vertical flow was mainly upwards although at times static and at times downwards. The horizontal flow in horizon 1 was from the field to the area near the drain. In horizons 3 and 4 the horizontal flow was as rather erratic - sometimes from the area near the drain to the field, sometimes from the field to the area near the drain and sometimes static - (BP2 - BPI, WP2 - WPI and YP2 - YPI in Appendix X, October, 1979).

Like other stages the vertical water flow during flowering stage (Fig 22(d), P.137 in horizon 1 and 3 and horizons 1 and 4 are downwards (BPI & WPI, BPI & YPI, BP2 & YP2). In horizons 3 and 4 near the drain the vertical water flow is erratic - sometimes upwards, sometimes static and sometimes downwards. In the same horizons (3 and 4) far away from the drain the vertical flow is upwards. The horizontal water flow in horizon 1 is from the field to the area near the drain, while in horizon 3 the horizontal water flow is from the area near the drain to the field. In horizon 4 the horizontal flow though erratic was mainly from the field area to the area near the drain - (Appendix X - November, 1979).

Again like other previous stages 1 the vertical water flow during maturing/harvesting stage (Fig 23 (e), P.141 is downwards in horizons 1 and 3 and horizons 1 and 4. In horizons 3 and 4 near the drain the vertical water flow is erratic - sometimes upwards, sometimes static and sometimes downwards while in the same horizons (3 and 4) the vertical flow is upwards during the early part of December and downwards during the latter part of the month (harvesting stage). The horizontal water flow in horizon 1 is erratic - sometimes from the field area to the area near the drain, sometimes from the area near the drain to the field area. In horizons 3 and 4 the horizontal water flow is from the field area to the area near the drain - (Appendix X December, 1979).

THE FOLLOWING DIAGRAMS SHOW GENERAL WATER FLOW PATTERN IN DIFFERENT HORIZONS AT VARIOUS RICE HUSBANDRY STAGES IN UNIT H1

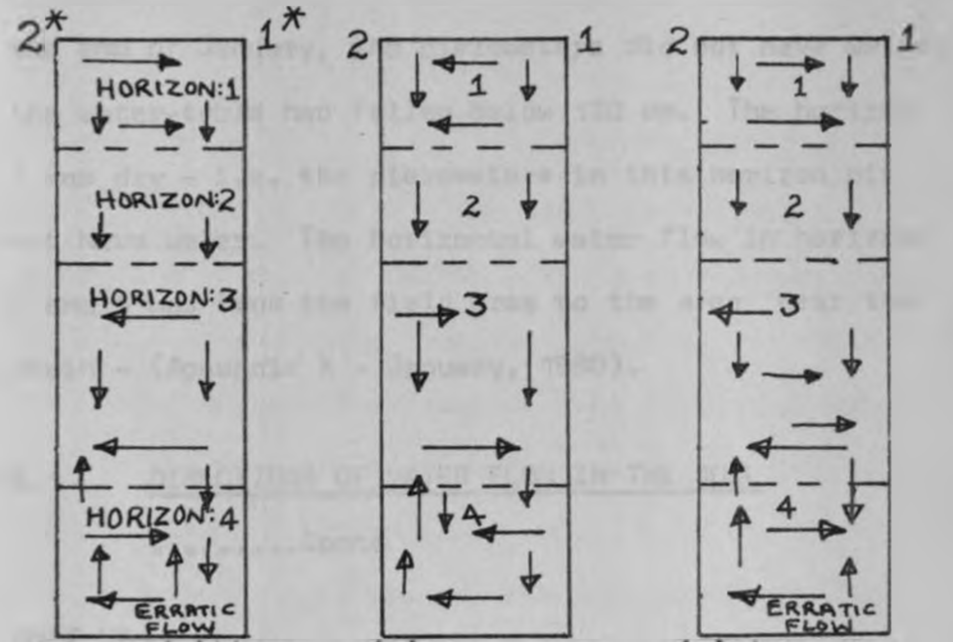
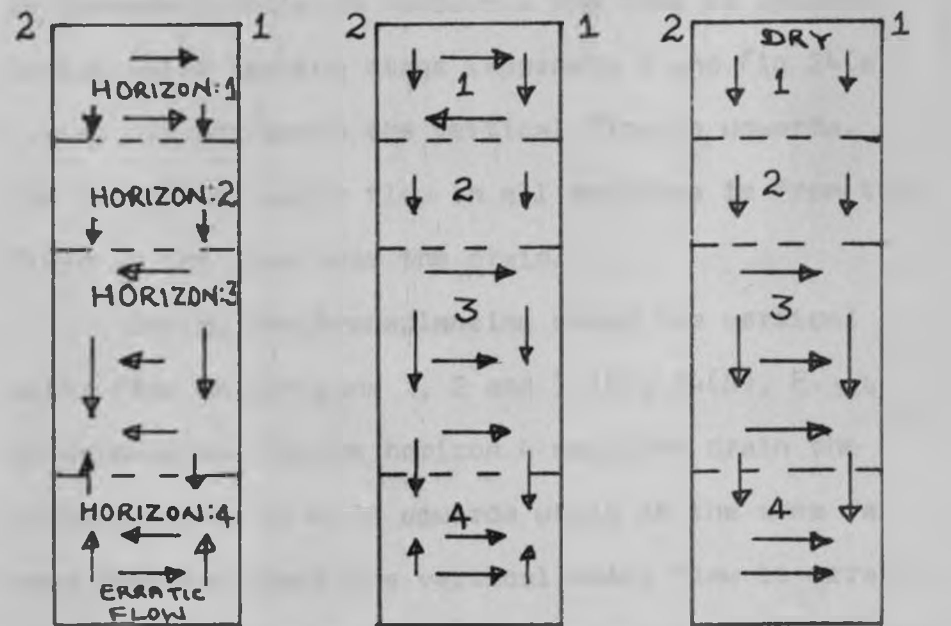


Fig.23(a) Water Flow Pattern During Water Topping Stage (Aug.1979)

(b) Water Flow Pattern During Transplanting Stage (Sept. 1979)

(c) Water Flow Pattern During Tillering Stage (Oct. 1979)



(d) Water Flow Pattern During Flowering Stage (Nov. 1979)

(e) Water Flow Pattern During Maturing/Harvesting Stage (Dec. 1979)

(f) Water Flow Pattern During Harvesting Stage (Jan. 1979)

* 1 = Drain Side
2 = Field Side

During the harvesting stage (January 1979) the vertical water flow in all horizons was downwards. At the end of January, the piezometers did not have water; the water-table had fallen below 120 cm. The horizon 1 was dry - i.e. the piezometers in this horizon did not have water. The horizontal water flow in horizons 3 and 4 was from the field area to the area near the drain - (Appendix X - January, 1980).

8.1 <u>DIRECTIONS OF WATER FLOW IN THE SOIL</u>

.........Contd

UNIT H2

The vertical water flow in horizons 1, 2 and 3 is downwards while in horizon 4 the flow is upwards during water topping stage (Appendix X and Fig 24(a) P.144. In horizon 4 the vertical flow is upwards. The horizontal water flow in all horizons is from the field to the area near the drain.

During the transplanting stage the vertical water flow in horizons 1, 2 and 3 (Fig 24(b), P.144 is downwards. In the horizon 4 near the drain the vertical water flow is upwards while in the area far away from the drain the vertical water flow is erratic - sometimes upwards, sometimes downwards and sometimes static. The horizontal water flow in all horizons is from the field to the area near the drain - (Appendix X September, 1979).

The vertical water flow during the tillering stage in horizons 1, 2 and 3 is upwards (Fig 24(c), P.144. In horizon 4 near the drain the vertical water flow is upwards while in the area far away from the field is erratic - sometimes upwards, sometimes downwards and sometimes static. The horizontal water flow in all horizons is from the field to the area near the drain - (Appendix X - October 1979).

During the flowering, maturing/harvesting and harvesting stages the water flow pattern was the same as the water flow pattern of tillering stage - Fig 24(d), (e), & (f), P.144 Appendix X, November, 1979, Dec. 1979 and January 1980). It was noted in this unit that the water table was falling very slowly. When the piezometers were uprooted on 25th February 1980, the water table was about 92 cm from the ground surface. While in other units (HI, H2 and H20) water table was 120 cm below ground surface at the same date. When the piezometers were uprooted, flooding for 1980/81 season had already started in the other plots of H2.

THE FOLLOWING DIAGRAM SHOW GENERAL WATER FLOW PATTERN IN DIFFERENT HORIZON AT VARIOUS RICE HUSBANDRY STAGES IN UNIT M2

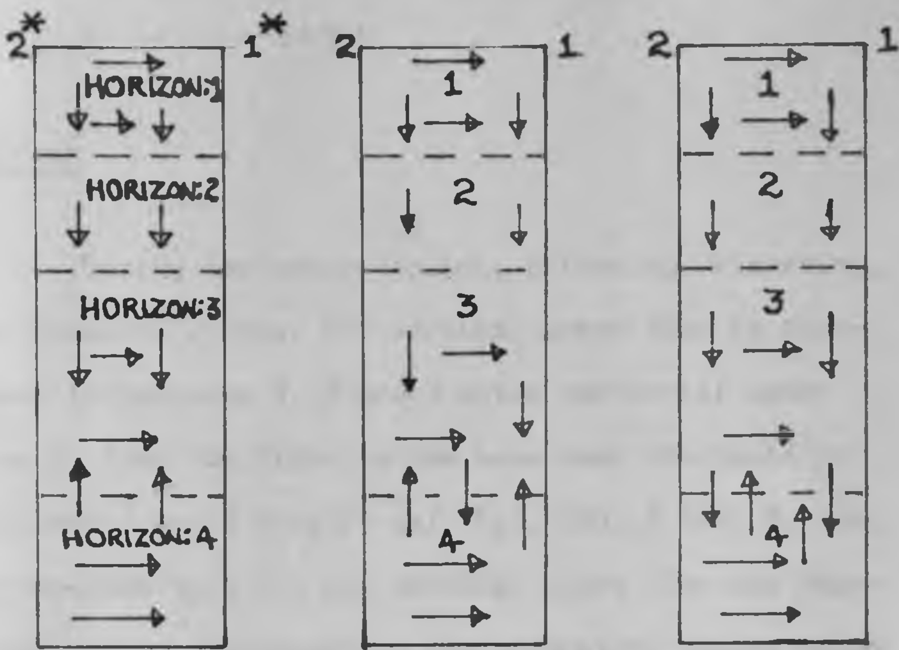
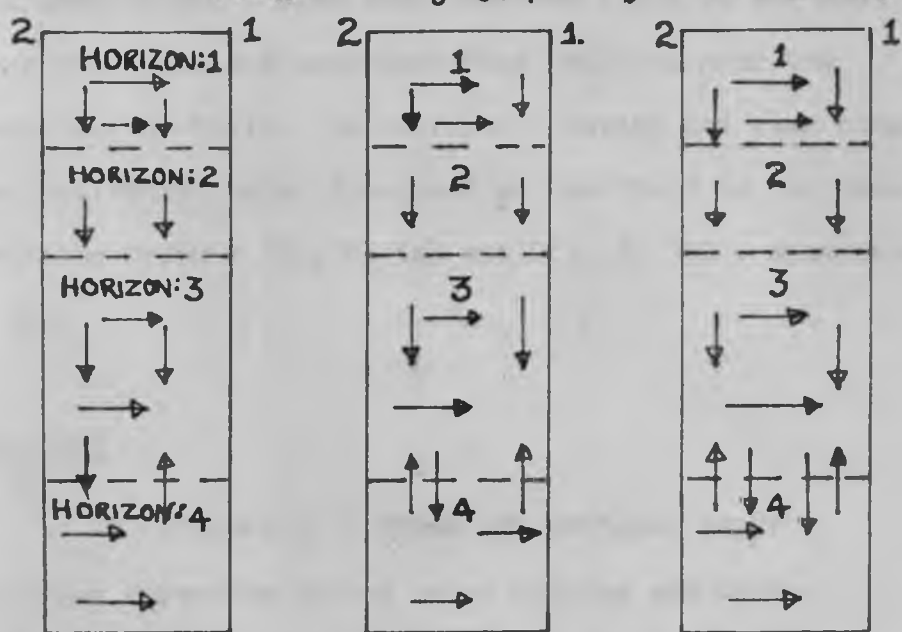


Fig. 24(a) Water Flow Pattern During Water Topping Stage (Aug. 1979)

(b) Water Flow Pattern During Transplanting Stage (Sept. 1979)

(c) Water Flow Pattern During Tillering Stage (Oct. 1979)



(d) Water Flow Pattern During Flowering Stage (Nov. 1979)

(e) Water Flow Pattern During Maturing/Harvesting Stage (Dec. 1979)

(f) Water Flow Pattern During Harvesting Stage (Jan. 1980)

* 1 = Drain Side
2 = Field Side

8.1 DIRECTIONS OF WATER FLOW IN THE SOIL

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UNIT H3

During the water topping, tillering, flowering, and maturing stages, the vertical water flow is downwards in horizons 1, 2 and 3 while horizontal water flow is from the field to the area near the drain in horizons 1 and 3 (Fig 25 (a), (c), (d), & (e), P. 146. In horizons 1, 2 & 3 the vertical water flow was downwards during transplanting and harvesting stages while the horizontal water flow in horizon 1 is erratic during the same stages - sometimes from the field to the area near the drain and sometimes from the area near the drain to the field. In horizons 3 during the same stages the horizontal water flow is from the field to the area near the drain - (Fig 25 (b) and (f), P. 146 - Appendix X H3).

UNIT H20

In horizons 1, 2 and 3 the vertical water flow was downwards during water topping and transplanting stages while in horizon 4 during the same stages the vertical water flow was upwards and

THE FOLLOWING DIAGRAMS SHOW GENERAL WATER FLOW PATTERN IN DIFFERENT HORIZONS AT VARIOUS RICE HUSBANDARY STAGES IN UNIT H3.

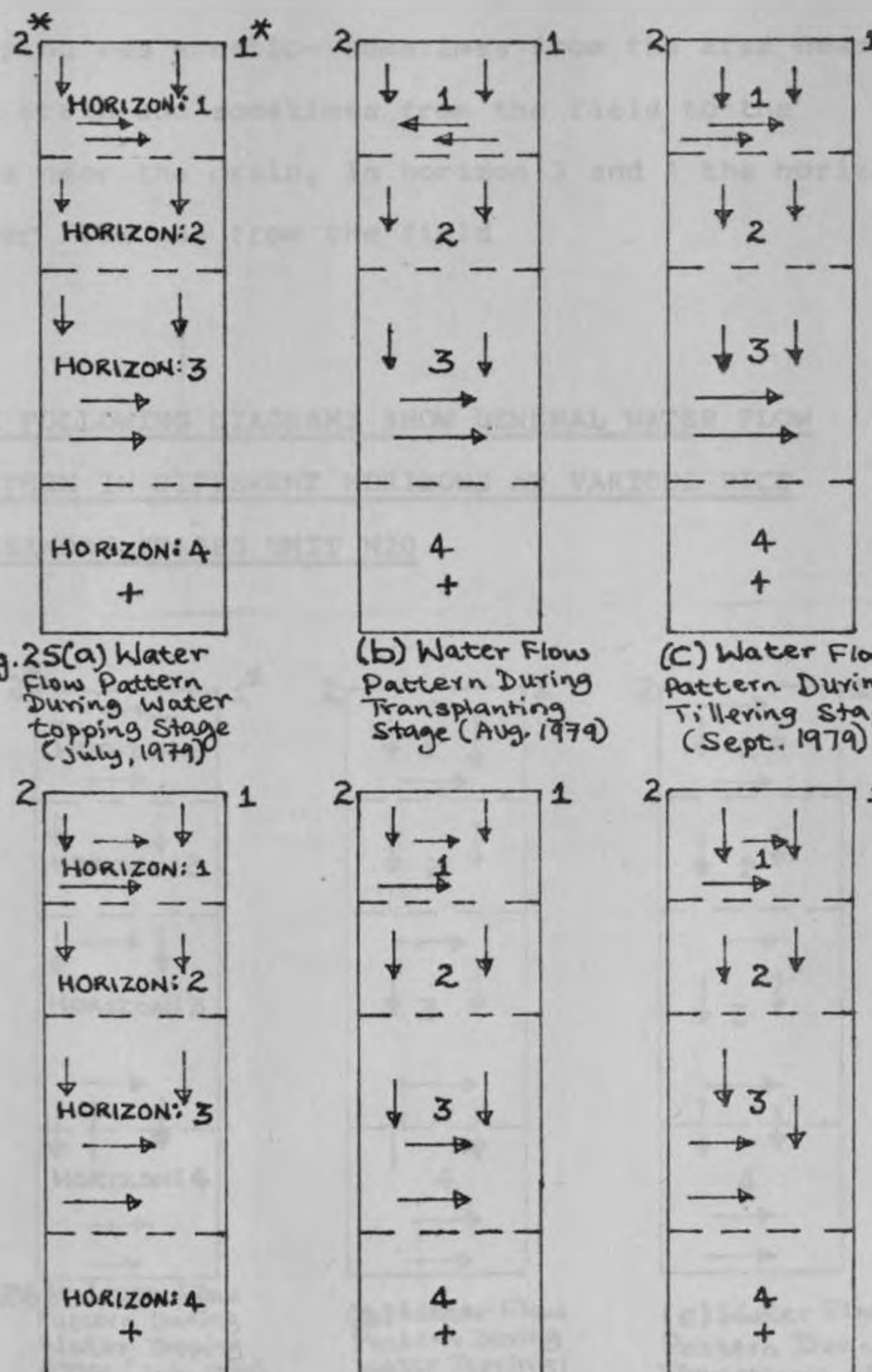

Fig. 25(a) Water Flow Pattern During Water topping Stage (July, 1979)

(b) Water Flow Pattern During Transplanting Stage (Aug. 1979)

(C) Water Flow Pattern During Tillering Stage (Sept. 1979)

(d) Water Flow Pattern During Flowering Stage (Oct. 1979)

(e) Water Flow Pattern During Maturing Stage (Nov. 1979)

(f) Water Flow Pattern During Harvesting Stage (Dec. 1979)

* 1 = Drain Side
2 = Field Side

\+ Not recorded, piezometers could not be installed because of rock downwards in the area near the drain and area far away from the drain respectively (Fig.26(a) and (b). The horizontal water flow in horizon 1 during water topping was erratic- sometimes from the area near the drain and sometimes from the field to the area near the drain. In horizon 3 and 4 the horizontal water flow was from the field

THE FOLLOWING DIAGRAMS SHOW GENERAL WATER FLOW PATTERN IN DIFFERENT HORIZONS AT VARIOUS RICE HUSBANDRY STAGES UNIT H20

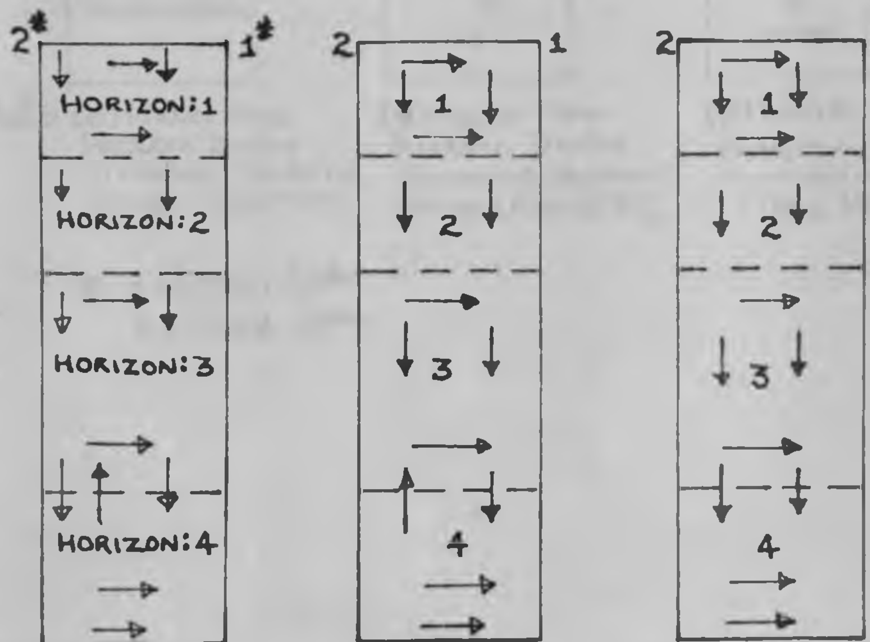

Fig.26(a) Water Flow Pattern During Water Topping Stage (July 1979)

(b) Water Flow Pattern During Water Topping/Transplanting Stage (Aug. 1979)

(c) Water Flow Pattern During Transplanting/Tillering Stage (Sept. 1979)

Fig.26 ----- Cont'd

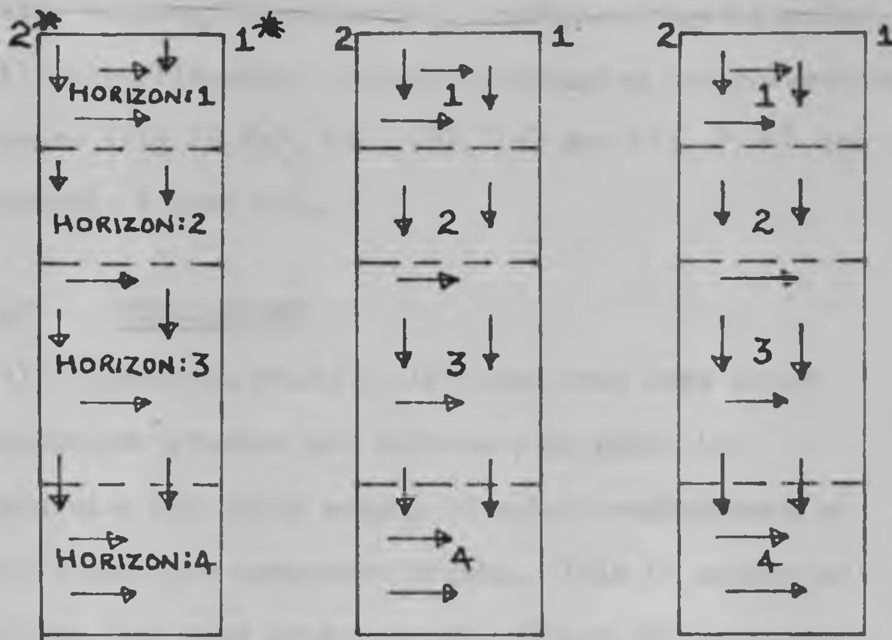

Fig.26 (d) Water Flow Pattern During Tillering/Flowering Stage (Oct. 1979)

(e) Water Flow Pattern During Flowering/Maturing Stage (Nov. 1979)

(f) Water Flow Pattern During Harvesting Stage (Dec. 1979)

* 1 = Drain Side
2 = Field Side

to the area near the drain during the same stage. The vertical water flow in all horizons was downwards during the stages of transplanting, tillering, flowering and harvesting, while the horizontal water flow was from the field to the area near the drain in all horizons during the water topping/transplanting, transplanting/tillering, tillering/flowering, flowering/maturing and harvesting stages (Fig 26 (b), (c), (d), (e) and (f), P.147 and 148 Appendix X unit H20.

8.2 CONCLUSIONS

(1) From this study it is clear that more water management studies are necessary in order to determine the right amount of water requirements at different rice husbandry stages. This is supported by the fact that units H1, H2, H3 and H20 consumed 34.96, 38.49, 21.72 and 61.86 mm of effective water per day for 1979/80 season respectively.

(2) The rice growth and development stage consumed between 50 - 60% of the effective water while land preparation consumed 10 - 30% of the effective water. But, the land preparation stage needed the highest rate of water supply followed by water topping stage and then by rice growth and development stage. Are these consumptions optimum? More investigations are required to ascertain the correct usage.

(3) The water usage can be minimised if water topping stage is reduced. The fields which are

rotavated first according to the cropping programme consume more water than the last units because water topping stage is longest in the first group of units and shortest in the last group of units.

(4) The soil in the units studied have no drainage problems. Water table rises during the growing season and then falls below 150 cm during the harvesting stage.

(5) The water quality for both irrigation and drain waters is good - (CLASS I water).

(6) The soil in Thiba Section has very low hydraulic conductivity, therefore, the water loss by deep percolation is negligible. The soil in unit H20 is alkaline and calcarous therefore, it requires good management practices for proper cultivation. However, detailed studies are required in other units not covered by this study.

(7) Most of the effective water was lost through evapotranspiration.

(8) The horizontal water flow was from the field to the drain but in the experimental plots the flow was restricted by the polythene sheets and therefore water tended to circulate within these plots.

(9) The figures for evapotranspiration rate by Penman Method and experimental plot method were very

close. In absence of climatic data experimental plot method can be used with acceptable accuracy to determine evapotranspiration rate.

(10) The capacity of the main canal has increased tremendously since it was constructed owing to soil erosion and regular clearing by the hydraulic excavators. Sedimentation takes place because of water-loving plants. In fact branch canal studied has decreased capacity because of sedimentation.

(11) The water losses in canal owing to seepage are negligible in the areas with black cotton soil.

8.3 DISCUSSIONS

The results of this study were obtained from only four units but these can be applied in other units of Mwea Irrigation Scheme with caution as the other units of the Scheme are similar to the ones studied. The results of this study have indicated that there is clear need for further detailed studies to establish the necessary measures to be employed to utilize the water sources effectively. The potential of storage ponds and dams has not been investigated. Storage ponds and dams will be very important in future when this scheme adapts two crops per year. The water management should be taken more seriously. If necessary water measuring structures should be installed in the appropriate units, the water guards can be instructed to collect the data to be used in formulating water management policies. Water management research should be started.

The most appropriate time to install water measuring structures is during harvesting time i.e. December to February. Normally after harvesting the cattle, goats and sheep owned by the tenants and neighbouring people can be found grazing in the units and can cause considerable damage to the water measuring structures. Some kind of protection is required for these water measuring structures especially those which are very delicate. Although there are regulations prohibiting grazing in the scheme, sometimes they are relaxed by the Scheme Management for better public relations.

DISCUSSION ON FLOW PATTERN IN UNITS HI, H2, H3 AND H20

During the water topping stage, vertical water flow in horizon 1 was downwards in all units and horizontal flow was from field side to drain side in units HI, H2, and H3. In unit H20 the horizontal water flow was rather erratic - horizontal water flow changing direction from time to time. In horizon 2 the vertical water flow was downwards.

In horizon 3 the vertical water flow was downwards while horizontal water flow in H1 was from the field side to drain side and in H2, H3 and H20 the horizontal water flow was opposite that of H1. In horizon 4 on drain side the vertical water flow was upwards in units H1, H2, and H20 and the field side the flow was upwards in units H1 and H2 while in unit H20 it was downwards. In unit H3 no records were possible because piezometers could not be installed because of hard rock. The horizontal water flow in the same horizon was erratic in unit H1 while it was from the field side to drain in units H2 and H20.

During the transplanting stage the vertical water flow was downwards in all units (H1, H2, H3 and H20) in horizon 1. The horizontal water flow in units H1 and H3 was from drain side to field side while in units H2 and H20 it was the opposite of that of units H2 and H3 in the same horizon. In horizon 2 the vertical water flow was downwards in all units. In horizon 3 the vertical water flow was downwards in all units and the horizontal water flow was from the field side to drain side in all units in the same horizon. In horizon 4 on the drain side the vertical water flow in unit H1 was downwards while it was upwards in units H2 and H20 on the field side the vertical water flow was rather erratic in units H1 and H2 while it was upwards in unit H20. The horizontal water flow was from drain side to field side in unit H1 in units H2 and H20.

<u>During the tillering stage</u> the vertical water flow in horizon 1 was downwards in all units, the horizontal water flow was from the field side to the drain side in all units. In horizon 2 the vertical water flow was downwards in all units. In horizons 3 the vertical water flow was downwards in all units. The horizontal water flow was erratic in H1 while it was from the field side to drain side in units H2, H3 and H20. In horizon 4 on the drain side the vertical water flow was upwards in units H1 and H2 and downwards in H20; on the field side the vertical water flow was upwards in unit H1, erratic in unit H2 and downwards in unit H20. The horizontal water flow in horizon 4 was erratic in unit H1, and from the field side to the drain side in units H2 and H20.

<u>During the flowering stage</u> the vertical water flow in horizon 1 was downwards in all units while the horizontal water flow was from the field side to the drain side in all units. In horizon 2 the vertical water flow was downwards in all units. In horizon 3 the vertical water flow was downwards in all units; the horizontal water flow was from the drain side to field

side in unit H1 while it was the opposite of that of unit H1 in units H2, H3 and H20. In horizon 4 on the drain side the vertical water flow was erratic in unit H1; upwards in unit H2 and downwards in unit H20; on the field side the vertical water flow was upwards in H1; erratic in unit H2 and downwards in unit H20. The horizontal water flow in unit H1 was erratic and from the field side to drain side in units H2 and H20.

<u>During the maturing/harvesting stage</u> the vertical water flow was downwards in all units. The horizontal water flow was erratic in unit H1, and from the field side to drain in units H2, H3 and H20. In horizon 2 the vertical water flow was downwards in all units. In horizon 3 the vertical water flow was downwards in all units while the horizontal water flow was from the field side to drain side in all units. In horizon 4 on the drain side the vertical water flow was upwards in units H1 and H2 and downwards in unit H20; on the field side the vertical water flow was upwards in unit H1, erratic in unit H2 and downwards in unit H20. The horizontal water flow was from the field side to drain side in all units.

<u>During the harvesting stage</u> in horizon 1 the vertical water flow was downwards in all units. The horizontal water flow was non-existent in unit H1 as

the soil was dry; in units H2 and H20 it was from the field side to drain side while it was erratic in unit H3. In horizon 2 the vertical water flow was downwards in all units. In horizon 3 the vertical water flow was downwards in all units and the horizontal water flow was from the field side to drain all units. In horizon 4, on the drain side the vertical water flow was downwards in units H1 and H2 while it was upwards in unit H2; on the field side it was downwards in units H1 and H20 and erratic in unit H2. The horizontal water flow was from the field side to drain side in all units.

8.4 RECOMMENDATIONS

(1) The technical staff in charge of water control needs training in elementary techniques of water measurement and maintenance of the relevant measuring structures. Irrigation officers should have a sufficient knowledge of irrigation practices.

(2) The tenants need to be educated in proper water utilisation and management. They should be closely supervised because some tenants misuse the water.

(3) The existing water measuring structures need regular maintenance. Some water measuring structures are in a very bad state.

(4) Additional water measuring structures should be installed in various canals and drains.

(5) Water measuring scheme should be worked out as a part of water management in the settlement.

(6) As the maximum water requirements are at transplanting and tillering stages, the possibility of building a storage dam should be investigated.

(7) At the moment the rice growth depends on the availability of irrigation water. The utilisation of long rains needs more studies with an aim of having two crops per year.

(8) The water requirements for the entire settlement should be worked out using the results of this study and other studies conducted in Mwea by other organisations so that the necessary measures can be taken. Now the long rains are not fully utilised, and if water requirements are high, it is possible to hold this water in ponds till required. The author is convinced that the Thiba river is not fully utilized under current water management.

APPENDIX I

DAILY INFLOW-OUTFLOW DATA

AND

FARMING ACTIVITIES

APPENDIX I (a)

FARMING ACTIVITIES

ACTIVITY CODE NUMBER	FARMING ACTIVITIES
1	Flooding
2	Rotavation
3	Nursery preparation
4	Water topping
5(a)	Seeds soaking
5(b)	Seed broadcasting
6	Ox-harrowing and manual seedbed preparation
7	Seeds in germination stage
8	Young seedlings in nurseries
9	Transplanting of seedlings and partial draining
10	Rice growing at very early stages; water added as needed
11	Tillers starting developing at very early stages; water added as needed
12	Tillers still developing and expanding; water added as needed
13	Tillers expanding vigorously; water added as needed
14	Manual weeding
[redacted]	[redacted]ertilizer broadcasting
[redacted]	[redacted]owering stages; water added as needed
[redacted]	[redacted]een stages; water added as needed
[redacted]	[redacted]turing-green stages
[redacted]	[redacted]nning stages
[redacted]	[redacted]eld draining
[redacted]	[redacted]ying stages

DAILY INFLOW-OUTFLOW DATA AND FARMING ACTIVITIES

MONTH OF: JUNE, 1979.

DATE	AVERAGE INFLOWRATE				AVERAGE OUTFLOWRATE				ACTIVITY CODE NUMBER				REMARKS
	H1	H2	H3	H20	H1	H2	H3	H20	H1	H2	H3	H20	
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11	NO FLOODING HAD STARTED	NO FLOODING HAD STARTED	25.05				0.00				1		Flooding started in H3
12			25.05				0.00				1		
13			13.39				2.80				1		
14			13.39				4.17				1		
15			13.39				4.90				1		
16			13.39				4.17				1		
17			13.39				5.46				1		
18			13.39				10.76				1		
19			25.05				5.65				1		
20			28.40				5.65				1		
21			24,98				6.04				1 & 2		
22			27.92				10.76				1 & 2		
23			27.92				10.75				1 & 2		
24			27.22				10.76				1 & 2		
25			11.30				15.61				1 & 2		
26			12.63				7.71				1 & 2		
27			15.64	44.42			3.83	0.00			1 & 2	1	Flooding started in H20
28			15.98	44.42			2.79	0.00			1 & 2	1	
29			13.89	42.12			2.79	1.66			1 & 2	1	
30			17.61	2.79			2.79	1.66			1 & 2	1	

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APPENDIX I(b)

MONTH OF: JULY, 1979

DAILY INFLOW-OUTFLOW DATA AND FARMING ACTIVITIES------Cont'd

DATE	AVERAGE INFLOWRATE, mm/day				AVERAGE OUTFLOWRATE, mm/day				ACTIVITY CODE NUMBER				REMARKS
	H1	H2	H3	H20	H1	H2	H3	H20	H1	H2	H3	H20	
1			17.22	38.48			4.33	2.18			4	1	
2			17.41	38.45			4.85	2.75			4	1	
3			16.91	38.45			7.98	3.36			4	1	
4			17.1[illegible]	33.67			7.98	4.01			4 & 6	1	
5			16.81	31.39			7.98	3.36			4 & 6	1	
6			15.79	42.12			7.98	2.75			4 & 6	1 & 2	
7			15.89	42.77			7.98	3.36			4 & 6	1 & 2	
8			16.08	41.53			9.[illegible]2	2.75			4 & 6	1 & 2	
9			15.69	30.62			13.20	2.18			4 & 6	1 & 2	
10			15.60	30.94			12.30	1.66			4 & 6	1 & 2	
11			15.40	29.99			10.44	2.18			4 & 6	1 & 2	
12	[redacted]	[redacted]	[redacted]	29.99			13.44	2.75			4 & 6	1 & 2	
13	[redacted]	[redacted]	[redacted]	32.15			9.69	2.75			4 & 6	1,2 & 4	
14	[redacted]	[redacted]	[redacted]	31.85	0.00		10.44	3.36	1		4 & 6	1,2 & 4	Flooding started in H1
[redacted]	[redacted]	[redacted]	[redacted]	31.55	0.00		6.16	3.36	1		4 & 6	1,2 & 4	
16	[redacted]	[redacted]	[redacted]	31.55	1.93		2.70	3.36	1		4 & 6	1, 2 & 4	
17	[redacted]	[redacted]	17.26	29.35	2.43		2.70	3.36	1		4 & 6	1, 2 & 4	
18	[redacted]	[redacted]	18.12	16.43	4.78		1.12	4.01	1		4 & 6	1, 2 & 4	
19	[redacted]	[redacted]	18.12	16.67	5.20	0.84	0.84	4.70	1	1	3 & 6	1,3 & 4	Flooding started in H2
20	[redacted]	[redacted]	16.27	16.67	5.05	2.67	0.94	4.35	1	1	3 & 6	1,3 & 4	
21	[redacted]	[redacted]	14.17	16.67	4.11	2.37	1.5[illegible]	4.70	1	1	3 & 6	3 & 4	
[redacted]	[redacted]	[redacted]	14.17	16.67	7.06	4.34	7.57	4.24	1	1	3 & 6	3 & 4	
[redacted]	[redacted]	[redacted]	10.02	17.09	6.51	5.15	7.94	4.70	1	1	3 & 6	3	
24	[redacted]	[redacted]	8.52	17.23	9.38	7.28	6.91	4.02	1 & 2	1 & 2	3 & 6	3	
[redacted]	[redacted]	[redacted]	11.45	17.19	8.19	8.47	3.68	4.02	2 & 3	1 & 2	3,5(a) & 6	3	

APPENDIX I(b)

MONTH OF: AUGUST, 1979

DAILY INFLOW-OUTFLOW DATA AND FARMING ACTIVITIES-----Cont'd

DATE	AVERAGE INFLOWRATE, MM/day				AVERAGE OUTFLOWRATE, mm/day				ACTIVITY CODE NUMBER				REMARKS
	H1	H2	H3	H20	H1	H2	H3	H20	H1	H2	H3	H20	
1	17.13	30.10	18.01	21.33	8.69	8.22	3.46	3.04	3 & 4	1,2,3, & 4	6 & 8	3 & 6	
2	15.52	30.76	19.01	21.33	12.02	8.79	5.24	2.92	3 & 4	1,2,3, & 4	6 & 8	3,5(a)& 6	
3	11.89	31.14	19.24	28.47	6.89	12.24	6.78	1.50	3 & 4	2,3, & 4	6 & 8	5(b) & 6	
4	12.65	27.92	18.27	29.91	6.40	12.73	11.13	4.68	3 & 4	2,3, & 4	6 & 8	5(b) & 6	
5	13.32	20.71	18.08	28.34	5.95	8.37	8.32	7.00	3	2,3, & 4	6 & 8	6 & 7	
6	13.40	24.69	17.89	30.70	4.79	6.34	12.39	8.09	3	2,3, & 4	6 & 8	6 & 7	
7	12.57	24.74	18.40	22.84	5.29	6.91	9.77	6.97	3	2,3, & 4	6 & 8	6 & 7	
8	12.99	23.31	0.00	18.69	6.41	9.39	2.60	5.31	5(a) & 6	2,3,4,&5a	6 & 8	6 & 7	
9	13.15	16.06	0.00	21.31	9.53	13.57	0.00	5.45	5(b) & 6	2,3,4,&5(a)	6 & 8	6 & 7	
10	12.91	12.62	0.00	22.15	8.18	8.33	1.79	3.79	5(b) & 6	2,4 & 5(b)	6 & 8	6 & 7	
11	12.91	12.62	0.00	22.73	7.45	5.06	12.02	4.82	5(b) & 6	4 & 5(b)	6 & 8	6 & 7	
12	11.84	12.62	19.23	22.73	5.88	3.98	8.40	4.58	6	4 & 5(b)	6 & 8	6 & 7	
13	12.61	10.98	19.32	16.81	5.72	6.59	11.74	4.35	6 & 7	4 & 5(b)	6 & 8	7 & 8	
14	13.18	9.77	19.18	21.56	5.37	7.46	10.54	4.83	6 & 7	6 & 7	6 & 8	7 & 8	
15	13.23	9.77	19.42	22.94	7.45	5.26	12.05	4.47	6 & 7	6 & 7	6 & 8	7 & 8	
16	13.65	10.03	5.05	20.85	6.91	10.44	6.78	3.34	6	6 & 7	6 & 8	7 & 8	
17	13.06	11.04	4.88	20.33	7.30	11.11	4.23	2.70	6 & 8	6 & 7	6 & 8	7 & 8	
18	13.15	11.51	10.13	20.54	6.75	7.05	6.45	2.75	6 & 8	6 & 7	6 & 8	7 & 8	
19	13.27	12.40	10.03	21.26	6.50	6.12	5.34	2.75	6 & 8	7 & 8	6 & 8	7 & 8	
[redacted]	13.68	11.96	11.34	22.44	5.11	8.66	5.99	2.40	6 & 8	7 & 8	9	7 & 8	
[redacted]	[redacted]	12.19	12.39	22.54	3.81	5.72	5.55	1.30	6 & 8	7 & 8	9	7 & 8	
[redacted]	[redacted]	13.19	12.39	22.73	3.24	4.10	5.52	0.77	6 & 8	7 & 8	9	7 & 8	
[redacted]	[redacted]	14.01	10.43	22.25	3.33	3.28	5.43	1.8[illegible]	6 & 8	7 & 8	9	7 & 8	
[redacted]	[redacted]	[illegible]	[illegible]	[illegible]	3.57	4.33	5.70	2.20	6 & 8	7 & 8	9	7 & 8	

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APPENDIX I (b)

MONTH OF: SEPTEMBER, 1979

DAILY INFLOW-OUTFLOW DATA AND FARMING ACTIVITIES ——— Cont'd

DATE	AVERAGE INFLOWRATE				AVERAGE OUTFLOWRATE				ACTIVITY CODE NUMBER				REMARKS
	H1	H2	H3	H20	H1	H2	H3	H20	H1	H2	H3	H20	
1	13.60	14.94	9.09	22.35	2.96	5.58	4.94	10.42	6 & 8	6 & 8	9	9	
2	13.61	16.06	9.05	22.59	3.81	5.58	2.21	9.52	6 & 8	6 & 8	[illegible]	9	
3	14.06	16.06	9.05	22.59	3.15	7.59	2.83	14.37	6 & 8	9	9	9	
4	13.67	17.44	20.14	23.51	2.97	6.85	1.81	13.01	9	9	9	9	
5	14.12	19.67	20.14	23.62	4.28	7.33	1.57	6.22	9	9	9	9	
6	14.85	14.64	18.75	23.62	7.46	13.08	3.91	3.79	9	9	9	9	
7	13.32	13.52	18.42	23.33	8.87	14.86	1.72	2.75	9	9	10	9	
8	13.81	14.22	10.00	23.49	10.98	10.15	2.33	3.37	9	9	10	9	
9	13.27	15.63	9.9[illegible]	23.56	10.11	6.95	1.69	2.20	9	9	10	9	
10	13.54	18.57	8.52	24.20	8.98	3.92	2.46	1.35	9	9	10	10	
11	11.66	18.58	14.06	24.31	5.89	5.57	[illegible].59	0.91	9	9	10	10	
12	8.46	17.24	16.02	28.15	3.81	3.44	3.25	1.50	9	9	10	10	
13	9.33	19.12	13.26	28.39	5.69	5.83	2.11	2.79	9	9	10	10	
14	11.96	19.51	11.39	25.65	3.89	4.34	1.82	4.01	9	9	10	10	
15	13.16	18.07	10.98	25.08	4.19	6.77	1.33	4.01	9	9	10	10	
16	15.83	18.71	12.48	22.70	2.65	6.23	0.53	5.43	9	9	10	10	
17	15.86	22.52	13.39	18.02	1.06	4.71	1.38	6.48	9	9	10	10	
18	[redacted]	22.20	13.51	17.58	0.46	3.30	2.85	2.85	9	9	10	10	
19	[redacted]	[redacted]	13.39	17.50	1.46	2.98	1.09	1.35	9	9	10	10	
20	[redacted]	[redacted]	13.39	17.32	2.86	3.20	9.02	1.35	10	9	11	11	
21	[redacted]	[redacted]	13.30	17.32	1.20	3.65	1.[illegible]7	1.19	10	9	11	11	
22	[redacted]	[redacted]	13.20	17.41	1.36	3.81	0.95	1.35	10	9	11	11	
[illegible]	[redacted]	[redacted]	12.21	17.85	1.94	2.37	1.69	2.28	10	10	11	11	

APPENDIX I(b)

MONTH OF: OCTOBER, 1979

DAILY INFLOW-OUTFLOW DATA AND FARMING ACTIVITIES——Cont'd

DATE	AVERAGE INFLOWRATE, MM/day				AVERAGE OUTFLOWRATE, mm/day				ACTIVITY CODE NUMBER				REMARKS
	H1	H2	H3	H20	H1	H2	H3	H20	H1	H2	H3	H20	
1	13.59	14.40	14.39	21.30	0.48	2.88	4.16	2.20	11	12	12	13	
2	11.98	10.32	11.28	21.56	0.48	2.13	2.57	1.66	11	12	12	13	
3	15.48	11.59	0.00	18.60	0.69	1.10	1.88	11.08	11	12	12	13	
4	13.31	7.78	0.00	17.05	1.95	1.92	2.15	1.35	11	12	12	13 & 14	
5	15.26	13.61	0.00	17.78	1.33	2.59	3.21	1.50	12	12	12	13 & 14	
6	14.11	10.61	9.51	17.67	1.78	4.54	1.15	1.68	12	12	12 & 13	13 & 14	
7	15.50	9.52	19.14	18.01	1.94	4.07	2.21	1.60	12 & 14	12	12 & 13	13 & 14	
8	16.08	10.46	18.02	17.80	2.02	3.34	3.21	1.04	12 & 14	12	12 & 13	13 & 14	
9	16.39	12.14	14.90	17.87	2.10	2.32	2.70	1.19	12 & 14	12	13 & 14	13 & 14	
10	13.49	18.90	6.82	17.69	2.60	1.92	1.43	1.35	13 & 14	12	13 & 14	13 & 14	
11	12.90	9.92	6.92	17.69	2.43	2.57	1.55	1.19	13 & 14	12	13 & 14	13 & 14	
12	14.20	14.71	14.54	23.71	2.26	2.19	1.66	1.05	13 & 14	12	13 & 14	13 & 14	
13	14.02	19.41	15.05	23.79	1.81	1.92	1.41	1.05	13 & 14	12	13 & 14	13 & 14	
14	13.69	0.00	15.05	20.81	1.63	2.32	3.33	2.76	13 & 14	12	13 & 14	13 & 14	
15	13.35	0.00	15.48	23.11	1.78	1.92	2.00	3.68	13 & 14	12	13 & 14	13 & 14	
16	15.83	10.34	15.05	26.73	1.78	0.21	2.14	3.60	13.14 & 15	13	13 & 14	13 & 14	
17	16.99	15.66	12.26	26.73	1.57	0.94	2.43	6.21	13,14 & 15	13	13 & 14	13 & 14	
18	16.56	16.34	11.71	26.28	1.81	1.50	2.57	5.95	13	13 & 14	13 & 14	13 &14	
19	14.15	20.75	14.10	22.53	1.97	2.53	2.48	4.25	13	13 & 14	13 & 14	13 & 14	
[redacted]	13.22	28.24	14.40	19.46	1.63	3.35	1.80	3.92	13	13 & 14	15 & 16	13 & 14	
[redacted]	12.54	27.83	14.04	19.70	1.94	6.21	2.48	3.30	13	13 & 14	15 & 16	15 & 16	
[redacted]	[redacted]3.16	5.53	10.80	20.23	1.47	4.22	2.80	3.04	13	13 & 14	15 & 16	15 & 16	
[redacted]	[redacted]8.42	9.60	8.49	20.74	2.10	3.68	2.40	5.46	13	13 & 14	15 & 16	15 & 16	
[redacted]	[redacted]	6.7[redacted]	[redacted]	[redacted].35	1.47	3.07	2.48	3.70	13	13 & 14	16	16	

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APPENDIX I(b)

MONTH OF: NOVEMBER 1979

DAILY INFLOW-OUTFLOW DATA AND FARMING ACTIVITIES-----Cont'd

DATE	AVERAGE INFLOWRATE				AVERAGE OUTFLOWRATE				ACTIVITY CODE NUMBER				REMARKS
	H1	H2	H3	H20	H1	H2	H3	H20	H1	H2	H3	H20	
1	17.71	6.66	13.05	17.82	1.47	1.25	9.40	1.19	16	16	16	16	
2	19.68	1.70	13.12	17.87	4.15	1.69	5.28	1.19	16	16	16	16	
3	20.97	0.00	10.93	16.93	22.53	10.55	12.70	31.46	16	16	16	16	
4	21.59	0.00	0.00	15.61	16.49	5.73	10.10	10.10	16	16	16	16	
5	0.72	0.00	0.00	15.10	21.16	5.52	11.24	16.65	16	16	16	16	
6	0.45	0.00	0.00	15.00	21.91	21.46	13.38	23.14	16	16	16	16	
7	0.45	0.00	0.00	15.00	10.77	10.87	7.40	11.74	16	16	16 & 17	16	
8	0.45	0.00	0.00	15.00	7.09	5.24	5.49	6.57	16	16 & 17	16 & 17	16	
9	0.45	0.00	0.00	15.20	4.96	2.73	4.74	4.24	16	16 & 17	16 & 17	16 & 17	
[redacted]	0.45	0.00	0.00	15.20	23.60	39.78	15.77	24.42	16	17	17	16 & 17	
[redacted]	[redacted]	0.00	0.00	15.20	32.31	31.19	21.13	33.37	16	17	17	17	
[redacted]	[redacted]	0.00	0.00	0.00	12.48	13.99	10.21	12.18	16	17	17	17	
[redacted]	[redacted]	0.00	0.00	0.00	29.51	27.84	22.69	33.24	16	17	17	17	
[redacted]	[redacted]	[redacted]	0.00	0.00	6.29	10.55	6.37	4.94	16	17	17	17	
[redacted]	[redacted]	[redacted]	0.00	0.00	4.12	4.66	3.78	3.37	16	17	17	17	
[redacted]	[redacted]	[redacted]	0.00	0.00	2.26	2.20	3.58	2.75	16	17	17	17	
[redacted]	[redacted]	[redacted]	[redacted]	5.00	1.93	2.73	3.13	1.84	16 & 17	17	17	17	
[redacted]	[redacted]	[redacted]	[redacted]	15.00	2.10	3.28	3.35	1.66	16 & 17	17	17 & 18	17	
[redacted]	[redacted]	[redacted]	[redacted]	15.00	1.47	2.46	2.80	1.66	17	17	17 & 18	17	
[redacted]	[redacted]	[redacted]	[redacted]	15.29	1.12	1.69	2.57	1.19	17	17 & 18	18	17	
[redacted]	[redacted]	[redacted]	[redacted]	15.39	1,06	1.74	2.47	1.50	17	18	18	17 & 18	
[redacted]	[redacted]	[redacted]	[redacted]	16.77	1.47	2.46	2.80	1.66	17	18	18	17 & 18	
[redacted]	[redacted]	[redacted]	[redacted]	16.77	0.69	1.69	2.14	1.19	17	18	18	17 & 18	
[redacted]	[redacted]	[redacted]	[redacted]	12.50	2.26	4.13	3.59	1.19	17	18	18	18	

APPENDIX I(b)

DAILY INFLOW-OUTFLOW DATA AND FARMING ACTIVITIES- ----Cont'd

MONTH OF DECEMBER, 1979

DATE	AVERAGE INFLOWRATE				AVERAGE OUTFLOWRATE				ACTIVITY CODE NUMBER				REMARKS
	H1	H2	H3	H20	H1	H2	H3	H20	H1	H2	H3	H20	
1	14.03	0.00	0.00	0.00	1.93	4.18	8.82	4.01	17 & 18	18	19 & 20	18 & 19	
2	13.59	0.00	0.00	0.00	5.18	2.46	5.01	4.70	17 & 18	18	19 & 20	18 & 19	
3	13.11	0.00	0.00	0.00	7.20	1.69	C.59	8.6?	17 & 18	18	20 & 21	18 & 19	
4	13.15	19.40	0.00	0.00	10.11	2.46	9.56	9.00	17 & 18	18	20 & 21	19	
5	13.31	20.32	0.00	0.00	8.18	3.28	2.57	6.72	17 & 18	18	21	15	
6	13.19	20.32	0.00	0.00	8.96	3.28	2.86	3.79	17 & 18	18	21	19	
7	1.64	0.00	0.00	0.00	4.94	3.28	1.80	2.98	19	18 & 19	21	19	
8	0.83	0.00	0.00	0.00	4.76	2.20	0.59	1.92	19	18 & 19	21	19	
9	0.63	0.00	0.00	0.00	3.81	2.48	1.23	1.?9	19	18 & 19	21	19 & 20	
10	0.83	0.00	0.00	0.00	6.04	3.05	1.06	1.19	19 & 20	19	21	19 & 20	
11	0.83	0.00	0.00	0.00	4.52	2.46	2.82	0.77	19 & 20	19 & 20	21	21	
12	0.63	0.00	0.00	0.00	4.33	2.20	1.23	0.65	19 & 20	19 & 20	21	21	
13	0.83	0.00	0.00	0.00	3.56	1.69	0.86	0.42	19 & 20	19 & 20	21	21	
14	0.45	0.00	0.00	0.00	3.52	1.69	1.42	0.42	19 & 21	19 & 20	22	21	
15	0.16	6.42	0.00	0.00	3.52	1.69	1.42	0.42	19 & 21	19	22	21	
16	0.26	0.00	0.00	0.00	3.52	1.07	0.82	0.42	21	19	22	21	
17	0.45	0.00	0.00	0.00	3.93	2.30	0.56	0.42	21	19	22	21	
18	0.16	0.00	0.00	0.00	4,52	4.21	1.08	0.98	21	19	22	21	
19	0.16	0.00	0.00	0.00	3.52	3.28	1.12	0.77	21	21	22	22	
20	0.16	0.00	0.00	0.00	6.76	2.46	2.76	0.77	21	21	22	22	
21	0.16	0.00	0.00	0.00	3.53	2.46	3.08	0.77	21 & 22	21	22	22	
22	0.16	[redacted]	0.00	0.00	2.60	1.69	2.36	0.77	22	21	22	22	
[redacted]	0.[redacted]	[redacted]	0.00	0.00	2.10	2.20	C.93	0.77	22	21	22	22	
[redacted]	0.1[redacted]	[redacted]	[redacted].00	0.00	1.93	1.07	0.78	0.42	22	21	22	22	
[redacted]	[redacted]	[redacted]	0.00	0.00	1.47	1.07	0.59	0.42	22	21	22	22	

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APPENDIX II

RAINFALL, EVAPOTRANSPIRATION, EVAPORATION AND PERCOLATION LOSSES

Appendix II

Table 1. Rainfall, evapotranspiration, evaporation and percolation losses
Month: June 1979

Date	Rainfall (mm/Day)	E_T (Penman) (mm/day)	Evaporation (Class "A" pan) (mm/Day)	Percolation losses (mm/day)			
				Unit H1	Unit H2	Unit H3	Unit H20
1	19.80	-	3.50				
2	1.00	-	1.50				
3	0.00	-	5.00				
4	4.00	-	3.00				
5	0.00	-	3.50				
6	0.00	-	4.50				
7	0.00	-	4.70				
8	0.90	-	4.90				
9	0.00	-	5.00				
10	0.00	-	5.00				
11	0.00	4.33	4.50	-	-	-	
12	0.00	5.03	5.00	-	-	-	
13	0.00	5.05	6.00	-	-	-	
14	0.00	4.55	7.00	-	-	-	
15	0.00	3.75	4.00	-	-	-	
16	0.00	4.36	6.50	-	-	-	
17	0.00	4.33	4.00	-	-	-	
18	0.00	4.51	6.00	-	-	-	
19	0.00	3.16	3.50	-	-	-	
20	0.00	3.39	5.50	-	-	-	
21	0.00	3.17	4.00	-	-	-	
22	0.00	3.56	4.50	-	-	-	
23	0.00	3.62	5.00	-	-	-	
24	0.00	2.54	2.50	-	-	-	
25	0.00	4.08	5.00	-	-	-	
26	0.00	4.39	5.00	-	-	-	
27	0.00	2.84	4.00	-	-	-	-
28	0.00	2.34	1.00	-	-	-	-
29	0.00	2.16	2.50	-	-	-	-
30	0.00	3.55	4.00	-	-	-	-

Appendix II (cont.)

Table 2. Rainfall, evapotranspiration, evaporation and percolation losses
Month: July 1979

Date	Rainfall (mm/day)	E_T (Penman) (mm/day)	Evaporation (Class "A" pan) (mm/day)	Percolation losses (mm/day)			
				Unit H1	Unit H2	Unit H3	Unit H20
1	0.00	2.90	4.00				
2	0.00	2.56	3.00				
3	0.00	2.10	1.50				
4	0.00	2.79	3.00				
5	0.00	3.96	5.50				
6	0.50	2.31	4.50				
7	6.90	2.97	2.90				
8	0.00	3.07	3.50				
9	0.00	4.71	5.50				
10	0.00	4.73	6.50				
11	0.00	3.19	4.00				
12	0.00	3.09	3.50				
13	0.00	2.27	3.00				
14	0.00	2.09	1.50	-	-	-	-
15	1.70	1.98	2.20	-	-	-	-
16	0.00	3.09	2.50	-	-	-	-
17	0.00	3.27	4.50	-	-	1.28	-
18	0.00	3.39	4.50	-	-	0.89	-
19	1.00	5.17	5.00	-	-	0.57	-
20	0.00	5.12	4.00	-	-	0.31	-
21	0.00	4.70	5.00	-	-	0.22	-
22	0.40	3.31	3.90	-	-	0.18	-
23	0.00	4.94	5.50	-	-	0.15	-
24	0.00	3.49	3.50	-	-	0.12	-
25	1.30	3.03	2.80	-	-	0.09	-
26	0.00	1.88	1.50	-	-	0.00	0.01
27	0.00	2.64	2.50	-	-	0.04	0.01
28	0.00	3.62	5.00	-	-	0.04	0.01
29	0.00	2.71	3.00	-	-	0.05	0.01
30	0.00	4.36	5.00	-	-	0.04	0.01
31	0.80	4.71	5.80	-	-	0.04	0.00

Appendix II (cont.)

Table 3. Rainfall, evapotranspiration, evaporation and percolation losses
Month : August 1979

Date	Rainfall (mm/day)	E_T (Penman) (mm/day)	Evaporation (Class "A" pan) (mm/day)	Percolation losses (mm/day)			
				Unit N1	Unit N2	Unit N3	Unit N20
1	1.00	1.99	1.50	-	-	0.04	0.01
2	0.00	3.45	3.50	-	-	0.04	0.00
3	0.00	4.04	4.50	-	-	0.05	0.00
4	0.00	4.78	5.00	-	-	0.05	0.00
5	0.00	4.84	5.50	4.08	3.96	0.02	0.00
6	0.00	4.26	5.50	3.58	3.66	0.01	0.00
7	0.00	2.27	2.00	3.02	2.34	0.02	0.00
8	0.00	3.54	3.00	2.86	1.70	0.02	0.00
9	0.00	4.63	6.00	2.33	1.89	0.01	0.00
10	0.00	2.15	3.00	2.27	1.89	0.02	0.00
11	0.00	2.21	1.50	2.14	1.89	0.02	0.00
12	0.00	4.45	5.00	2.23	1.85	0.02	0.00
13	1.10	2.33	1.60	2.25	1.70	0.02	0.00
14	0.00	2.37	2.00	2.23	1.59	0.02	0.00
15	0.90	2.22	1.90	2.09	1.58	0.03	0.00
16	0.00	3.85	4.00	2.07	1.58	0.03	0.00
17	0.00	2.89	2.50	2.05	1.46	0.03	0.00
18	0.00	4.61	5.00	1.90	1.37	0.02	0.00
19	0.00	4.24	5.50	1.91	1.44	0.03	0.00
20	0.00	5.46	6.00	2.07	1.35	0.04	0.00
21	0.00	5.04	6.00	1.90	1.44	0.03	0.00
22	0.00	5.14	7.00	1.89	1.58	0.03	0.00
23	0.00	5.00	5.00	1.87	1.86	0.04	0.00
24	0.00	4.89	6.00	1.88	1.86	0.05	0.00
25	1.00	5.03	5.50	1.72	1.90	0.05	0.00
26	0.00	4.45	5.00	1.71	1.75	0.06	0.00
27	0.00	4.38	6.00	1.61	1.72	0.09	0.00
28	0.00	5.57	6.50	1.70	1.35	0.08	0.00
29	0.00	5.87	7.50	1.61	1.33	0.10	0.00
30	0.00	5.11	7.50	1.57	1.25	0.07	0.00
31	0.00	3.26	5.00	1.49	1.23	0.06	0.00

Appendix II (cont.)

Table 4. Rainfall, evapotranspiration, evaporation and percolation losses
Month : September 1979

Date	Rainfall (mm/day)	E_T (Penman) (mm/day)	Evaporation (Class "A" pan) (mm/day)	Percolation losses (mm/day)			
				Unit H1	Unit H2	Unit H3	Unit H20
1	0.00	4.15	5.00	1.58	1.18	0.07	0.00
2	0.60	4.75	5.00	1.58	1.16	0.06	0.00
3	0.00	6.27	7.00	1.74	1.16	0.07	0.00
4	0.00	6.40	9.00	1.60	1.25	0.07	0.00
5	0.00	3.91	3.50	1.76	1.25	0.09	0.00
6	0.00	4.97	8.00	1.48	1.49	0.09	0.00
7	0.00	4.44	5.50	1.69	1.44	0.09	0.00
8	0.50	4.65	6.50	1.56	1.37	0.23	0.00
9	0.00	4.21	5.00	1.56	1.26	0.20	0.00
10	0.00	3.51	5.00	1.62	1.25	0.19	0.00
11	3.20	3.69	4.20	1.58	1.18	0.17	0.00
12	0.00	4.23	5.50	1.48	1.25	0.15	0.00
13	0.00	5.28	6.00	1.38	1.18	0.15	0.00
14	0.00	5.77	6.50	1.46	1.16	0.16	0.00
15	0.00	5.99	8.00	1.44	1.24	0.12	0.00
16	0.00	6.36	7.00	1.26	1.24	0.15	0.00
17	0.00	6.52	8.50	1.10	1.25	0.11	0.00
18	0.00	5.91	8.00	1.08	1.26	0.10	0.00
19	0.00	5.21	8.70	1.22	1.34	0.11	0.00
20	0.00	5.85	9.50	1.37	1.34	0.09	0.00
21	0.00	6.06	9.00	1.23	1.16	0.10	0.00
22	0.00	6.34	8.50	1.11	1.10	0.10	0.00
23	0.00	6.03	5.50	1.09	1.03	0.11	0.00
24	0.00	5.39	6.00	1.27	1.01	0.01	0.00
25	0.00	5.88	8.00	1.23	0.96	0.14	0.00
26	0.00	4.56	7.50	1.18	0.94	0.13	0.00
27	0.00	6.01	7.00	1.10	0.94	0.12	0.00
28	0.00	5.34	6.50	1.24	0.96	0.11	0.00
29	0.00	5.68	8.00	1.15	0.94	0.10	0.00
30	0.00	5.51	7.50	1.02	0.94	0.09	0.00

Appendix II (cont.)

Table 5. Rainfall, evapotranspiration, evaporation and percolation losses
Month : October 1979

Date	Rainfall (mm/day)	E_T (Penman) (mm/day)	Evaporation (Class "A" pan) (mm/day)	Percolation losses (mm/day)			
				Unit H1	Unit H2	Unit H3	Unit H20
1	0.00	5.56	7.50	1.03	1.11	0.08	0.00
2	0.00	5.24	7.50	1.03	1.33	0.12	0.00
3	0.90	5.02	6.40	1.24	1.27	0.18	0.00
4	3.10	4.55	5.10	1.24	1.16	0.16	0.00
5	3.40	4.68	5.90	1.03	1.15	0.15	0.00
6	0.00	4.63	5.50	1.03	1.10	0.19	0.00
7	0.00	5.31	7.00	1.37	1.03	0.16	0.00
8	0.00	5.19	7.50	1.34	1.02	0.16	0.00
9	0.00	6.26	8.00	1.34	1.03	0.16	0.00
10	0.00	5.73	7.50	1.26	1.01	0.14	0.00
11	0.00	5.62	8.00	1.25	0.97	0.14	0.00
12	0.00	5.53	7.40	1.17	0.89	0.11	0.00
13	0.00	4.52	8.00	1.17	0.83	0.12	0.00
14	0.00	6.07	9.50	1.11	0.88	0.10	0.00
15	0.00	5.40	6.50	1.10	1.26	0.10	0.00
16	0.00	5.33	6.00	1.33	1.25	0.11	0.00
17	0.00	4.39	5.00	1.26	1.17	0.12	0.00
18	0.00	5.83	7.00	1.25	1.10	0.12	0.00
19	0.00	5.89	7.50	1.18	1.08	0.12	0.00
20	0.00	5.66	8.00	1.16	1.01	0.12	0.00
21	0.70	5.25	6.70	1.11	0.97	0.14	0.00
22	4.30	4.99	5.30	1.10	0.95	0.13	0.00
23	0.20	5.12	5.20	1.09	0.88	0.12	0.00
24	28.20	5.13	7.20	1.08	0.90	0.15	0.00
25	0.00	3.24	4.00	1.57	0.91	0.14	0.00
26	0.00	4.64	4.00	1.48	0.97	0.16	0.00
27	0.20	4.60	6.20	1.45	0.96	0.12	0.00
28	0.00	5.59	6.50	1.33	0.89	0.18	0.00
29	0.00	5.28	7.00	1.25	0.84	0.16	0.00
30	0.00	5.13	6.50	1.15	0.80	0.12	0.00
31	0.00	5.24	7.00	1.09	0.80	0.15	0.00

Appendix II (cont.)

Table 6. Rainfall, evapotranspiration, evaporation and percolation losses. Month : November 1979

Date	Rainfall (mm/day)	E_T (Penman) (mm/day)	Evaporation (Class "A" pan) (mm/day)	Percolation losses (mm/day)			
				Unit H1	Unit H2	Unit H3	Unit H20
1	0.00	5.65	7.00	1.08	0.79	1.08	0.00
2	55.10	5.02	10.10	0.95	0.75	1.01	0.00
3	4.20	3.76	7.70	1.36	0.90	1.17	0.00
4	9.80	4.22	5.80	1.34	0.96	1.16	0.00
5	28.70	3.57	4.70	1.37	1.01	1.12	0.00
6	0.00	2.56	2.50	1.24	0.88	1.21	0.00
7	0.20	2.68	2.70	1.17	0.84	1.19	0.00
8	0.00	2.70	2.50	1.03	0.84	1.08	0.00
9	58.50	3.38	6.00	0.94	0.84	0.98	0.00
10	36.10	1.96	4.60	1.10	0.79	1.16	0.00
11	5.30	2.19	2.80	1.08	0.78	1.08	0.00
12	16.10	3.73	4.10	0.97	0.74	0.98	0.00
13	3.10	3.12	3.60	0.94	0.71	1.04	0.00
14	0.40	5.14	4.90	0.88	0.67	0.94	0.00
15	0.00	3.75	5.50	0.84	0.68	0.92	0.00
16	0.00	4.69	6.00	0.80	0.66	0.87	0.00
17	0.00	4.04	4.50	0.71	0.60	0.86	0.00
18	3.30	4.17	4.30	0.63	0.60	0.86	0.00
19	0.00	3.58	4.00	0.57	0.55	0.83	0.00
20	0.00	3.02	3.50	0.55	0.52	0.76	0.00
21	0.00	4.78	5.50	0.50	0.50	0.73	0.00
22	0.00	5.12	5.50	0.46	0.49	0.72	0.00
23	0.00	4.65	5.50	0.42	0.48	0.71	0.00
24	0.00	4.85	5.50	0.41	0.47	0.76	0.00
25	0.00	5.50	5.50	0.38	0.44	0.73	0.00
26	0.00	4.93	4.50	0.37	0.42	0.69	0.00
27	0.00	5.16	6.50	0.71	0.45	0.65	0.00
28	0.00	5.41	6.50	0.58	0.49	0.69	0.00
29	0.00	4.74	6.00	0.52	0.51	0.60	0.00
30	0.00	5.31	6.00	0.64	0.50	0.54	0.00

Appendix II (cont.)

Table 7. Rainfall, evapotranspiration, evaporation and percolation losses
Month : December 1979

Date	Rainfall (mm/day)	E_T (Penman) (mm/day)	Evaporation (Class "A" pan) (mm/day)	Percolation losses (mm/day)			
				Unit H1	Unit H2	Unit H3	Unit H20
1	1.80	4.57	5.30	0.42	0.49	0.04	0.00
2	0.00	4.82	5.00	0.37	0.45	0.04	0.00
3	0.00	4.54	6.00	0.33	0.46	0.05	0.00
4	0.00	5.05	6.50	0.27	0.41	0.05	0.00
5	0.00	4.95	5.50	0.25	0.41	0.05	0.00
6	0.00	4.29	6.50	0.22	0.47	0.07	0.00
7	0.00	4.91	5.00	0.20	0.52	0.05	0.00
8	0.00	4.82	6.50	0.19	0.50	0.43	0.00
9	2.70	4.44	6.70	0.18	0.49	0.46	0.00
10	0.00	4.31	6.00	0.16	0.45	0.51	0.00
11	0.00	4.50	5.50	0.17	0.42	0.63	0.00
12	0.00	5.09	6.50	0.14	0.40	0.79	0.00
13	0.00	5.30	7.00	0.31	0.37	0.94	0.00
14	0.00	5.10	7.50	0.28	0.33	1.01	0.00
15	0.00	5.24	6.50	0.25	0.79	1.16	0.00
16	0.20	4.78	6.70	0.16	0.75	1.24	0.00
17	15.60	2.77	3.10	0.18	0.64	1.28	0.00
18	4.80	3.63	4.80	0.29	0.70	0.96	0.00
19	13.00	3.68	6.00	0.24	0.75	0.85	0.00
20	0.00	3.17	4.00	0.30	0.75	0.67	0.00
21	0.00	3.30	4.50	0.26	0.75	0.61	0.00
22	8.70	3.05	4.20	0.23	0.75	0.60	0.00
23	0.00	3.92	4.50	0.21	0.67	0.58	0.00
24	0.00	3.55	4.00	0.35	0.60	0.60	0.00
25	6.40	4.15	5.40	0.35	0.42	0.61	0.00
26	0.00	4.71	6.00	0.35	0.38	0.61	0.00
27	0.40	3.98	4.90	0.35	0.36	0.67	0.00
28	4.50	4.20	5.50	0.35	0.37	0.67	0.00
29	0.00	5.30	7.00	0.38	0.38	0.74	0.00
30	0.00	4.84	6.50	0.45	0.38	0.79	0.00
31	0.00	4.92	6.00	0.48	0.40	0.84	0.00

APPENDIX III

EVAPOTRANSPIRATION (E_T) BY EXPERIMENTAL PLOTS

Appendix III

Table 1. E_T by experimental plot (B1)

Date	Water* losses[1] (mm/day)	Deep percolation losses by Darcy equation[2] (mm/day)	Field determined E_T 1-2-3 (mm/day)	E_T by Penman[4]+ (mm/day)	Evaporation class "A" pan[5] (mm/day)	Remarks[6]
27.8.79	7.00	1.61	5.39	5.57	6.50	
30.8.79	9.00	1.57	7.43	5.11	7.50	
31.8.79	5.00	1.49	3.51	3.26	5.00	
8.9.79	6.00	1.56	4.44	4.65	6.50	
13.9.79	7.00	1.38	5.62	5.28	6.00	
14.9.79	6.50	1.46	5.04	5.77	6.50	
15.9.79	7.00	1.44	5.56	5.99	8.00	
23.9.79	8.00	1.00	6.91	6.03	5.50	
25.9.79	8.00	1.23	6.77	5.88	8.00	
29.9.79	8.00	1.15	6.85	5.68	8.00	
8.10.79	8.00	1.34	6.66	5.19	7.50	
10.10.79	6.50	1.26	5.24	5.73	7.50	
11.10.79	6.50	1.25	5.25	5.62	8.00	
12.10.79	8.00	1.17	6.83	5.53	7.50	
14.10.79	10.00	1.11	8.89	6.07	9.50	
15.10.79	6.50	1.10	5.40	5.40	6.50	
17.10.79	6.00	1.26	4.74	4.39	5.00	
19.10.79	8.00	1.18	6.82	5.89	7.50	
22.10.79	5.50	1.10	4.40	4.99	5.30	
24.10.79	6.50	1.08	5.42	5.13	7.70	
29.10.79	8.00	1.25	6.75	5.28	7.00	
31.10.79	6.50	1.09	5.41	5.24	7.00	
1.11.79	8.00	1.08	6.92	5.65	7.00	
2.11.79	6.00	0.95	5.05	5.02	10.10	
24.11.79	5.00	0.41	4.59	4.85	5.50	
25.11.79	6.00	0.38	5.62	5.00	5.50	
4.12.79	5.50	0.27	5.23	5.05	6.50	
5.12.79	5.00	0.25	4.75	4.95	5.50	
8.12.79	5.00	0.19	4.81	4.82	6.50	
9.12.79	5.00	0.18	4.82	4.44	6.70	
10.12.79	5.00	0.16	4.84	4.31	6.04	
11.12.79	5.00	0.17	4.83	4.50	5.50	
TOTAL	212.00	32.12	189.79	166.27	217.84	
AVERAGE (days sampled = 32)	6.66	1.00	5.65	5.20	6.81	

* error correction:; +2mm +calculated from 1979 weather data.

Appendix III (cont.)

Table 2. E_T by experimental plot (H2)

Date	Water*[1] losses (mm/day)	Deep percolation[2] losses by Darcy equation (mm/day)	Field determined E_T 1-2=3 (mm/day)	E_T by[4] Penman+ (mm/day)	Evaporation[5] class "A" pan (mm/day)	Remarks[6]
5.9.79	5.00	1.25	3.75	3.91	3.50	
8.9.79	6.00	1.37	4.63	4.65	6.50	
11.9.79	5.00	1.18	3.82	3.69	4.20	
12.9.79	6.00	1.25	4.75	4.23	5.50	
18.9.79	9.00	1.26	7.74	5.91	8.00	
19.9.79	7.00	1.34	5.66	5.21	8.70	
23.9.79	6.00	1.03	4.97	6.03	5.50	
24.9.79	8.00	1.01	6.99	5.39	6.00	
25.9.79	6.00	0.96	5.04	5.88	8.00	
3.10.79	8.00	1.27	6.73	5.02	6.40	
4.10.79	7.00	1.16	5.84	4.55	5.10	
6.10.79	6.00	1.10	4.90	4.63	5.50	
7.10.79	6.50	1.03	5.47	5.31	7.00	
8.10.79	8.00	1.02	6.98	5.19	7.50	
9.10.79	8.00	1.03	6.97	6.26	8.00	
10.10.79	7.00	1.01	5.99	5.73	7.50	
11.10.79	6.00	0.97	5.03	5.62	8.00	
16.10.79	6.00	1.25	4.75	5.33	6.00	
19.10.79	8.00	1.08	6.92	5.89	7.50	
20.10.79	8.00	1.01	6.99	5.66	8.00	
22.10.79	5.00	0.95	4.05	4.99	5.80	
23.10.79	6.00	0.88	5.12	5.12	5.20	
28.10.79	6.00	0.89	5.11	5.59	6.50	
31.10.79	6.00	0.80	5.20	5.24	7.00	
1.11.79	8.00	0.79	7.21	5.65	7.00	
2.11.79	6.00	0.75	5.25	5.02	10.10	
16.11.79	5.00	0.66	4.34	4.69	6.00	
17.11.79	5.00	0.60	4.40	4.04	4.50	
20.11.79	4.00	0.52	3.48	3.02	8.50	
21.11.79	5.00	0.50	4.50	4.78	5.50	
24.11.79	5.00	0.47	4.53	4.85	5.50	
25.11.79	5.50	0.44	5.06	5.00	5.50	
30.11.79	6.00	0.50	5.50	5.31	6.00	
1.12.79	5.00	0.49	4.51	4.57	5.30	
2.12.79	5.00	0.45	4.55	4.82	5.00	
3.12.79	5.00	0.46	4.54	4.54	6.00	
4.12.79	6.00	0.41	5.59	5.05	6.50	
5.12.79	5.00	0.41	4.59	4.95	5.50	
8.12.79	5.00	0.50	4.50	4.82	6.50	
9.12.79	5.00	0.49	4.51	4.44	6.70	
11.12.79	5.00	0.42	4.58	4.50	5.50	
12.12.79	6.00	0.40	5.60	5.09	6.50	
13.12.79	6.00	0.37	5.63	5.30	7.00	
TOTAL	262.01	35.69	226.27	215.47	270.50	
AVERAGE (days sampled = 43)	6.09	0.83	5.26	5.01	6.29	

*error correction : +2; +calculated from 1979 weather data

Appendix III (cont.)

Table 3. E_T by experimental plot (E3)

Date	Water* losses[1] (mm/day)	Deep percolation losses by Darcy equation[2] (mm/day)	Field determined E_T 1-2=3 (mm/day)	E_T by Penman[4]+ (mm/day)	Evaporation class "A" pan[5] (mm/day)	Remarks[6]
24.7.79	5.00	0.12	4.88	3.49	3.50	
25.7.79	5.00	0.09	4.91	3.03	2.80	
8.8.79	5.00	0.02	4.98	3.54	3.00	
19.8.79	5.00	0.03	4.97	4.24	5.50	
21.8.79	5.00	0.03	4.97	5.04	6.00	
22.8.79	5.00	0.03	4.97	5.14	7.00	
23.8.79	5.00	0.04	4.96	5.00	5.00	
4.9.79	8.00	0.07	7.93	6.40	9.00	
15.9.79	6.00	0.12	5.88	5.99	8.00	
17.9.79	6.00	0.11	5.89	6.52	8.50	
18.9.79	8.00	0.10	7.90	5.91	8.00	
19.9.79	6.00	0.11	5.89	5.21	8.70	
20.9.79	6.00	0.09	5.91	5.85	9.50	
21.9.79	6.00	0.10	5.90	6.06	9.00	
22.9.79	7.00	0.10	6.90	6.34	8.50	
23.9.79	6.00	0.11	5.89	6.03	5.50	
25.9.79	8.00	0.14	7.86	5.88	8.00	
27.9.79	8.00	0.12	7.88	6.01	7.00	
28.9.79	6.00	0.11	5.89	5.34	8.50	
29.9.79	8.00	0.10	7.90	5.68	8.00	
30.9.79	8.00	0.09	7.91	5.51	7.50	
4.10.79	5.00	0.16	4.84	4.55	5.10	
7.10.79	8.00	0.16	7.84	5.31	7.00	
8.10.79	8.00	0.16	7.84	5.19	7.50	
9.10.79	7.00	0.16	6.84	6.26	8.00	
11.10.79	6.00	0.14	5.86	5.62	8.00	
13.10.79	8.00	0.12	7.88	4.52	9.00	
14.10.79	9.00	0.10	8.90	6.07	9.50	
27.10.79	5.00	0.12	4.88	4.60	6.20	
2.11.79	6.00	1.01	4.99	5.02	10.10	
4.11.79	6.00	1.16	4.84	4.22	5.80	
8.11.79	5.00	1.08	3.92	2.70	2.50	
9.11.79	5.00	0.98	4.02	3.38	8.00	
17.11.79	5.00	0.86	4.11	4.04	4.50	
20.11.79	5.00	0.76	4.24	3.02	3.50	
21.11.79	5.00	0.73	4.27	4.78	5.50	
24.11.79	5.00	0.76	4.24	4.85	3.50	
25.11.79	6.00	0.73	5.27	5.00	6.50	
30.11.79	6.00	0.54	5.46	5.31	6.00	
4.12.79	6.00	0.05	5.95	5.50	6.50	
5.12.79	5.00	0.05	4.95	4.95	5.50	
TOTAL	253.02	11.73	241.31	206.65	270.70	
AVERAGE (days sampled = 41)	6.17	0.29	5.89	5.04	6.60	

* error correction : ± 2 mm; +calculated from 1979 weather data

Appendix III (cont.)

Table 4. E_T by experimental plot (H20)

Date	Water*[1] losses (mm/day)	Deep percolation[2] losses by Darcy equation (mm/day)	Field determined E_T 1-2=3 (mm/day)	E_T by[4] Penman+ (mm/day)	Evaporation[5] class "A" pan (mm/day)	Remarks[6]
19.8.79	5.00	0.00	5.00	4.24	5.50	
23.8.79	5.00	0.00	5.00	5.00	5.00	
29.8.79	5.00	0.00	5.00	5.87	7.50	
3.9.79	6.00	0.00	6.00	6.27	7.00	
4.9.79	6.00	0.00	6.00	6.40	9.00	
6.9.79	5.00	0.00	5.00	4.97	9.00	
7.9.79	5.00	0.00	5.00	4.44	5.50	
8.9.79	5.00	0.00	5.00	4.65	6.50	
11.9.79	5.00	0.00	5.00	3.69	4.20	
12.9.79	5.00	0.00	5.00	4.23	5.50	
14.9.79	5.00	0.00	5.00	5.77	6.55	
15.9.79	5.00	0.00	5.00	5.99	6.00	
22.9.79	8.00	0.00	8.00	6.34	8.50	
23.9.79	7.00	0.00	7.00	6.03	5.50	
24.9.79	5.00	0.00	5.00	5.39	6.00	
28.9.79	5.00	0.00	5.00	5.34	6.50	
29.9.79	8.00	0.00	8.00	5.68	8.00	
30.9.79	6.00	0.00	6.00	5.51	7.50	
10.10.79	6.00	0.00	6.00	5.73	7.50	
11.10.79	6.00	0.00	6.00	5.62	8.00	
13.10.79	5.00	0.00	5.00	4.52	8.00	
14.10.79	10.00	0.00	10.00	6.07	6.50	
16.10.79	5.00	0.00	5.00	5.33	6.00	
17.10.79	5.00	0.00	5.00	4.39	5.00	
18.10.79	6.00	0.00	6.00	5.83	7.00	
20.10.79	6.00	0.00	6.00	5.66	8.00	
27.10.79	5.00	0.00	5.00	4.60	6.20	
28.10.79	6.00	0.00	6.00	5.59	6.20	
29.10.79	5.00	0.00	5.00	5.28	7.00	
30.10.79	6.00	0.00	6.00	5.13	6.50	
2.11.79	5.00	0.00	5.00	5.02	10.10	
9.11.79	6.00	0.00	6.00	3.38	6.00	
15.11.79	5.00	0.00	5.00	3.75	5.50	
16.11.79	5.00	0.00	5.00	4.69	6.00	
17.11.79	5.00	0.00	5.00	4.04	4.50	
24.11.79	5.00	0.00	5.00	4.85	5.50	
25.11.79	5.00	0.00	5.00	5.00	5.50	
26.11.79	5.00	0.00	5.00	4.93	4.50	
28.11.79	5.00	0.00	5.00	5.41	6.50	
5.12.79	5.00	0.00	5.00	4.95	5.50	
11.12.79	5.00	0.00	5.00	4.50	5.50	
TOTAL	228.00	0.00	228.00	210.08	272.5[illegible]	
AVERAGE (days sampled = 40)	5.70	0.00	5.70	5.25	6.76	

* error correction ± 2 mm; +calculated from 1979 weather data

APPENDIX IV

METEOROLOGICAL DATA

APPENDIX IV

METEOROLOGICAL DATA

Table 1. Rainfall (mm). Water Balance Study, M.I.S. - Thiba Section

Station name and/or no.	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Embu-Mwea	1963	46.3	33.0	66.3	476.1	216.3	38.2	0.0	0.0	14.8	72.7	184.1	139.2	1278
(Thiba Reception Centre)	1964	15.3	18.8	184.7	325.7	4.3	7.1	7.4	131.8	20.4	171.9	85.7	98.2	1071
90 37 112	1965	30.2	0.8	43.5	199.3	23.6	5.6	8.7	16.6	10.7	45.4	297.8	48.9	731
	1966	41.9	3.3	143.9	5.1	45.0	41.2	6.3	6.3	14.6	85.3	202.8	7.4	603
	1967	2.3	0.0	38.1	288.3	391.4	38.7	20.1	20.7	15.5	236.4	206.1	0.0	1258
	1968	0.0	127.9	122.9	303.5	94.8	17.1	19.9	9.0	0.3	168.4	335.0	136.1	1335
	1969	49.0	123.1	168.7	47.0	144.9	10.0	5.1	8.1	0.5	19.6	170.7	22.8	740
	1970	59.8	0.0	162.8	454.8	133.3	3.4	7.2	14.3	2.1	27.0	125.2	30.0	1020
	1971	0.0	4.1	29.9	225.6	183.2	13.2	180.4	0.0	1.2	30.6	80.2	51.8	830
	1972	40.1	28.1	43.1	16.9	257.3	47.3	4.5	3.4	33.3	199.8	165.6	37.0	876
	1973	58.2	65.6	33.9	110.3	49.6	7.0	9.2	1.3	30.6	70.4	222.7	16.6	675
	1974	0.0	16.2	49.4	232.4	67.3	125.3	108.0	41.8	11.6	14.8	149.3	16.6	833
	1975	5.3	14.7	25.3	231.7	104.4	10.0	71.4	4.3	37.6	126.5	57.5	20.4	745
	1976	0.0	5.1	6.2	180.0	110.9	95.0	5.2	2.1	19.6	88.4	136.3	30.5	679
	1977	24.5	38.8	61.8	469.6	147.4	12.8	3.2	6.0	18.7	51.3	326.1	58.7	1219
	1978	14.4	89.1	129.3	377.0	73.5	2.5	8.8	4.0	48.1	264.7	96.7	55.7	1164
	1979	102.9	5.3	158.7	333.5	109.1	27.3	12.6	4.0	4.3	41.0	220.8	58.1	1180
	AVE.	28.83	33.76	87	251	127	30	28	16	16	101	181	49	955

APPENDIX IV .. cont.
METEOROLOGICAL DATA

Table II. Wind speed (miles/hour). Water Balance Study, M.I.S. Thiba Section

Station name and/or no.	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
Embu-Mwea (Thiba reception Centre) 90 37 112	1963	0.6	2.4	3.0	2.2	1.7	1.7	+	+	1.7	5.2	2.5	3.1	+
	1964	3.5	+	2.7	+	+	1.3	1.3	1.3	+	2.9	+	2.9	+
	1965	2.6	3.0	3.4	1.5	1.1	2.2	1.2	2.4	3.7	2.9	3.0	2.5	2.5
	1966	+	+	+	+	2.6	2.6	2.8	3.3	4.2	4.8	4.5	4.6	+
	1967	5.4	5.5	4.4	3.5	1.9	1.6	2.1	2.6	3.4	3.4	3.5	3.1	3.3
	1968	3.6	3.4	3.1	2.5	2.2	1.8	1.9	3.2	3.2	3.2	2.9	2.8	2.7
	1969	3.3	3.2	3.0	2.8	2.3	2.6	3.1	4.3	4.8	4.6	3.5	4.1	3.5
	1970	3.6	4.4	4.2	3.4	2.6	2.3	2.6	3.3	4.2	4.7	3.6	4.0	3.6
	1971	4.3	5.2	5.6	3.4	2.6	2.4	3.0	3.3	4.4	4.8	4.0	4.2	3.9
	1972	4.1	4.1	4.3	4.8	3.2	2.2	3.4	3.9	4.5	3.8	2.8	2.8	3.7
	1973	3.0	3.6	3.9	3.3	3.2	3.1	3.0	4.4	4.3	5.0	3.3	3.4	3.6
	1974	3.9	4.1	4.2	2.9	2.3	2.3	2.2	2.5	2.9	3.4	3.1	3.5	3.1
	1975	4.3	4.3	4.7	3.5	2.5	2.3	2.5	2.9	3.9	3.4	2.9	3.7	3.4
	1976	4.3	4.7	5.0	4.1	2.9	2.8	3.2	5.6	5.0	4.2	3.4	4.2	4.1
	1977	4.3	4.4	4.7	3.1	2.6	2.3	2.6	3.5	3.8	+	2.9	3.2	+
	1978	3.6	3.2	3.0	2.6	2.4	2.6	2.9	3.6	5.2	3.0	2.9	3.7	3.2
	1979	3.1	3.3	3.2	2.8	2.7	2.7	2.5	3.2	4.2	2.4	2.8	3.5	3.0
	AVE.	3.6	4.0	3.9	3.2	2.4	2.1	2.6	3.3	4.0	3.9	3.2	3.5	3.3

APPENDIX IV

Table III. Evaporation (Class "A") (mm) Water Balance Study, M.I.S. - Thiba Section

Station Name and/or No.	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Embu-Mwea	1963	160	174	157	107	115	86	+	+	167	202	182	158	+
(Thiba reception Centre)	1964	183	192	167	+	128	131	85	146	98	+	125	136	+
90 37 112	1965	170	197	254	179	140	121	111	126	189	180	134	187	1988
	1966	196	204	154	200	134	128	107	140	183	235	183	203	2067
	1967	227	247	236	171	156	115	116	139	182	194	142	174	2099
	1968	162	170	160	137	128	113	101	102	190	174	127	154	1718
	1969	178	149	168	179	154	144	135	72	228	244	176	199	2026
	1970	195	247	262	180	151	120	124	136	186	243	163	209	2216
	1971	241	276	284	178	133	124	120	132	208	243	190	201	2330
	1972	205	193	254	244	162	129	150	174	223	202	157	160	2253
	1973	185	212	262	206	176	162	146	172	203	236	172	192	2324
	1974	241	214	221	151	152	111	117	117	146	212	146	188	2016
	1975	230	248	279	191	153	132	126	272	187	195	172	200	2385
	1976	252	240	289	194	179	145	141	170	210	231	171	164	2386
	1977	224	232	226	180	167	135	122	184	197	+	135	152	+
	1978	-	-	-	-	129	123	118	137	190	171	151	151	+
	1979	152.9	154.8	203.7	154.5	143.6	129.8	118.1	141.5	174.3	206.5	148.8	175.1	1904
	AVE.	194	210	224	177	147	126	121	148	186	212	158	177	2078

APPENDIX IV

METEOROLOGICAL DATA

Table IV. Relative Humidity (%). Water Balance Study, M.I.S. - Thiba Section

Station name and/or No.	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
Embu-Mwea	1963	62	58	60	64	70	70	+	+	58	57	70	74	+
(Thiba Reception	1964	66	56	61	68	70	63	65	68	70	60	62	76	65
Centre)														
90 37 112	1965	68	56	62	72	68	+	+	60	54	54	71	60	+
	1966	57	58	68	75	66	70	70	62	54	54	70	55	63
	1967	52	47	56	69	74	57	63	61	57	64	75	66	63
	1968	49	60	72	73	74	70	71	70	56	57	71	66	66
	1969	58	58	72	63	62	62	71	78	63	52	64	60	64
	1970	56	49	57	68	68	67	64	53	56	50	62	60	60
	1971	47	37	46	64	69	66	53	64	48	58	56	57	55
	1972	58	58	49	50	64	64	62	58	+	55	68	65	+
	1973	57	52	47	56	59	58	60	60	55	52	66	60	57
	1974	48	48	53	68	62	67	66	71	59	55	66	56	60
	1975	46	42	45	58	64	62	62	62	56	56	56	56	55
	1976	48	52	47	62	64	62	66	58	54	56	60	63	58
	1977	56	46	56	69	68	64	66	59	54	+	70	68	+
	1978	56	57	66	70	63	62	64	63	53	57	66	66	62
	1979	66.45	57.7	56.2	63.85	64.45	62.25	64.25	60.2	54.25	53.2	77.9	62	62
	AVE	56	52	57	66	67	66	67	64	57	56	66.7	63	61

APPENDIX IV

METEOROLOGICAL DATA

Table V. Mean Temperature ^{o}C. Water Balance Study, M.I.S. - Thiba Section

Station name and/or number	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
Embu-Mwea	1963	20.9	22.2	23.7	22.7	21.9	20.0	+	+	20.8	23.0	21.7	20.7	+
(Thiba Reception	1964	19.1	22.0	22.7	22.5	21.5	21.5	19.3	19.4	20.2	21.3	23.4	20.6	21.2
Centre)	1965	21.8	21.6	22.9	22.9	22.2	20.5	19.8	20.0	22.5	23.1	21.5	20.6	21.6
90 37 112	1966	21.8	23.4	23.2	22.0	21.8	21.1	20.1	20.7	21.1	22.5	+	20.4	+
	1967	20.5	22.1	22.7	22.0	21.7	20.0	19.9	21.3	21.9	21.9	20.9	19.9	21.2
	1968	21.1	21.7	21.6	21.0	21.1	20.1	19.2	19.1	21.6	22.7	21.3	20.4	20.9
	1969	20.6	21.7	21.9	22.8	22.7	21.5	20.9	22.2	22.7	24.2	22.8	21.2	22.1
	1970	22.5	23.3	24.0	22.8	22.2	20.8	20.1	19.9	21.6	23.8	21.9	21.5	22.0
	1971	22.0	22.6	23.3	23.3	21.7	19.8	19.8	19.9	22.2	23.2	22.4	21.4	21.8
	1972	21.1	22.2	23.5	25.1	23.0	21.3	21.2	21.6	23.1	23.5	22.1	21.5	22.4
	1973	21.7	23.5	24.1	24.7	23.2	21.5	20.1	21.3	22.9	23.7	22.3	20.6	22.5
	1974	21.4	22.0	23.0	23.0	22.2	21.2	20.3	19.8	21.2	23.4	21.6	21.1	21.7
	1975	21.7	22.9	24.8	23.6	22.5	20.5	20.5	20.0	22.0	22.6	24.3	21.2	22.2
	1976	21.7	23.7	24.4	23.2	23.0	21.4	20.4	21.1	22.8	23.1	22.8	21.8	22.4
	1977	22.2	23.5	24.2	23.2	22.8	21.3	20.7	21.5	22.4	+	22.1	21.4	+
	1978	21.0	22.4	22.8	22.5	22.2	21.8	20.4	20.8	22.7	22.9	21.8	21.6	21.9
	1979	21.6	22.2	22.8	23.1	22.4	21.1	20.0	21.0	22.7	23.9	21.9	21.7	22.0
	AVERAGE	21.3	22.6	23.3	23.0	22.2	21.0	20.2	20.5	22.0	23.1	22.2	21.0	21.9

APPENDIX IV
METEOROLOGICAL DATA

Table VI. Sunshine hours/day. Water Balance Study, M.I.S. - Thiba Section

Station name and/or number	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
Embu-Mwea	1963	8.0	9.2	7.8	-	-	5.8	-	-	-	-	-	-	-
(Thiba Reception	1964	-	-	-	-	-	-	-	-	-	-	-	-	-
Centre)	1965	-	10.2	-	-	-	6.3	-	-	-	-	-	-	-
90 37 112	1966	-	-	-	-	-	-	-	-	-	-	6.3	8.9	-
	1967	9.9	9.9	9.3	6.9	6.2	4.9	4.2	5.0	7.2	6.8	6.7	10.0	7.2
	1968	8.7	7.0	6.8	5.8	6.1	4.6	2.6	2.4	7.1	6.4	5.7	9.3	6.0
	1969	9.5	7.2	7.7	8.7	7.4	5.7	3.5	6.7	7.1	8.7	6.9	9.9	7.4
	1970	7.0	10.4	7.4	7.7	7.2	4.7	4.2	3.3	6.0	7.7	7.8	9.1	6.9
	1971	9.2	10.5	9.1	7.7	5.8	-	2.7	4.1	7.1	7.6	7.8	7.9	-
	1972	9.1	7.0	9.1	7.6	6.2	5.2	4.1	4.5	7.2	6.6	7.6	8.0	6.8
	1973	9.1	9.2	9.5	8.3	7.1	5.6	4.2	3.2	6.1	7.7	7.0	9.8	7.2
	1974	10.2	9.7	6.4	6.7	7.1	4.0	4.3	2.7	4.8	7.9	6.6	9.1	6.6
	1975	9.9	10.0	8.3	8.6	7.3	5.1	4.1	2.3	5.3	6.2	8.3	9.4	7.1
	1976	10.2	8.4	8.7	6.3	7.0	6.4	5.5	4.5	7.5	8.2	7.3	8.3	7.4
	1977	8.4	9.0	7.6	5.8	7.9	-	1.7	5.5	6.3	-	5.5	6.5	-
	1978	8.7	8.3	6.8	6.7	7.1	5.2	3.2	2.9	6.0	5.9	7.3	6.8	6.2
	1979	6.7	8.3	8.6	6.6	6.2	5.3	3.9	4.7	7.0	7.8	6.8	7.8	
	AVERAGE	8.9	9.0	8.0	7.3	6.8	5.3	3.7	4.0	6.5	7.3	7.0	8.6	6.9

APPENDIX V

DEFINITIONS AND CONVERSION FORMULAS

APPENDIX V

DEFINITIONS

SECTION	an area of about 1215 ha. which is completely self-contained with an administrative centre fully equipped to receive, weigh, dry, rebag and store the crop.
UNIT	a sub-division of a section composed of fields each of 0.0405 ha. and are the administrative, agricultural and hydraulic divisions of the scheme.
MAIN CANAL	conveys water from the headworks through central part of the scheme.
MAIN FEEDER	(sometimes called a Unit Feeder), is the main irrigation channel of a unit which draws irrigation water from the main canal or branch canal(s).
FIELD CHANNEL	the smallest irrigation channel which draws water from the unit feeder and distributes it to individual fields.
ROAD DRAIN	runs alongside an access road and collects drain water from the fields and conveys the drain water into a unit drain.
UNIT DRAIN	the main drain of a unit and is fed by road drains.
COLLECTOR DRAIN	collects the drain water from the unit drains.
M.I.S.	Mwea Irrigation Scheme
N.I.B.	National Irrigation Board, responsible for the management of all major Government irrigation schemes.
S.R.D.	Scientific Research Division - a division of the Ministry of Agriculture.

CONVERSION FORMULAS (From litres per second to mm. per day)

$$\text{mm/day} = 8.64\,\frac{X}{A} = \frac{8.64\,X}{A} \qquad (11)$$

where X = litres per second
and A = area. in ha.

APPENDIX VI

SUMMARY OF PROFILE SURVEY

FOR MAIN AND BRANCH CANALS

APPENDIX VI

Table I. Summary of profile survey of canal bed of main canal (From Permanent B.M.* at Wamumu off-take to H20 off-take)

Station (m)	Elevation, m. (along the middle of the canal)	Remarks
0 + 00	1149.33	Located near bridge of main road to Embu, this bridge is near Thiba Research Station
2 + 00	1149.68	
4 + 00 - 16 + 00	-	Water too deep, no elevations were determined
18 + 00	1150.04	
20 + 00	1151.22	
22 + 00	1150.76	
24 + 00	1148.07	
26 + 00	1150.90	
28 + 00	1148.19	
30 + 00	1151.01	
32 + 00	1148.33	
34 + 00	1151.30	
36 + 00	1149.49	
38 + 00	1152.36	
40 + 00	1149.42	
42 + 00	1151.37	
44 + 00	1149.73	
46 + 00	1152.82	
48 + 00	1149.93	

* B.M. (R.L. = 1150.98 m) located on top of the off-take of branch canal supplying water to H2, H3, H4, H5 and Wamumu Section

APPENDIX VI

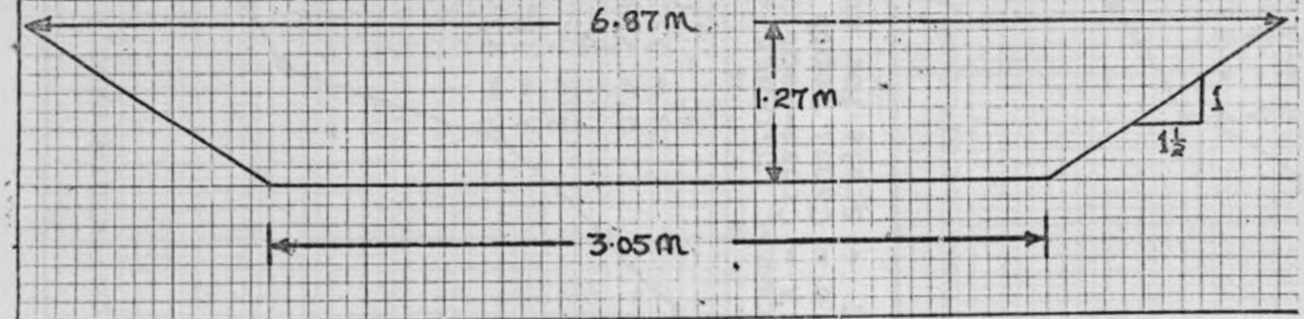
Table II. Summary of profile survey of the branch canal supplying water to H1, H6, H7 and H8

Station (m)	Elevation, m (along the middle of the canal)	Remarks
0 + 00	1149.10	Near H1 off-take
1 + 00	1149.16	
2 + 00	1148.96	
3 + 00	1148.87	
4 + 00	1149.28	
5 + 00	1149.47	
6 + 00	1149.35	
7 + 00	1149.34	
8 + 00	1149.22	
9 + 00	1149.21	
10 + 00	1149.15	

APPENDIX VII

SPECIFICATIONS OF THE ORIGINAL AND CURRENT CROSS-SECTIONS OF MAIN CANAL

FIG. I ORIGINAL CROSS-SECTION OF MAIN CANAL



DESIGN SPECIFICATIONS

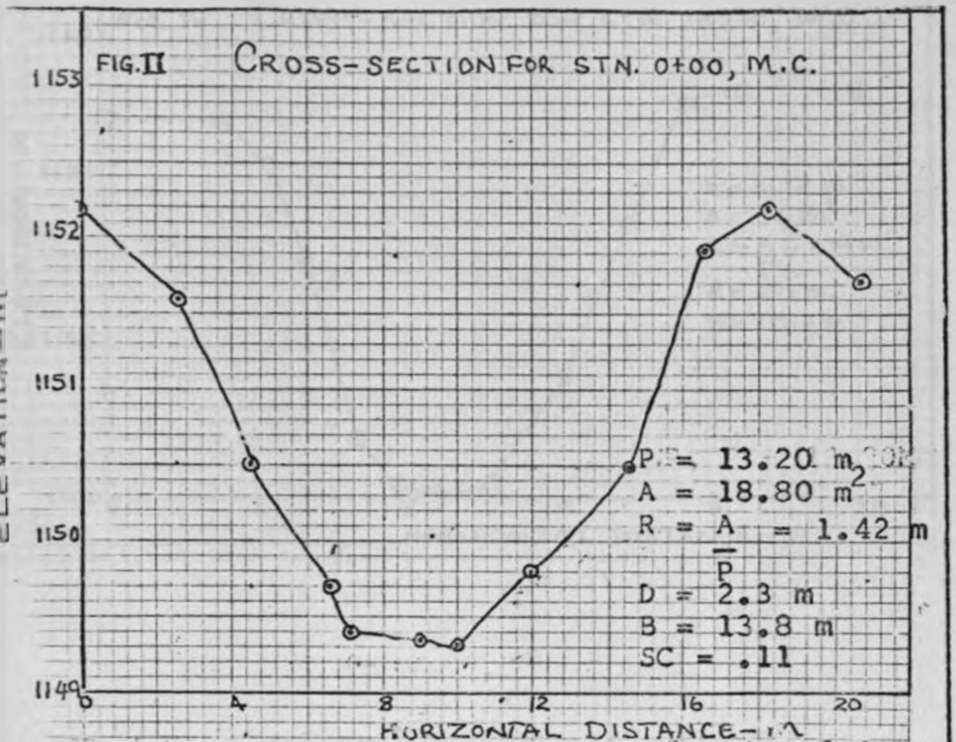
Design Capacity:	$2.83\ m^3/sec.$		$A = 6.32\ m^2$
Gradient, S:	$1/3500 = 0.000286$		$P = 7.64\ M.$
Bed Width, B:	3.05 m.		$R = \frac{A}{P} = 0.83\ m.$
Design Water-depth:	1.27 m.		
Side Slopes, Z:	1½ to 1		
Roughness Coefficient, n:	0.033		
Resulting Velocity, V:	1.56 fps		

THE ABOVE SPECIFICATIONS ARE FOR THE MAIN CANAL FROM THE HEADWORKS INTAKE TO THE WAMUMU – THIBA ROAD

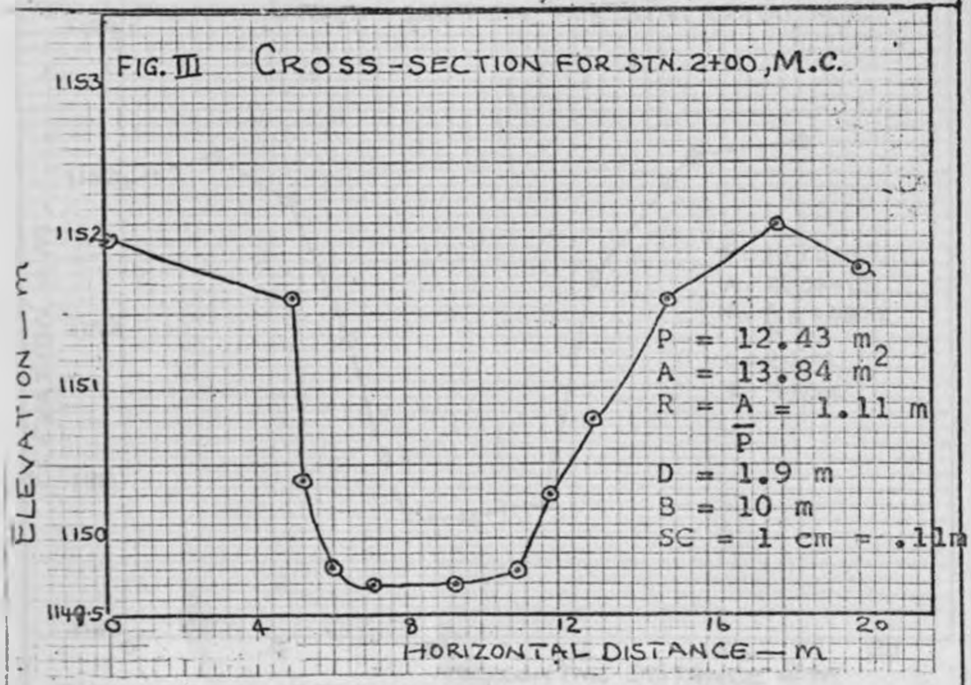
FORMULA: $V = \frac{1}{n} R^{2/3} S^{1/2}$

APPENDIX VII

SECTIONS FOR MAIN CANAL MAIN CANAL (FROM PERMANENT B.M. NEAR CHO OF H1 TO INLET OF H20)



P = Wetted Perimeter - A = Cross-Sectional Area
R = Hydraulic Radius - D = Canal Depth
B = Top Width SC = Scale for curve



P = Wetted Perimeter - A = Cross-Sectional Area
R = Hydraulic Radius - D = Canal Depth
B = Top Width sc = Scale for curve

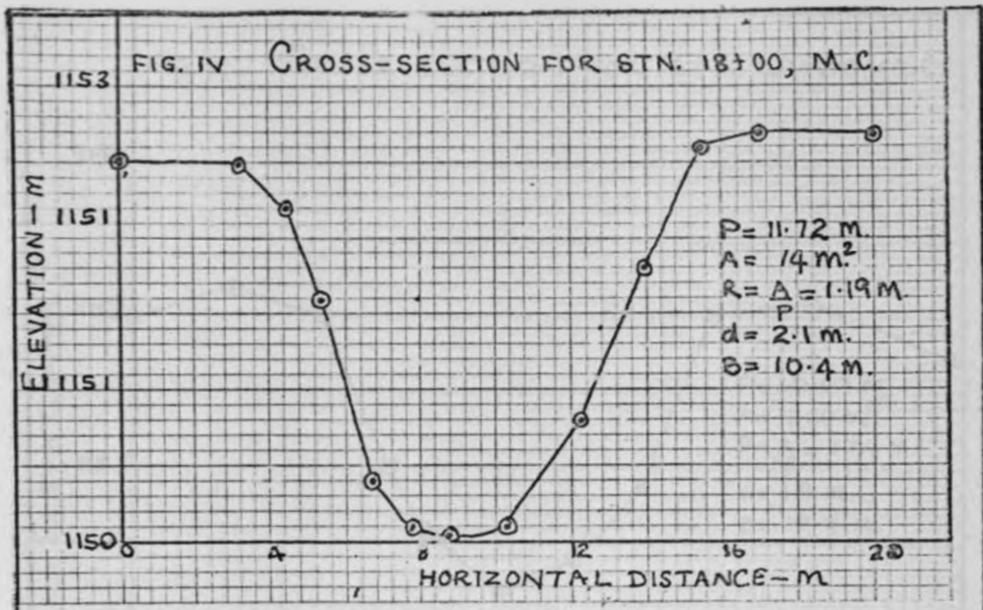


FIG. IV CROSS-SECTION FOR STN. 18+00, M.C.
1153
1151
1151
1150
ELEVATION – m
P= 11·72 m.
A= 14 m.²
R= A/P = 1·19 M.
d= 2·1 m.
B= 10·4 m.
0
4
8
12
16
20
HORIZONTAL DISTANCE – m

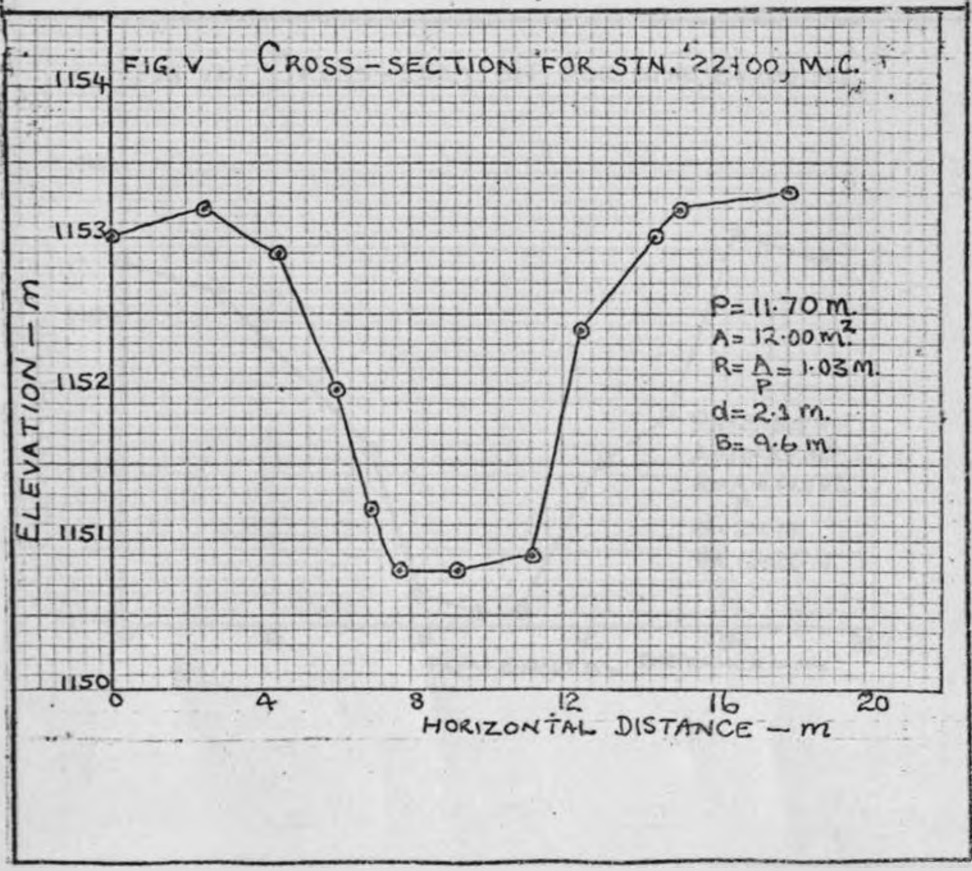
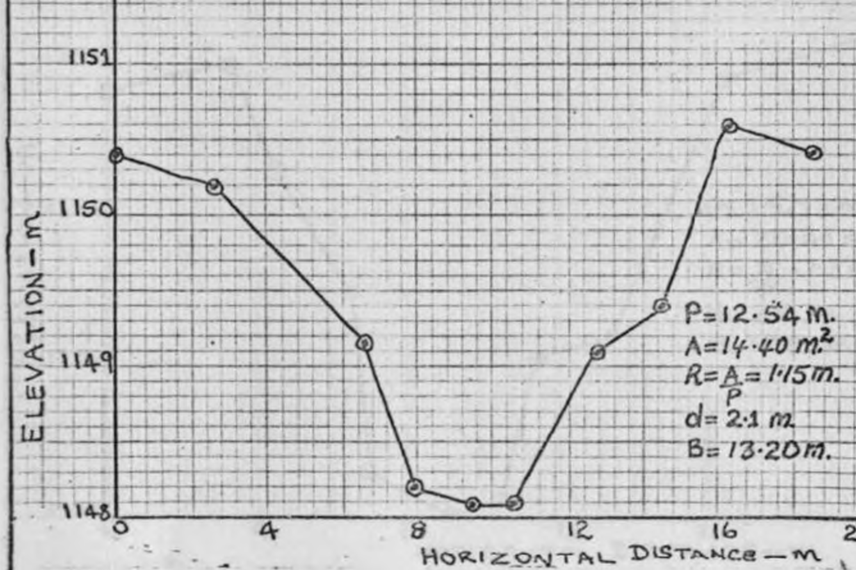


FIG. V CROSS-SECTION FOR STN. 22+00, M.C.
1154
1153
1152
1151
1150
ELEVATION – m
P= 11·70 m.
A= 12·00 m.²
R= A/P = 1·03 m.
d= 2·1 m.
B= 9·6 m.
0
4
8
12
16
20
HORIZONTAL DISTANCE – m

FIG. VII CROSS-SECTION FOR STN. 24+00, M.C.



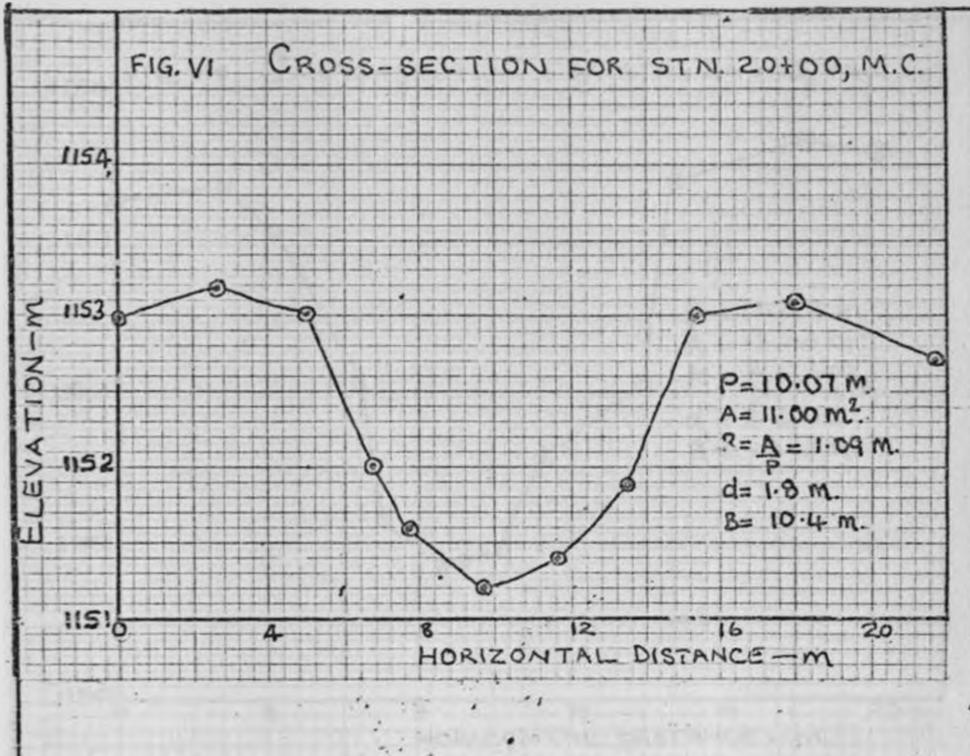
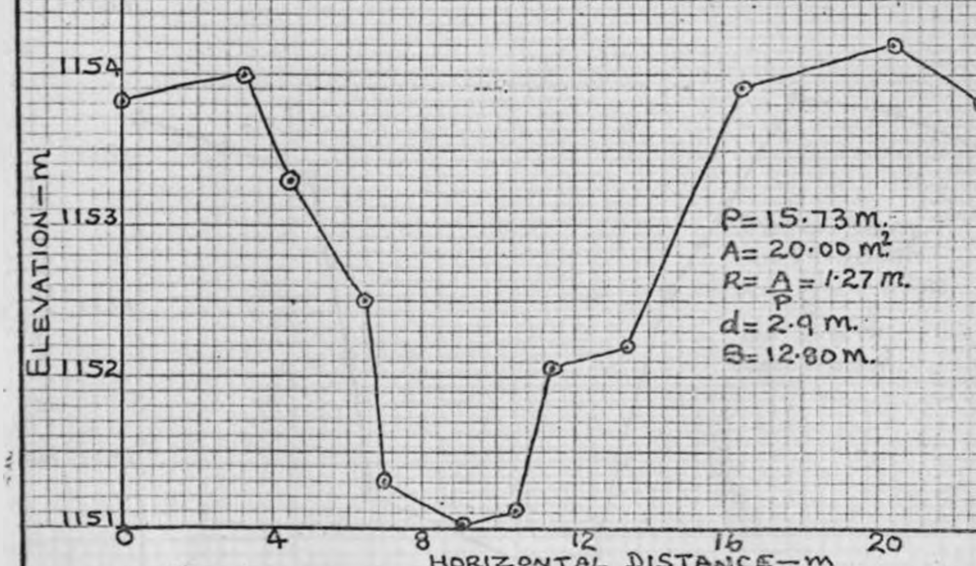


FIG. VI CROSS-SECTION FOR STN. 20+00, M.C.
ELEVATION—m
1154
1153
1152
1151
0
4
8
12
16
20
HORIZONTAL DISTANCE—m
P=10.07 M.
A= 11.00 m².
R= A/P = 1.09 M.
d= 1.8 m.
B= 10.4 m.

FIG. IX CROSS-SECTION FOR STN. 30+00, M.C.



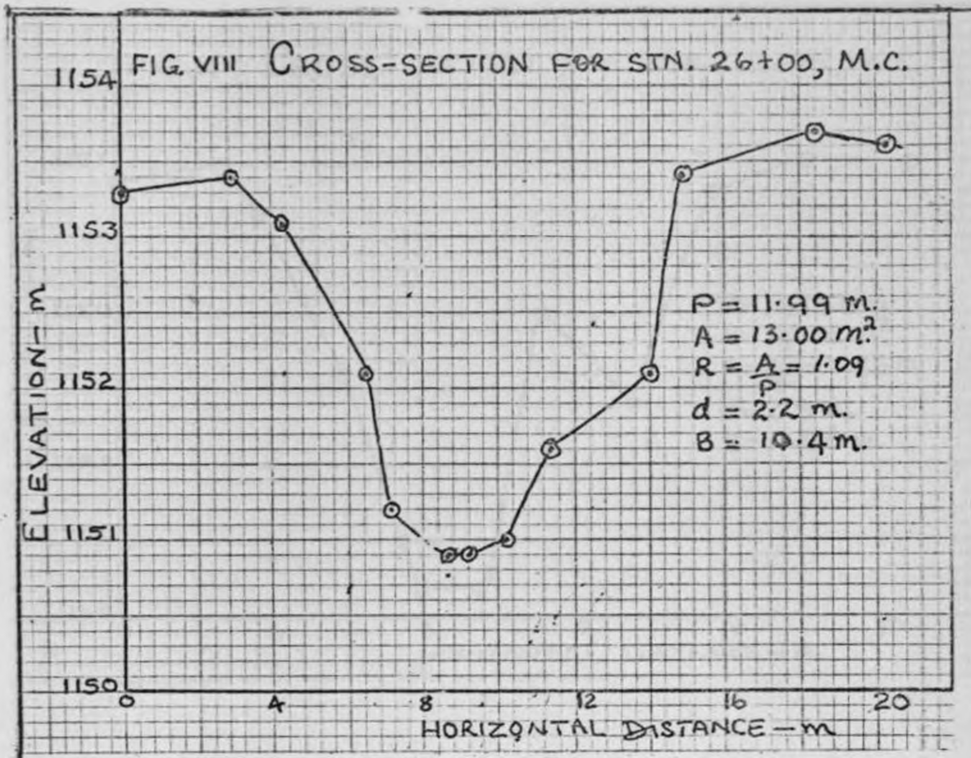


FIG. VIII CROSS-SECTION FOR STN. 26+00, M.C.

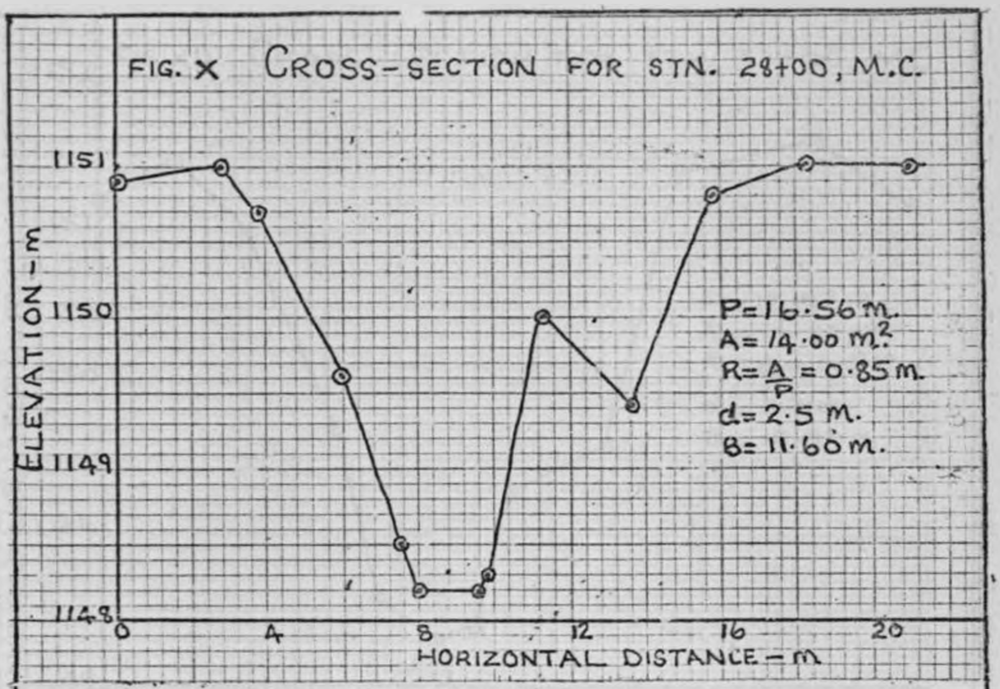


FIG. X CROSS-SECTION FOR STN. 28+00, M.C.

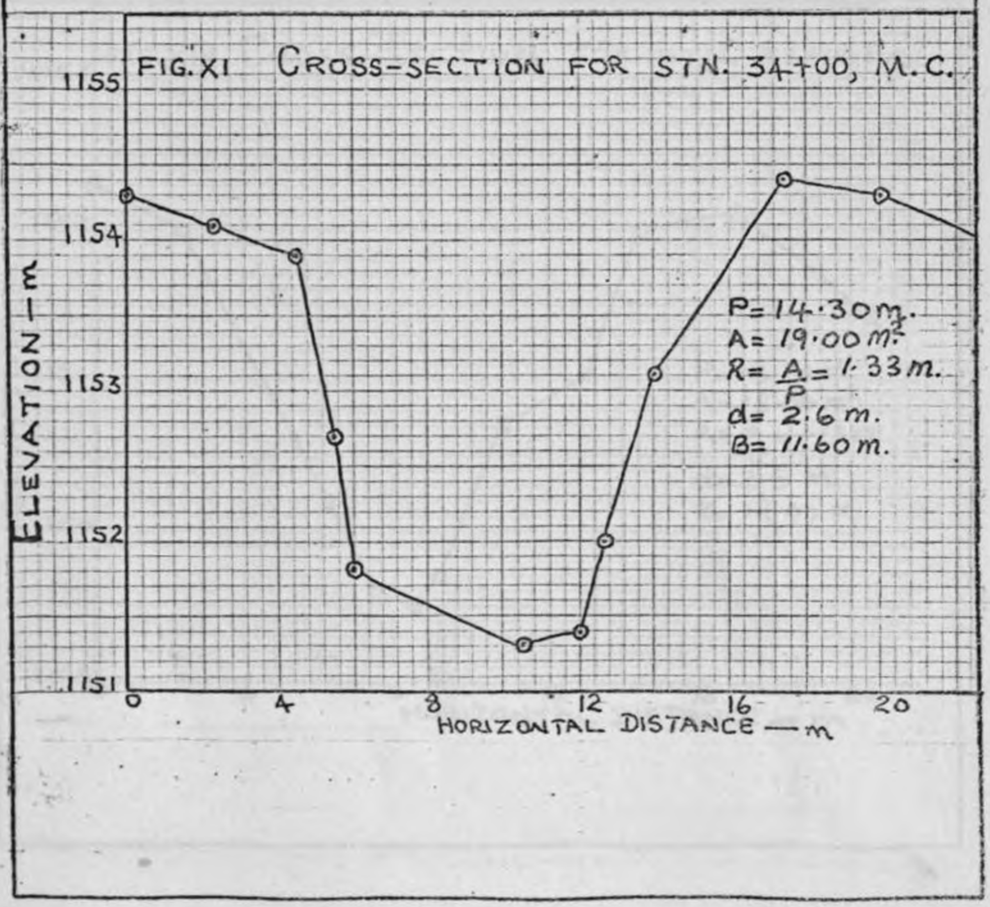


FIG. XI CROSS-SECTION FOR STN. 34+00, M.C.

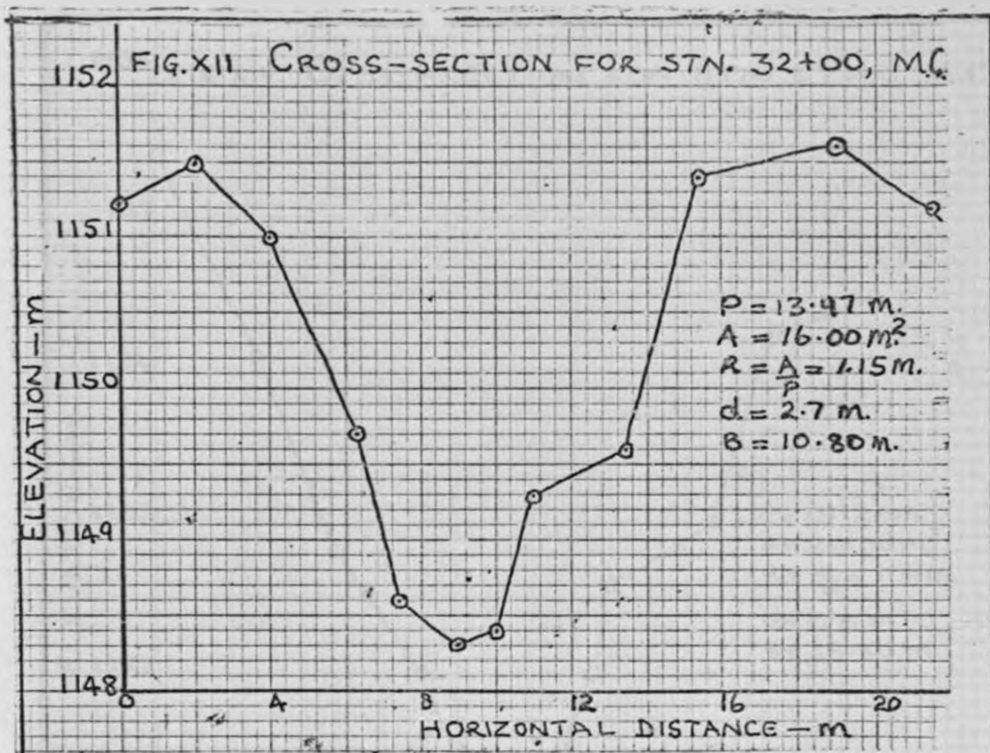


FIG. XII CROSS-SECTION FOR STN. 32+00, M.C.
ELEVATION — m
1152
1151
1150
1149
1148
0
4
8
12
16
20
HORIZONTAL DISTANCE — m
P = 13·47 m.
A = 16·00 m²
R = A/P = 1.15 m.
d = 2·7 m.
B = 10·80 m.

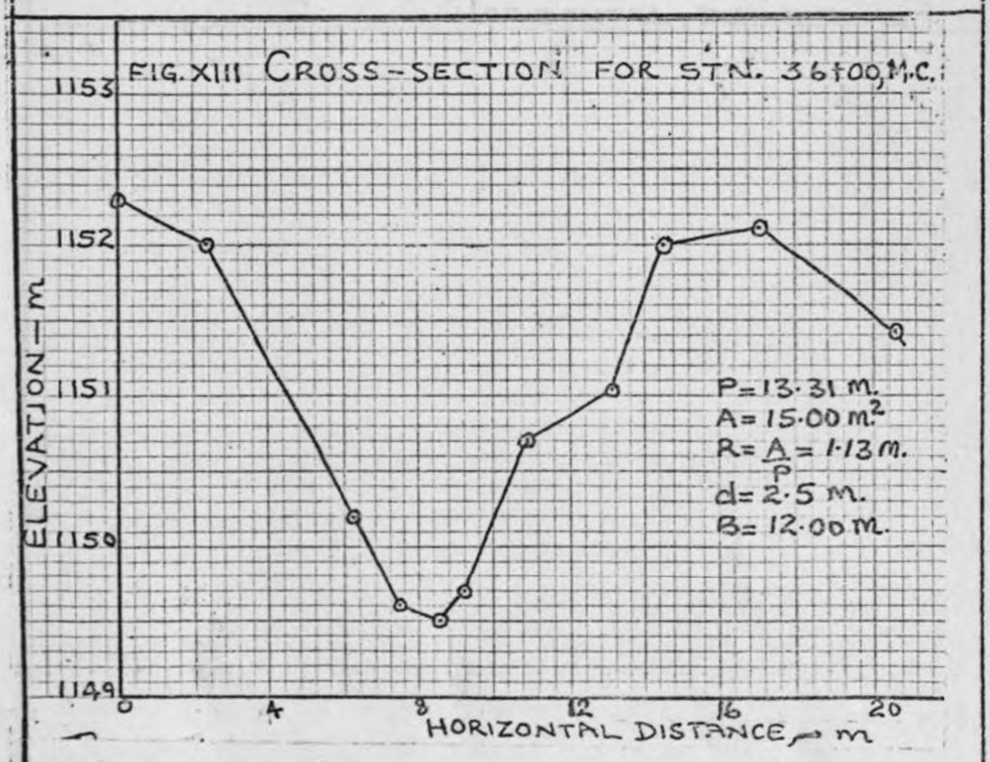


FIG. XIII CROSS-SECTION FOR STN. 36+00, M.C.
ELEVATION — m
1153
1152
1151
1150
1149
0
4
8
12
16
20
HORIZONTAL DISTANCE — m
P = 13·31 m.
A = 15·00 m²
R = A/P = 1·13 m.
d = 2·5 m.
B = 12·00 m.

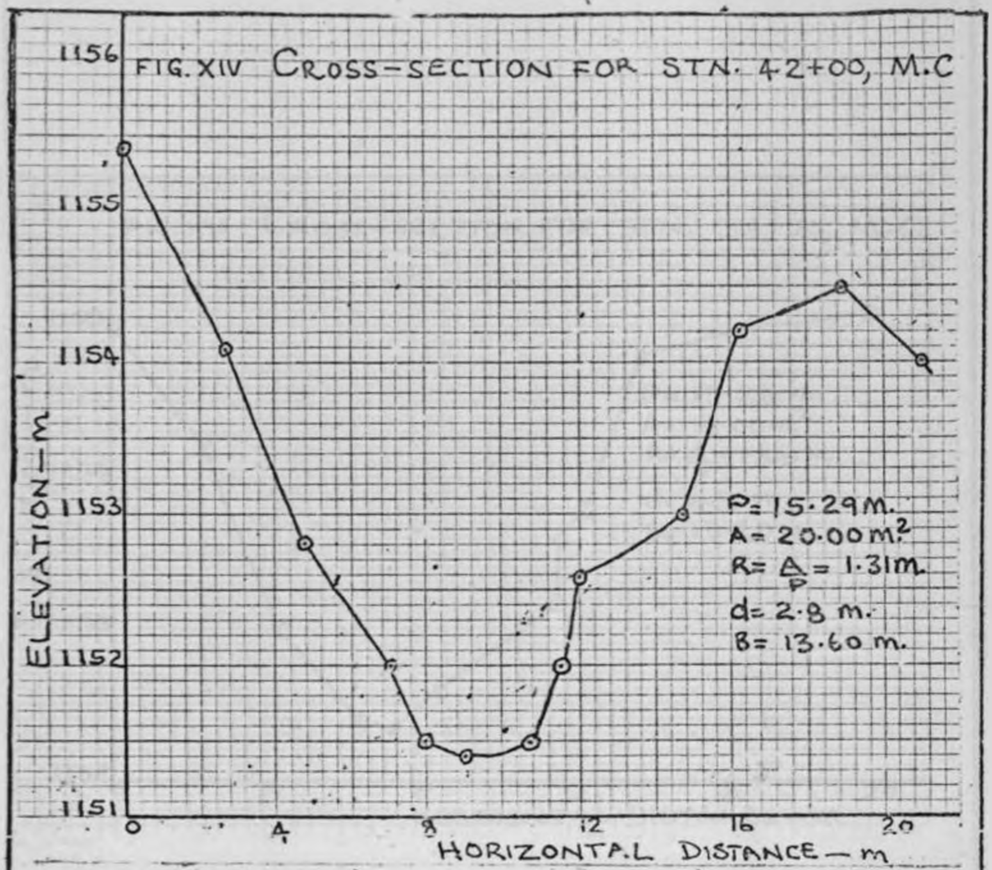


FIG. XIV CROSS-SECTION FOR STN. 42+00, M.C
1156
1155
1154
1153
1152
1151
ELEVATION — m
0
4
8
12
16
20
HORIZONTAL DISTANCE — m
P= 15·29 m.
A= 20·00 m²
R= A/P = 1·31 m.
d= 2·8 m.
B= 13·60 m.

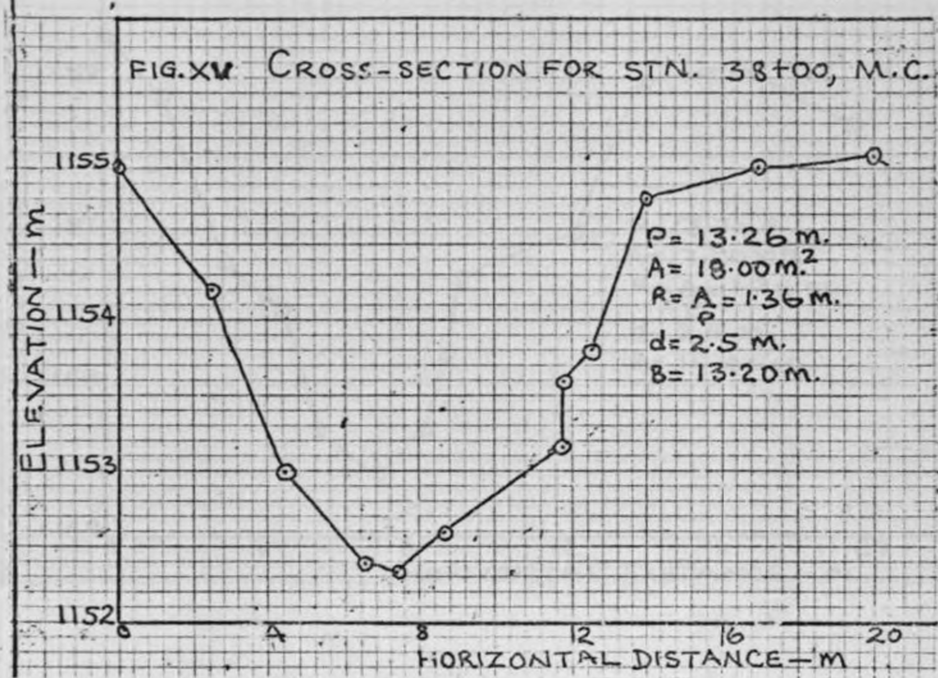


FIG. XV CROSS-SECTION FOR STN. 38+00, M.C.
ELEVATION — m
1155
1154
1153
1152
0
4
8
12
16
20
HORIZONTAL DISTANCE — m
P = 13·26 m.
A = 18·00 m.²
R = A/P = 1·36 m.
d = 2·5 m.
B = 13·20 m.

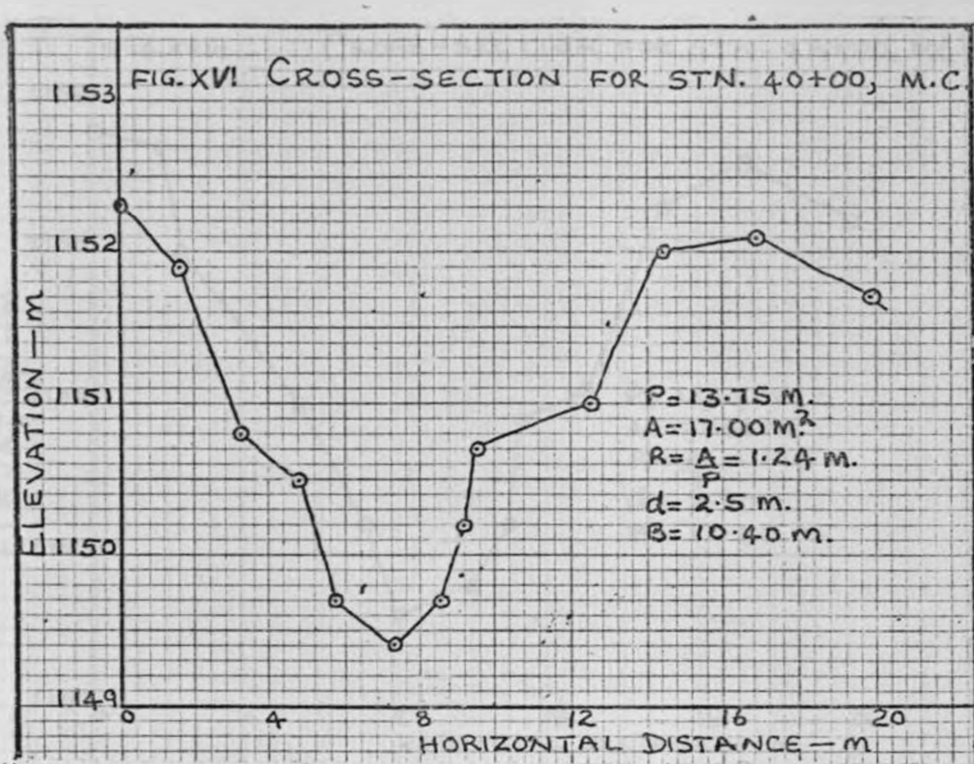


FIG. XVI CROSS-SECTION FOR STN. 40+00, M.C.
1153
1152
1151
1150
1149
ELEVATION — m
0
4
8
12
16
20
HORIZONTAL DISTANCE — m
P=13.75 M.
A=17.00 M.²
R= A/P = 1.24 M.
d= 2.5 m.
B= 10.40 m.

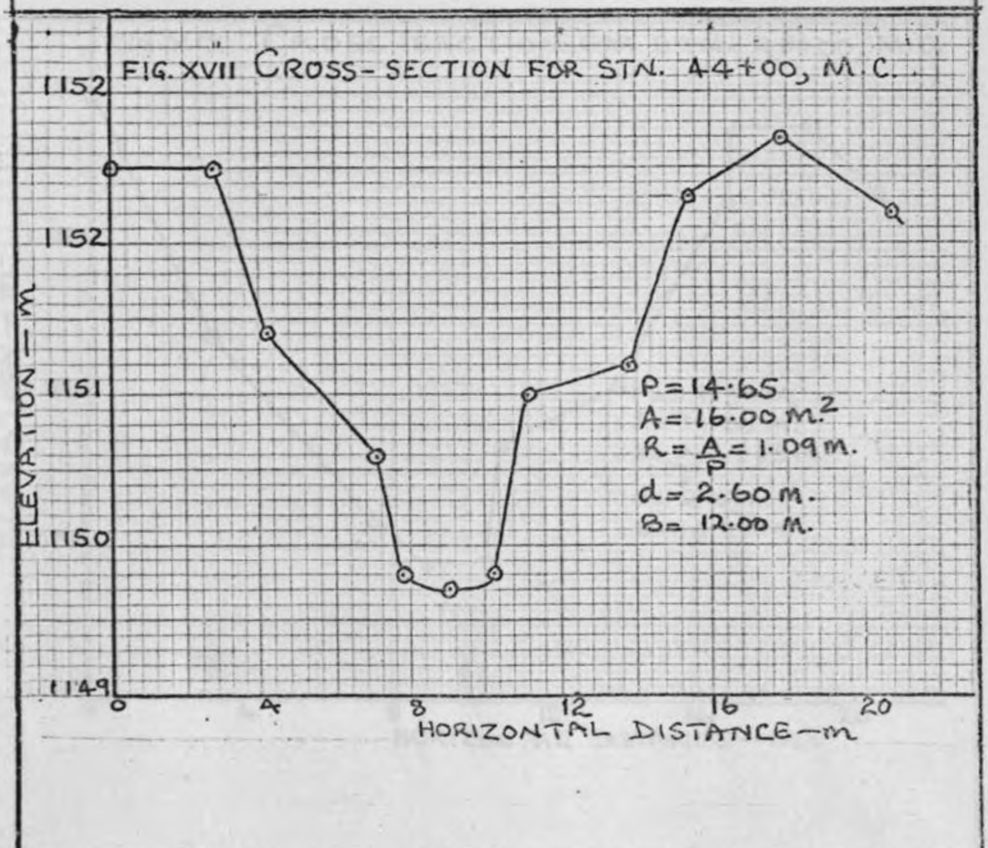
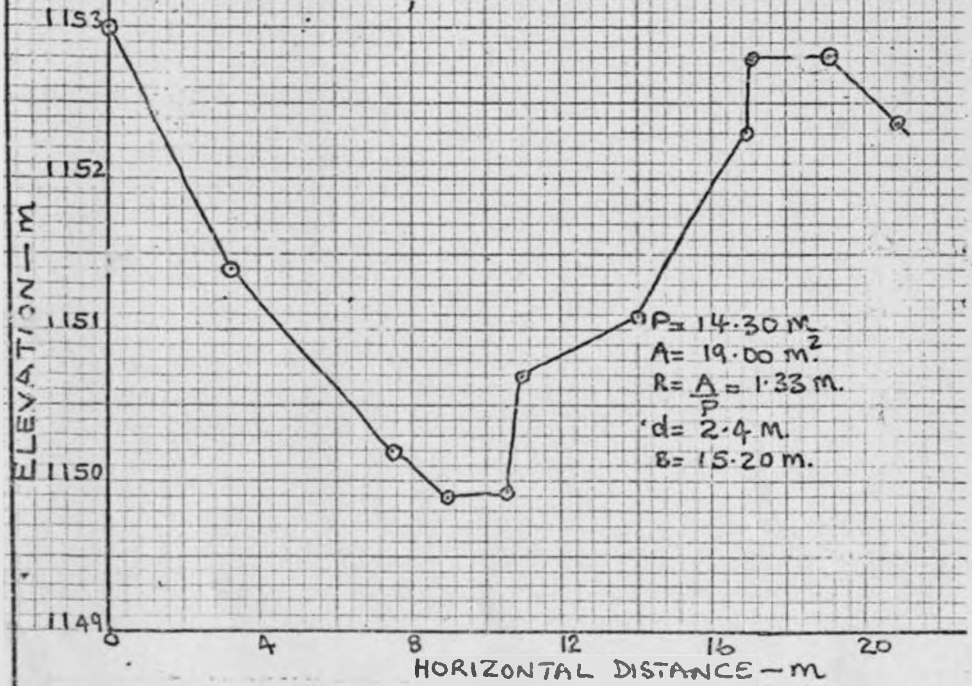


FIG. XVII CROSS-SECTION FOR STN. 44+00, M.C.
1152
1152
1151
1150
1149
ELEVATION — m
0
4
8
12
16
20
HORIZONTAL DISTANCE — m
P=14.65
A=16.00 M.²
R= A/P = 1.09 m.
d= 2.60 m.
B= 12.00 M.

FIG. XIX CROSS-SECTION FOR STN. 48+00, M.C.



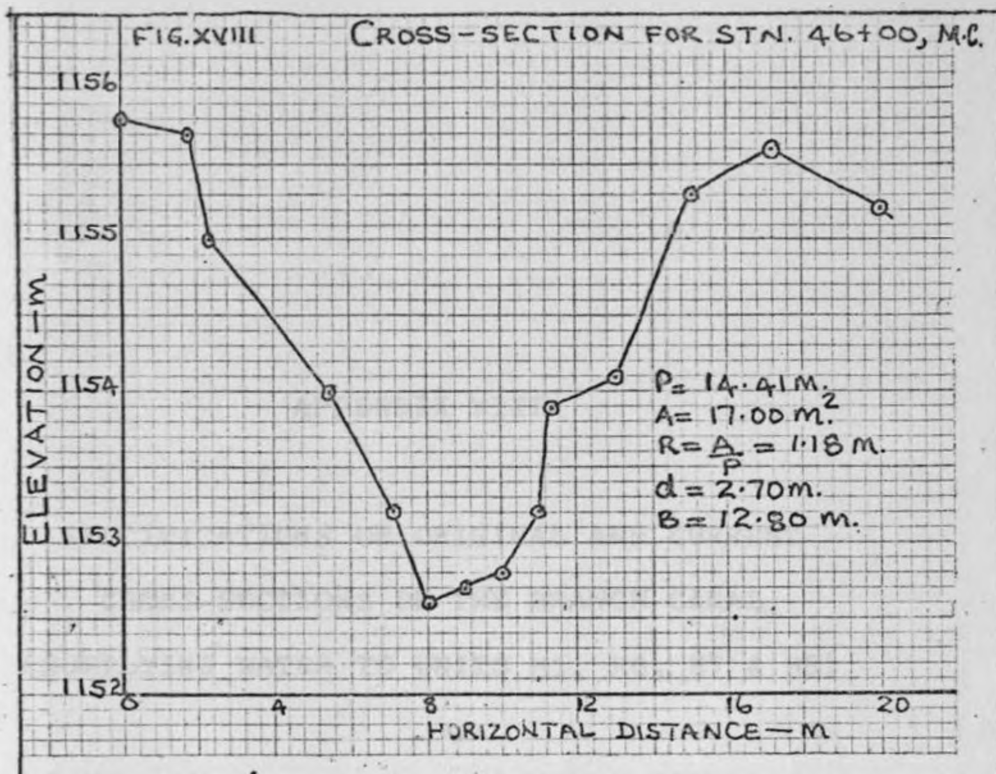
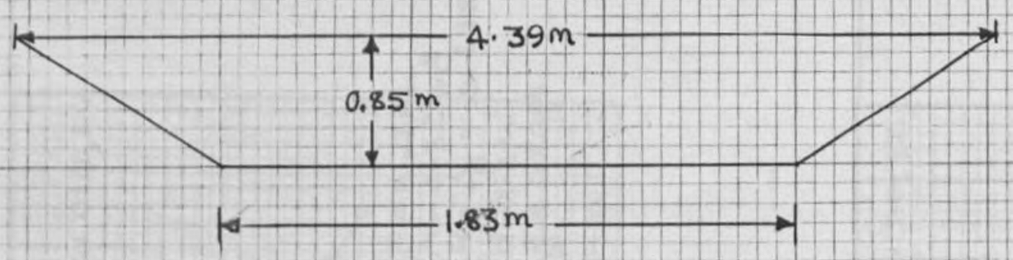


FIG. XVIII
CROSS-SECTION FOR STN. 46+00, M.C.
ELEVATION — M
1156
1155
1154
1153
1152
0
4
8
12
16
20
HORIZONTAL DISTANCE — M
P = 14.41 M.
A = 17.00 m.²
R = A/P = 1.18 m.
d = 2.70 m.
B = 12.80 m.

APPENDIX VIII

SPECIFICATIONS OF ORIGINAL AND CURRENT CROSS-SECTIONS OF THE BRANCH CANAL (SUPPLYING WATER TO UNITS H1, H6, H7 & H8)

FIG. I ORIGINAL CROSS-SECTION FOR BRANCH CANAL



DESIGN SPECIFICATIONS

Design capacity :	1·415 m^3/Sec.
Gradient, S :	1/2500 = 0·0004
Bed Width, b:	1·829 m.
Side Slopes, Z	$1\frac{1}{2}$ to 1
Roughness Coefficient, n:	0·025
Water Depth, d :	0·853 m.
Consequent Velocity, V:	0·534 m./Sec

FORMULA: $V = \frac{1}{n} R^{2/3} S^{1/2}$

Cross-sectional area, A = 2·65 m^2

Wetted Perimeter, P = 4·91 m.

Hydraulic Radius, $R = \frac{A}{P}$ = 0·54 m.

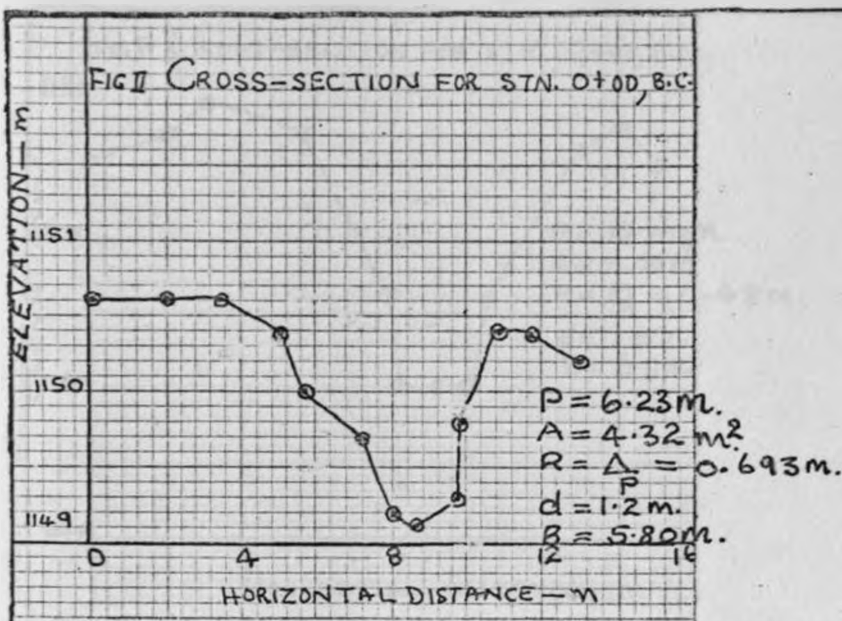


FIG II CROSS-SECTION FOR STN. 0+00, B.C.
ELEVATION — m
1151
1150
1149
0
4
8
12
16
HORIZONTAL DISTANCE — m
P = 6·23m.
A = 4·32 m².
R = A/P = 0·693m.
d = 1·2m.
B = 5·80m.

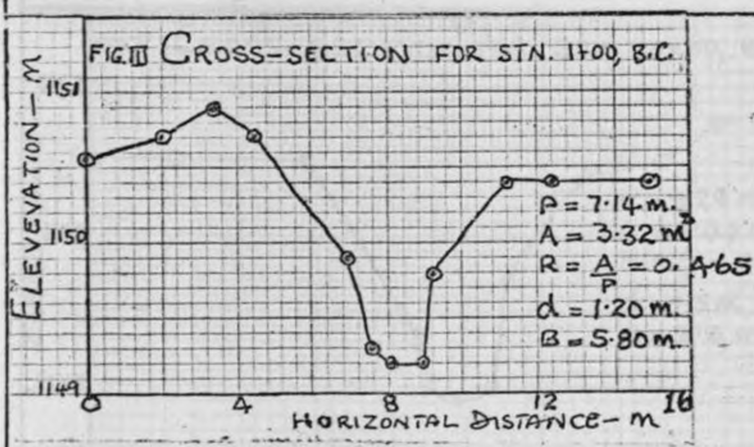


FIG. III CROSS-SECTION FOR STN. 1+00, B.C.
ELEVEVATION — M
1151
1150
1149
0
4
8
12
16
HORIZONTAL DISTANCE — M
P = 7·14m.
A = 3·32 m²
R = A/P = 0.465
d = 1·20m.
B = 5·80m.

FIG. IV CROSS-SECTION FOR STN. 2+00, B.C.

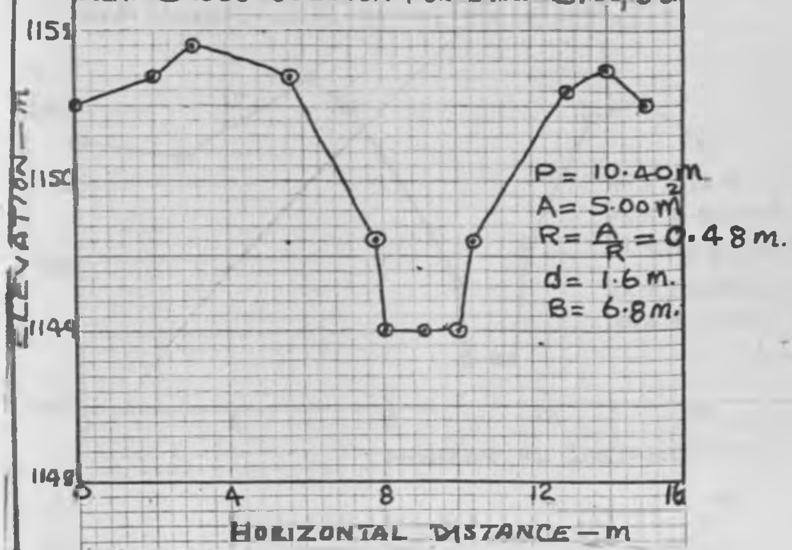
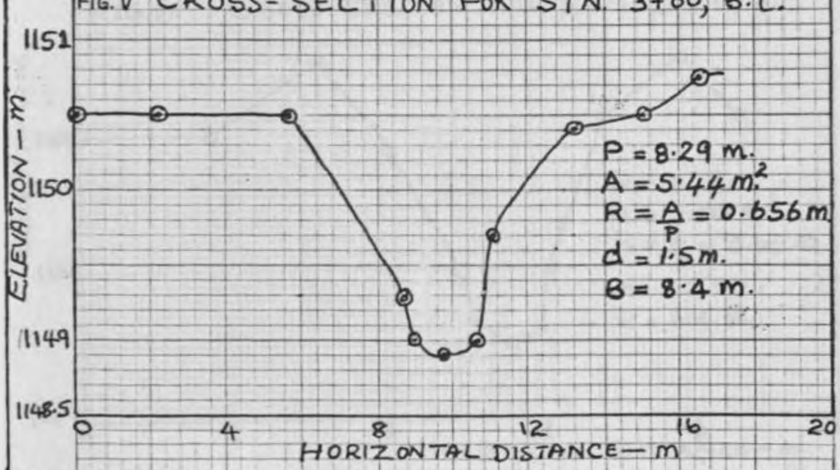


FIG. V CROSS-SECTION FOR STN. 3+00, B.C.



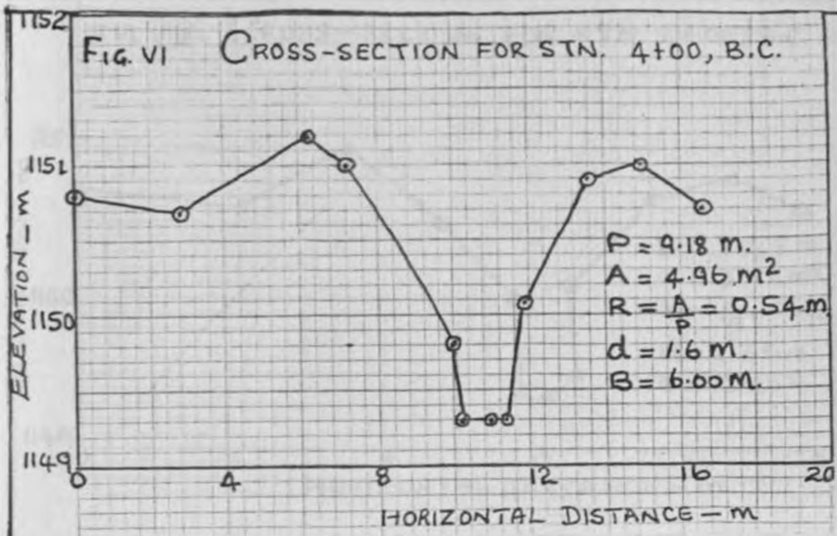


FIG. VI CROSS-SECTION FOR STN. 4+00, B.C.
1152
1151
1150
1149
ELEVATION – m
0
4
8
12
16
20
HORIZONTAL DISTANCE – m
P = 9.18 m.
A = 4.96 m²
R = A/P = 0.54 m
d = 1.6 m.
B = 6.00 m.

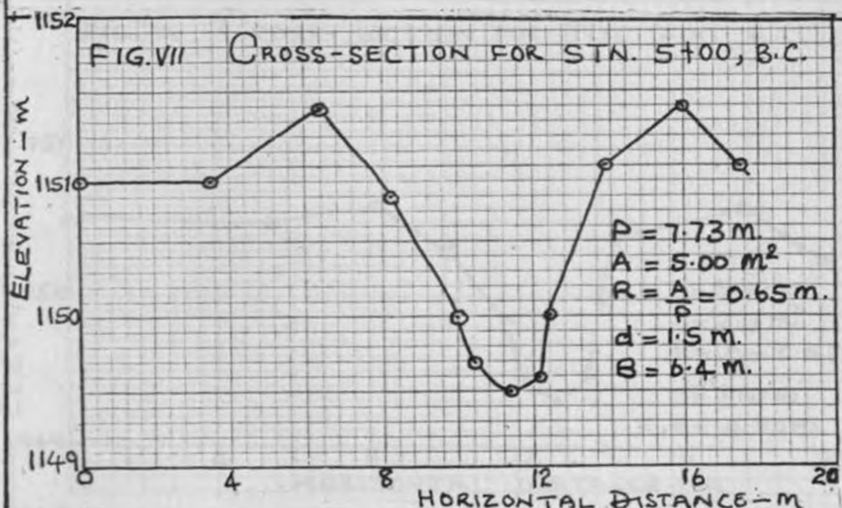


FIG. VII CROSS-SECTION FOR STN. 5+00, B.C.
1152
1151
1150
1149
ELEVATION – m
0
4
8
12
16
20
HORIZONTAL DISTANCE – m
P = 7.73 m.
A = 5.00 m²
R = A/P = 0.65 m.
d = 1.5 m.
B = 6.4 m.

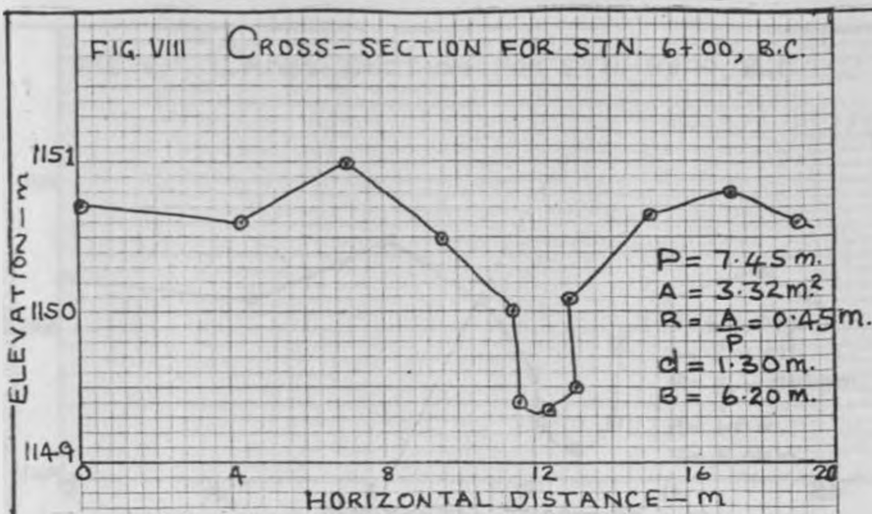


FIG. VIII CROSS-SECTION FOR STN. 6+00, B.C.
ELEVATION—m
1151
1150
1149
HORIZONTAL DISTANCE—m
0
4
8
12
16
20
P= 7·45 m.
A = 3·32 m²
R = A/P = 0·45 m.
d = 1·30 m.
B = 6·20 m.

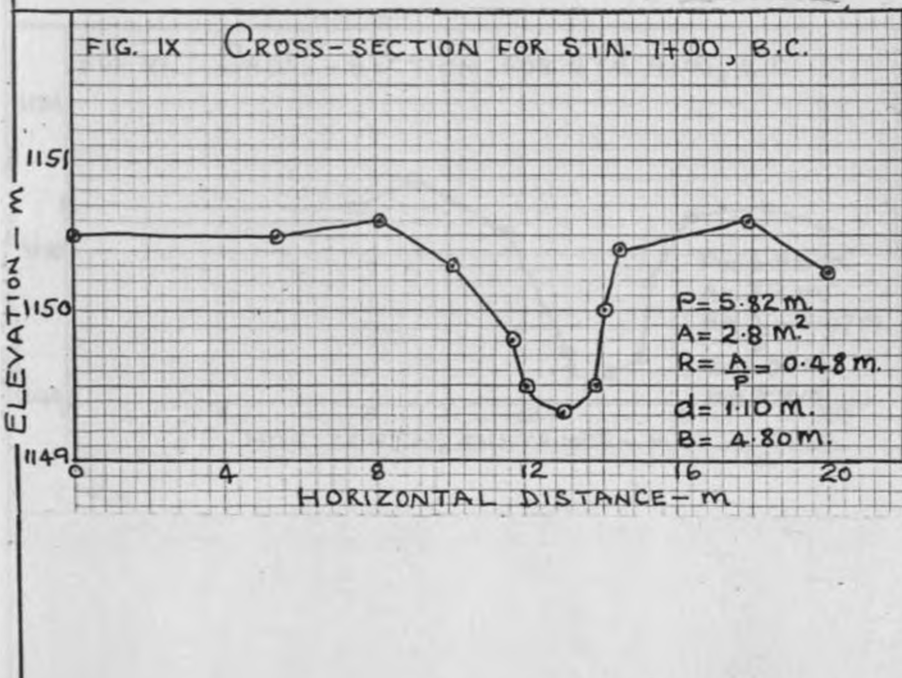


FIG. IX CROSS-SECTION FOR STN. 7+00, B.C.
ELEVATION—m
1151
1150
1149
HORIZONTAL DISTANCE—m
0
4
8
12
16
20
P= 5·82 m.
A= 2·8 m²
R= A/P = 0·48 m.
d= 1·10 m.
B= 4·80 m.

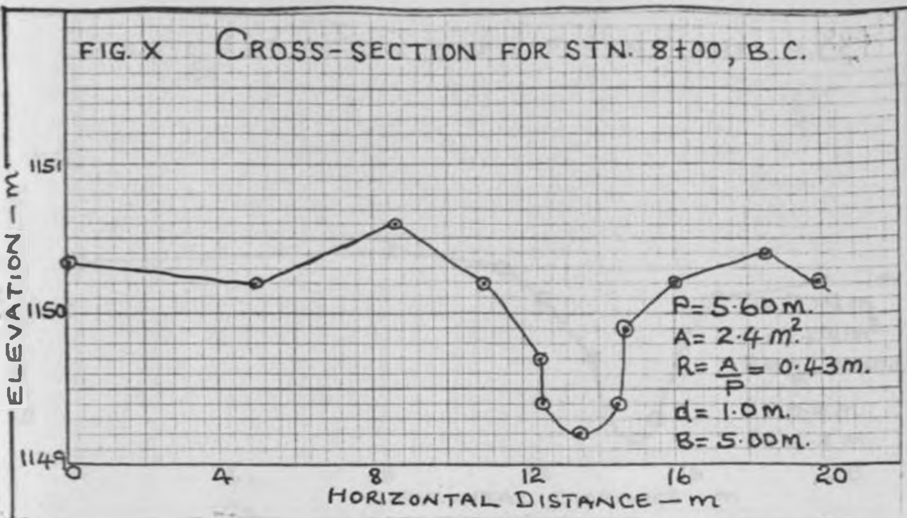


FIG. X CROSS-SECTION FOR STN. 8+00, B.C.
ELEVATION — m
1151
1150
1149
0
4
8
12
16
20
HORIZONTAL DISTANCE — m
P= 5.60 m.
A= 2.4 m².
R= A/P = 0.43 m.
d= 1.0 m.
B= 5.00 m.

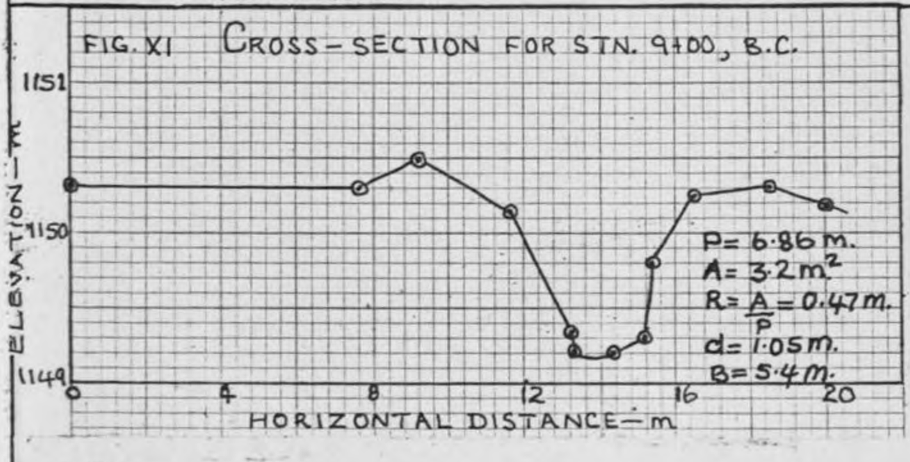
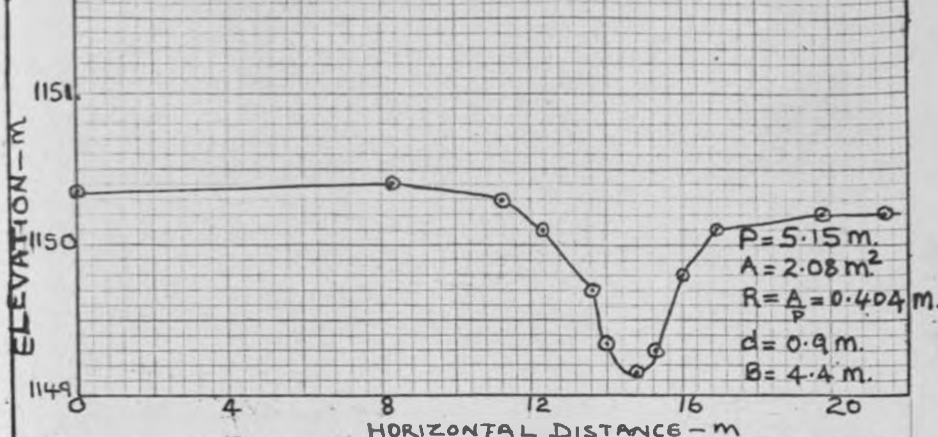


FIG. XI CROSS-SECTION FOR STN. 9+00, B.C.
ELEVATION — m
1151
1150
1149
0
4
8
12
16
20
HORIZONTAL DISTANCE — m
P= 6.86 m.
A= 3.2 m².
R= A/P = 0.47 m.
d= 1.05 m.
B= 5.4 m.

FIG. XII CROSS-SECTION FOR STN. 10+00, B.C.



APPENDIX IX

PONDED WATER IN EXPERIMENTAL PLOTS

APPENDIX IX

Table 1. Ponded water (in cm.) for H1 plot

DATE	Month (for 1979)						REMARKS
	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	
1			5.0	1.0	10.5	15.0	
2			6.0	1.0	10.0	13.0	
3			10.0	0.5	22.0	10.5	
4			8.0	0.5	21.5	10.0	
5			7.0	0.25	24.0	9.0	
6		5.0+	8.0	0.25	23.0	7.0	+gauges installed
7		5.0	10.0	9.0	22.0	6.5	
8		5.0	9.5	8.0	20.0	6.0	
9		0.0	9.0	8.0	17.0	5.0	
10		0.0	11.5	7.5	23.0	4.5	
11		0.0	10.5	7.0	24.0	4.0	
12		0.0	9.5	6.0	23.0	2.5	
13		0.0	8.0	6.0	22.5	0.0+	+field drain
14		0.0	7.5	5.0	22.0	0.0	
15		0.0	7.0	4.5	21.0	0.0	
16		0.0	5.5	9.5	20.0	0.0	
17		0.0	2.0	9.0	18.0	0.0	
18		0.0	0.0	9.0	16.0	0.0	
19		1.0	4.0	8.5	14.0	0.0	
20		2.0	7.0	8.0	13.0	0.0	
21		2.5	5.0	7.5	12.0	0.0	
22		3.0	3.0	7.0	11.0	0.0	
23		4.0	2.0	7.0	10.0	0.0	
24		4.0	6.0	6.5	9.5	0.0	
25		3.0	5.0	18.0	8.5	0.0	
26		4.0	4.0	17.5	10.0	0.0	
27		3.5	3.0	17.0	22.5	0.0	
28		4.0	6.0	15.5	20.0	0.0	
29		4.5	5.0	14.5	19.5	0.0	
30		3.5	3.0	12.0	19.0	0.0	
31		3.0		11.5		0.0	

APPENDIX IX

Table 2. Ponded water (in cm) for H2 plot

DATE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	REMARKS
	Month (for 1979						
1			4.0	5.0	4.5	5.0	
2			3.5	8.5	4.0	4.5	
3			3.0	8.0	8.0	4.0	
4			6.0	7.0	9.0	3.5	
5			5.5	6.5	10.0	3.0	
6		5.0+	9.5	6.0	9.0	5.0	+gauges installed
7		5.0	8.0	5.5	9.0	7.0	
8		0.0	7.5	5.0	9.0	6.5	
9		0.0	5.0	4.5	9.5	6.0	
10		0.0	4.5	4.0	9.5	5.0	
11		0.0	4.0	3.5	9.0	4.5	
12		0.0	3.5	2.0	8.5	4.0	
13		0.0	3.0	1.0	8.0	3.5	
14		0.0	2.5	3.0	8.0	2.0	
15		0.0	4.0	11.0	8.0	9.0+	+water drain from fields
16		0.0	5.0	10.5	7.5	0.0	
17		0.0	6.0	9.0	6.5	0.0	
18		0.0	6.5	8.0	6.0	0.0	
19		0.0	7.0	7.5	5.5	0.0	
20		0.0	6.0	6.5	5.0	0.0	
21		0.0	5.0	6.0	4.5	0.0	
22		0.0	4.0	5.0	4.0	0.0	
23		0.0	3.5	4.5	3.5	0.0	
24		0.0	2.5	4.5	3.0	0.0	
25		0.0	2.0	6.0	2.0	0.0	
26		0.0	1.0	7.0	2.0	0.0	
27		0.0	1.0	6.5	3.0	0.0	
28		5.5	1.0	6.0	4.0	0.0	
29		5.5	1.0	5.0	6.0	0.0	
30		5.0	1.0	4.5	5.5	0.0	
31		4.5		4.5		0.0	

APPENDIX IX

Table 3. Ponded water (in cm) for H3 plot

DATE	Month (for 1979)						REMARKS
	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	
1		1.0	4.5	0.5	9.5	7.5	
2		1.0	3.5	2.0	9.0	6.5	
3		1.0	2.0	9.5	13.5	5.5	
4		1.0	1.0	9.0	13.0	5.0	
5		1.0	1.0	8.5	14.0	4.5	
6		1.0	1.0	9.5	17.0	3.5	
7		1.0	1.0	8.5	17.0	1.5	
8		0.5	1.0	7.5	16.5	0.0	
9		0.5	1.0	7.0	16.0	0.0	
10		3.0	2.0	5.5	18.5	0.0	
11		3.0	3.0	5.0	19.0	0.0	
12		3.0	4.0	3.5	18.0	0.0	
13		3.0	6.0	2.5	19.5	0.0	
14		3.0	8.0	1.5	18.5	0.0	
15		4.0	8.0	0.5	17.0	0.0	
16		5.0	7.5	0.5	17.0	0.0	
17		4.5	7.0	1.0	16.5	0.0	
18		3.5	6.5	1.0	16.5	0.0	
19	1.0+	3.0	6.0	2.0	16.0	0.0	+gauges installed
20	1.0	3.0	5.5	3.0	15.5	0.0	
21	2.0	2.5	5.0	5.0	15.0	0.0	
22	3.5	2.0	3.5	4.0	14.5	0.0	
23	4.0	1.5	3.0	4.0	14.0	0.0	
24	4.0	4.5	7.0	4.0	13.5	0.0	
25	3.5	5.0	6.0	5.0	13.0	0.0	
26	1.0	8.0	5.5	7.0	13.0	0.0	
27	1.0	10.5	4.5	6.5	13.0+	0.0	+field draining started
28	1.0	9.0	4.0	11.5	11.5	0.0	
29	1.0	11.0	3.0	11.5	9.5	0.0	
30	1.0	9.0	1.5	10.0	8.5	0.0	
31	1.0	5.0		11.0		0.0	

APPENDIX IX

Table 4. Ponded water (in cm) for H20

DATE	Month (for 1979)						REMARKS
	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	
1		0.0	12.0	1.0	13.0	8.0	
2		0.0	10.0	0.5	12.5	9.0	
3		0.0	9.5	2.0	18.5	9.5	
4		0.0	9.0	4.0	18.5	9.5+	+field draining started
5		0.0	7.5	6.0	18.5	9.0	
6		0.0	7.0	12.5	20.5	8.0	
7		0.0	6.5	13.0	19.5	6.5	
8		0.0	6.0	15.0	18.5	5.5	
9		0.0	4.0	16.5	17.5	5.5	
10		0.0	3.5	16.0	21.5	4.5	
11		0.0	3.0	15.5	21.5	4.0	
12		0.0	3.0	14.0	21.5	2.5	
13		0.0	3.0	13.5	20.5	2.0	
14		1.0	2.5	12.5	18.0	1.0	
15		1.0	2.0	11.5	17.5	0.0	
16		2.0	1.0	11.0	17.0	0.0	
17		1.5	1.0	10.0	16.5	0.0	
18		2.0	0.5	9.5	16.0	0.0	
19		1.5	1.5	8.5	15.5	0.0	
20		4.0	3.0	8.0	14.5	0.0	
21		3.0	5.5	8.5	14.5	0.0	
22		5.0	4.5	8.0	13.5	0.0	
23		4.0	3.5	16.0	12.5	0.0	
24		3.5	3.0	16.5	12.0	0.0	
25		7.0	2.5	16.5	11.0	0.0	
26	1.0+	8.0	4.0	17.5	10.5	0.0	+gauges installed
27	1.0	9.5	5.0	17.0	9.5	0.0	
28	1.0	10.0	4.0	16.0	9.0	0.0	
29	1.0	9.0	3.0	15.5	7.5	0.0	
30	2.0	10.0	1.5	14.5	7.5	0.0	
31	2.0	11.0		14.5		0.0	

APPENDIX X

WATER RISE IN PIEZOMETERS AND WATER FLOW DIRECTION IN THE SOIL IN UNITS H1, H2, H3 AND H20

APPENDIX X

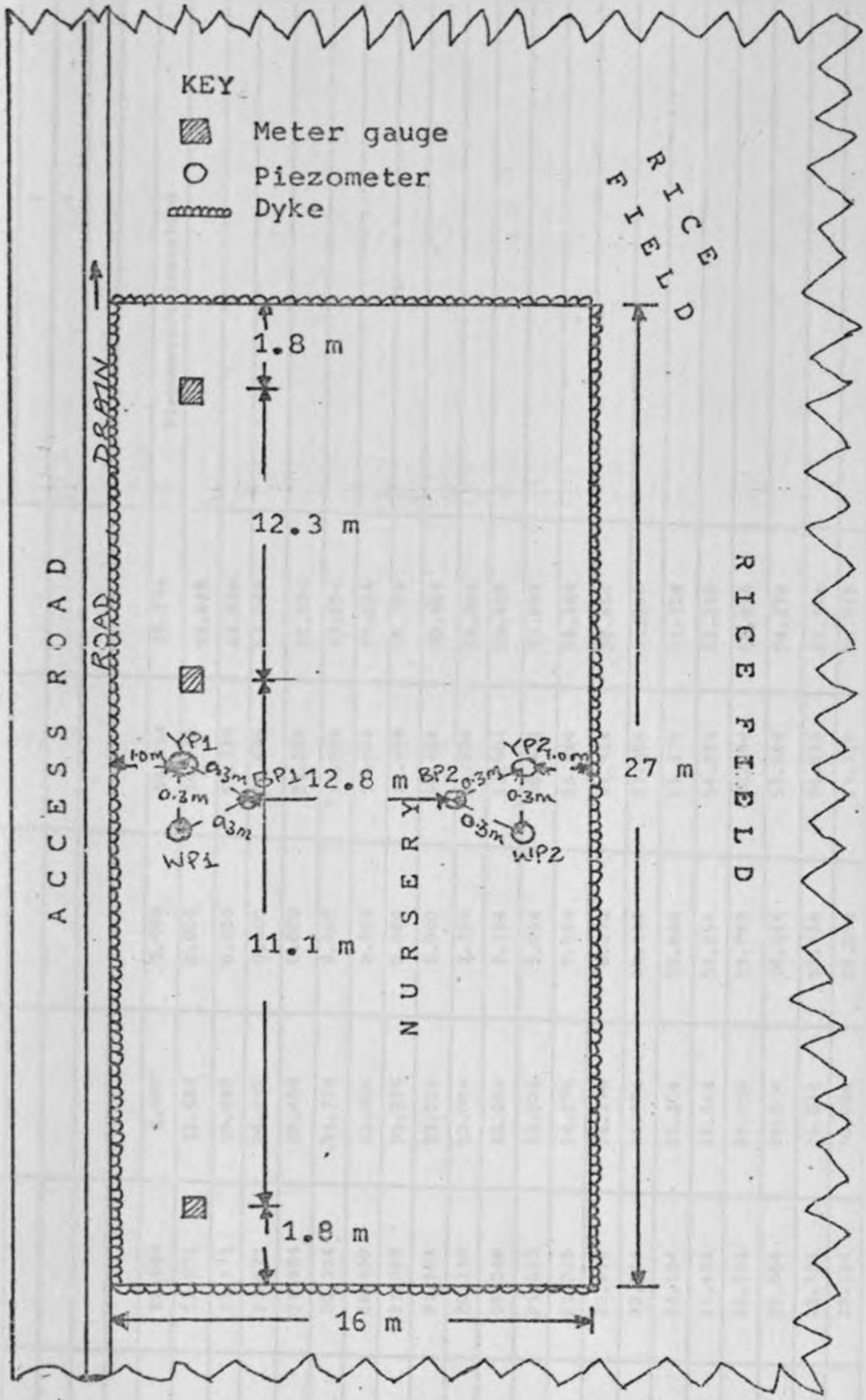


Fig. I: H1 Nursery Layout

APPENDIX X

TABLE I WATER RISE IN PIEZOMETERS. UNIT:N1 MONTH OF: AUGUST , 1979

DATE	BLUE PIEZOMETERS		WHITE PIEZOMETERS		YELLOW PIEZOMETERS		R E M A R K S
	BP1 cm	BP2 cm	WP1 cm	WP2 cm	YP1 cm	YP2 cm	
1							
2							
3							
4							
5							
6	11.424	26.664	0.000	0.000	55.554	55.544	Piezometers installed
7	4.439	23.971	12.684	0.000	54.909	53.639	
8	5.074	23.971	19.669	0.000	51.734	49.829	
9	5.709	23.971	26.019	0.000	53.639	52.369	
10	6.344	21.584	30.464	0.000	53.004	53.004	
11	6.919	20.314	31.734	0.000	53.004	53.004	
12	7.614	18.409	33.004	0.000	53.004	53.004	
13	8.249	21.025	31.734	0.000	50.464	49.194	
14	7.614	21.584	33.004	0.000	50.464	50.464	
15	7.614	20.314	33.004	2.524	51.734	53.004	
[redacted]	7.614	19.044	33.004	3.794	53.004	53.639	
[redacted]	[redacted].249	21.025	33.004	5.064	50.464	53.639	
[redacted]	7.614	21.025	34.274	7.604	55.544	55.544	
[redacted]	7.614	22.219	34.274	8.874	51.734	50.464	
[redacted]	[redacted].614	22.854	34.274	10.144	53.004	51.099	
[redacted]	7.614	24.124	34.274	12.684	53.639	51.734	
[redacted]	8.249	24.124	35.544	13.954	54.274	52.369	
[redacted]	8.884	25.394	36.914	15.859	58.084	56.814	
[redacted]	[redacted]249	26.664	35.5[illegible]4	16.494	55.544	54.274	
[redacted]	[redacted]884	25.394	36.814	19.034	56.814	55.544	
[redacted]	[redacted]49	25.394	38.084	20.304	53.719	55.719	
[redacted]	8.884	24.759	38.084	21.574	58.719	58.084	
[redacted]	8.249	24.759	38.084	21.574	56.179	54.274	
[redacted]	9.88[redacted]	25.394	38.084	24.114	59.354	58.084	
[redacted]	[redacted]	25.394	38.084	25.384	[redacted]354	58.719	

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APPENDIX X

TABLE II WATER FLOW DIRECTIONS IN SOIL, UNIT: H1 MONTH OF: AUGUST, 1979

DATE	VERTICAL FLOW						HORIZONTAL FLOW			REMARKS
	BP1 & WP1	BP1 & YP1	WP1 & YP1	BP2 & WP2	BP2 & YP2	WP2 & YP2	BP2 - BP1	WP2-WP1	YP2-YP1	
1										
2										
3										
4										
5										
6	DOWN	DOWN	UP	DOWN	DOWN	UP	2 to 1*	1 to 2	+	+ No Water Movement
7	"	"	"	"	"	"	"	"	1 to 2	
8	"	"	"	"	"	"	"	"	"	* 1 - Ist Piezometer near Drain
9	"	"	"	"	"	"	"	"	"	2 - 2nd Piezometer away from Drain
10	"	"	"	"	"	"	"	"	+	
11	"	"	"	"	"	"	"	"	"	
12	"	"	+	"	"	"	"	"	"	
13	"	"	DOWN	"	"	"	"	"	1 to 2	
14	"	"	"	"	"	"	"	"	+	
15	"	"	"	"	"	"	"	"	2 to 1	
16	"	"	+	"	"	"	"	"	"	
17	"	"	DOWN	"	"	"	"	"	"	
18	"	"	UP	"	"	"	"	"	+	
						-	"	"	1 to 2	

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APPENDIX X

TABLE III WATER RISE IN PIEZOMETERS. UNIT:H1 MONTH OF: SEPTEMBER, 1979

DATE	BLUE PIEZOMETERS		WHITE PIEZOMETERS		YELLOW PIEZOMETERS		R E M A R K S
	BP1 cm	BP2 cm	WP1 cm	WP2 cm	YP1 cm	YP2 cm	
1	8.884	25.394	38.719	26.654	58.084	56.814	
2	8.884	26.025	39.354	27.924	59.354	58.084	
3	8.864	30.374	39.354	28.559	58.084	55.544	
4	8.884	29.204	39.354	30.464	58.084	56.814	
5	8.884	28.569	40.624	30.464	58.719	55.544	
6	10.154	33.014	43.164	31.374	60.624	60.624	
7	10.154	30.474	40.624	31.374	61.894	60.624	
9	10.154	29.204	43.164	33.004	59.354	55.544	
	10.154	33.014	41.894	33.004	63.164	59.354	
[redacted]	[redacted].154	33.014	41.894	33.639	60.624	58.084	
[redacted]	[redacted].154	32.379	41.894	[redacted]	59.354	54.909	
[redacted]	[redacted].154	31.744	41.894	[redacted]	58.084	54.274	
[redacted]	[redacted].154	29.204	43.[redacted]	[redacted]	59.354	58.084	
[redacted]	10.154	29.204	39.354	[redacted]	56.814	53.004	
[redacted]	[redacted].154	27.934	39.989	[redacted]	57.449	54.274	
[redacted]	10.154	25.394	43.164	[redacted]	61.894	60.624	
[redacted]	[redacted].154	24.759	43.[redacted]	[redacted]	61.894	59.989	
[redacted]	[redacted].154	23.489	43.164	[redacted]	57.449	59.354	
[redacted]	[redacted].154	24.124	43.164	[redacted]	60.624	58.084	
[redacted]	[redacted].154	26.664	39.3[redacted]	[redacted]	58.084	55.544	
[redacted]	10.[redacted]	26.664	43.16[redacted]	[redacted]	[redacted]	[redacted].624	
[redacted]	[redacted]	26.029	43.[redacted]	[redacted]	[redacted]	[redacted].894	
[redacted]	10.1[redacted]	[redacted].124	43.164	[redacted]	[redacted]	[redacted].084	
[redacted]	[redacted]	[redacted].934	41.[redacted]	[redacted]	[redacted]	[redacted].164	

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APPENDIX X

TABLE IV WATER FLOW DIRECTIONS IN SOIL. UNIT: [illegible] MONTH OF: SEPTEMBER, 1979

DATE	VERTICAL FLOW						HORIZONTAL FLOW			REMARKS
	BP1 & WP1	BP1 & YP1	WP1 & YP1	BP2 & WP2	BP2 & YP2	WP2 & YP2	BP2 -BP1	WP2-WP1	YP2-YP1	
1	DOWN	DOWN	DOWN	DOWN	DOWN	UP	1 to 2	2 to 1	1 to 2	
2	"	"	+	"	"	"	"	"	"	+ No Water Movement
3	"	"	DOWN	"	"	"	"	"	"	
4	"	"	"	"	"	"	"	"	"	
5	"	"	"	"	"	"	"	"	"	
6	"	"	"	"	"	"	"	"	+	
7	"	"	"	"	"	"	"	"	1 to 2	
8	"	"	"	"	"	"	"	"	"	
9	"	"	"	"	"	"	"	"	"	
10	"	"	"	"	"	"	"	"	"	
11	"	"	"	"	"	"	"	"	"	
12	"	"	"	"	"	DOWN	"	"	"	
13	"	"	"	"	"	UP	"	"	"	
14	"	"	"	"	"	DOWN	"	"	"	
15	"	"	"	"	"	"	"	"	"	
16	"	"	"	"	"	UP	"	"	"	
17	"	"	"	"	"	"	"	"	"	
18	"	"	"	"	"	"	"	"	"	
19	"	"	"	"	"	+	"	"	"	
20	"	"	"	"	"	DOWN	"	"	"	
21	"	"	+	"	"	UP	"	"	"	
22	"	"	DOWN	"	"	"	"	"	+	
23	"	"	"	"	"	"	"	"	1 to 2	
24	"	"	"	"	"	UP	"	"	"	
25	"	"	"	"	"	DOWN	"	"	"	
26	"	"	"	"	"	+	"	"	"	
27	"	"	"	"	"	UP	"	"	"	
28	"	"	+	"	"	"	"	"	1 to 2	
29	"	"	DOWN	"	"	DOWN	"	"	"	
	[illegible]	[illegible]	-	"	"	"	+	"	+	

APPENDIX X

TABLE V WATER RISE IN PIEZOMETERS. UNIT:M1 MONTH OF: OCTOBER, 1979

DATE	BLUE PIEZOMETERS		WHITE PIEZOMETERS		YELLOW PIEZOMETERS		REMARKS
	BP1 cm	DP2 cm	WP1 cm	WP2 cm	YP1 cm	YP2 cm	
1	10.154	23.439	40.624	40.624	61.894	61.894	
2	10.154	21.584	40.624	40.624	54.084	56.814	
3	10.154	22.854	40.624	40.624	60.624	60.624	
4	10.154	16.504	40.624	40.624	60.624	60.624	
5	10.154	12.694	39.354	40.624	60.624	59.354	
6	10.154	13.694	39.354	39.989	55.544	56.814	
7	10.154	29.204	40.624	40.624	64.434	63.164	
8	10.154	29.204	40.624	41.894	64.434	63.164	
9	10.154	28.569	41.894	40.624	64.434	63.154	
10	10.154	28.569	43.164	40.624	64.434	63.164	
11	10.154	29.204	43.164	40.624	61.894	60.624	
12	10.154	27.934	43.164	41.894	64.434	63.799	
13	10.154	24.124	43.164	41.894	64.434	64.434	
14	10.154	24.124	43.164	41.894	64.434	65.704	
15	10.154	26.029	43.164	41,894	64.434	63.164	
16	10.154	30.474	43.164	42.529	64.434	63.164	
17	10.154	30.474	43.164	43.164	65.704	65.704	
18	10.154	31.109	44.434	43.164	64.434	63.154	
19	10.154	30.474	45.069	44.434	65.704	65.704	
20	10.154	29.204	45.704	44.434	66.974	66.974	
21	10.154	27.934	45.704	44.434	66.974	66.974	
22	10.154	27.299	45.704	44.434	63.974	66.974	
23	10.154	27.934	45.704	45.069	68.244	68.244	
24	10.154	24.124	45.704	45.069	64.434	62.529	
25	10.154	31.744	46.974	45.704	65.704	65.704	
26	10.154	34.284	48.244	45.704	68.244	66.974	
27	10.154	36.824	49.514	45.704	69.514	66.974	
28	10.154	36.189	50.784	46.974	70.784	69.514	
29	10.154	35.554	50.784	47.609	69.514	68.244	
30	10.154	33.649	50.784	48.244	70.784	72.054	
[redacted]	[redacted]	[redacted]	51.[redacted]	48.244	[redacted]	[redacted]9.514	

APPENDIX X

TABLE VI WATER FLOW DIRECTIONS IN SOIL. UNIT: H1 MONTH OF: OCTOBER, 1979

DATE	VERTICAL FLOW						HORIZONTAL FLOW			REMARKS
	BP1 & WP1	BP1 & YP1	WP1 & YP1	BP2 & WP2	BP2 & YP2	WP2 & YP2	BP2 - BP1	WP2-WP1	YP2-YP1	
1	DOWN	DOWN	UP	DOWN	DOWN	UP	2 to 1	+	+	+ No Water Movement
2	"	"	DOWN	"	"	DOWN	"	"	1 to 2	
3	"	"	+	"	"	+	"	"	+	
4	"	"	"	"	"	"	"	"	"	
5	"	"	UP	"	"	DOWN	"	2 to 1	1 to 2	
6	"	"	DOWN	"	"	"	"	"	2 to 1	
7	"	"	UP	"	"	UP	"	+	1 to 2	
8	"	"	"	"	"	"	"	2 to 1	"	
9	"	"	"	"	"	"	"	1 to 2	"	
10	"	"	"	"	"	"	"	"	"	
11	"	"	DOWN	"	"	+	+	+	"	
12	"	"	UP	"	"	UP	"	"	"	
13	"	"	"	"	"	"	"	"	+	
14	"	"	"	"	"	"	"	"	2 to 1	
15	"	"	"	"	"	"	"	"	1 to 2	
16	"	"	"	"	"	"	"	"	"	
17	"	"	"	"	"	"	"	+	+	
18	"	"	+	"	"	+	"	1 to 2	1 to 2	
19	"	"	"	"	"	UP	"	"	+	
20	"	"	UP	"	"	"	"	"	"	
21	"	"	"	"	"	"	"	"	"	
22	"	"	"	"	"	"	"	+	"	
[illegible]	"	"	"	"	"	"	"	+	"	

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TABLE VII WATER RISE IN PIEZOMETERS. UNIT:H 1 MONTH OF: NOVEMBER, 1979

DATE	BLUE PIEZOMETERS		WHITE PIEZOMETERS		YELLOW PIEZOMETERS		R E M A R K S
	BP1 cm	BP2 cm	WP1 cm	WP2 cm	YP1 cm	YP2 cm	
1	10.154	30.474	50.784	48.244	70.789	70.789	
2	10.154	30.474	53.324	50.784	75.864	73.324	
3	38.094	41.110	54.594	53.324	79.674	75.864	
4	36.824	39.840	55.864	53.324	77.134	75.864	
5	38.094	43.650	58.324	53.324	80.944	79.674	
6	37.30	40.380	60.944	55.864	83.484	83.484	
7	37.30	40.380	60.944	55.864	80.944	80.309	
8	42.38	46.190	62.214	57.134	82.214	83.484	
9	36.824	38.094	62.214	57.134	82.214	83.484	
10	36.824	43.650	63.484	58.404	87.294	86.024	
11	36.824	43.650	66.024	59.674	89.834	88.564	
12	37.300	43.650	67.294	60.944	88.564	88.564	
13	37.300	42.380	67.929	62.214	88.564	89.834	
14	37.300	41.110	68.564	63.484	88.564	91.104	
15	37.300	42.380	68.564	63.484	86.024	88.564	
16	37.300	42.380	68.564	63.484	87.294	90.469	
17	37.300	37.300	68.564	64.754	86.024	91.104	
18	36.824	36.824	68.564	66.024	87.294	93.644	
19	35.554	35.554	68.564	66.024	83.564	94.914	
20	34.284	34.284	67.294	66.659	83.564	94.914	
21	34.284	34.[redacted]	[redacted].564	67.294	86.024	93.644	
22	33.014	33.0[redacted]	[redacted]29	68.564	87.294	96.184	
[redacted]	31.744	31.74[redacted]	[redacted].294	69.834	88.564	97.[illegible]54	
[redacted]	31.109	31.[redacted]	[redacted].294	69.834	86.024	92.374	
[redacted]	[redacted].839	29.[redacted]	[redacted].294	69.[redacted]	[redacted]6.024	92.374	
[redacted]	[redacted].474	37.[redacted]	71.104	70.[redacted]	[redacted].104	101.264	
[redacted]	31.744	[redacted]	[redacted]	71.[redacted]	[redacted].184	105.074	
[redacted]	33.[redacted]	[redacted]	73.[redacted]	72.[redacted]	96.184	106.344	

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TABLE VII WATER FLOW DIRECTIONS IN SOIL, UNIT: H1 MONTH OF: NOVEMBER, 1979

DATE	VERTICAL FLOW						HORIZONTAL FLOW			REMARKS
	BP1 & WP1	BP1 & YP1	WP1 & YP1	BP2 & WP2	BP2 & YP2	WP2 & YP2	BP2 - BP1	WP2-WP1	YP2-YP1	
1	DOWN	DOWN	+	DOWN	DOWN	UP	2 to 1	1 to 2	+	+ No Water Movement
2	"	"	UP	"	"	"	"	"	1 to 2	
3	"	"	"	"	"	"	"	"	"	
4	"	"	"	"	"	"	"	"	"	
5	"	"	"	"	"	"	"	"	"	
6	"	"	"	"	"	"	"	"	+	
7	"	"	+	"	"	"	"	"	1 to 2	
8	"	"	"	"	"	"	"	"	2 to 1	
9	"	"	[redacted]	"	"	"	"	"	"	
10	"	"	[redacted]	"	"	"	"	"	1 to 2	
11	"	"	[redacted]	"	"	"	"	"	"	
12	"	"	[redacted]	"	"	"	"	"	+	
13	"	"	[redacted]	"	"	"	"	"	2 to 1	
14	"	"	[redacted]	"	"	"	"	"	"	
15	"	"	[redacted]	"	"	"	"	"	"	
16	"	"	[redacted]	"	"	"	"	"	"	
[redacted]	[redacted]	[redacted]	[redacted]	"	"	"	+	"	"	
[redacted]	[redacted]	[redacted]	[redacted]	"	"	"	"	"	"	
[redacted]	[redacted]	[redacted]	[redacted]	"	"	"	"	"	"	
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	"	"	"	"	"	
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	"	"	"	"	"	
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	"	"	"	2 to 1	"	
23	[redacted]	[redacted]	[redacted]	[redacted]	"	"	"	"	"	
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	"	"	"	"	"	

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TABLE IX WATER RISE IN PIEZOMETERS, UNIT:M1 MONTH OF: DECEMBER, 1979

DATE	BLUE PIEZOMETERS		WHITE PIEZOMETERS		YELLOW PIEZOMETERS		R E M A R K S
	BP1 cm	BP2 cm	WP1 cm	WP2 cm	YP1 cm	YP2 cm	
1	33.014	35.554	73.644	73.644	91.914	106.344	
2	32.374	34.284	73.009	74.914	93.644	105.074	
3	31.744	31.744	72.374	76.184	93.644	103.804	
4	31.109	31.744	72.374	78.089	93.644	102.534	
[illegible]	[illegible]	31.109	73.009	77.454	91.104	101.264	
[illegible]	29.839	29.839	73.009	78.089	92.374	102.534	
[illegible]	29.204	27.934	73.374	78.724	93.644	103.804	
[illegible]	[illegible]	27.934	72.374	78.724	93.644	106.344	
[illegible]	[illegible]	27.299	72.374	78.724	91.102	101.264	
[illegible]	[illegible]	27.299	73.644	78.724	90.469	101.264	
[illegible]	[illegible]	[illegible]	71.104	78.724	91.104	101.264	
[illegible]	[illegible]	[illegible]	71.104	79.994	90.469	101.264	
[illegible]	[illegible]	[illegible]	71.104	79.994	88.564	98.724	
[illegible]	[illegible]	[illegible]	67.294	78.724	68.244	93.644	
[illegible]	[illegible]	[illegible]	63.484	78.089	68.244	88.564	
[illegible]	[illegible]	[illegible]	59.674	77.454	68.244	83.484	
[illegible]	[illegible]	[illegible]	55.864	76.184	68.244	75.864	
[illegible]	[illegible]	[illegible]	53.324	[illegible]	[illegible]	80.944	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	78.404	86.024	

APPENDIX X

TABLE X   WATER FLOW DIRECTIONS IN SOIL.   UNIT: H1   MONTH OF: DECEMBER, 1979

DATE	VERTICAL FLOW						HORIZONTAL FLOW			REMARKS
	BP1 & WP1	BP1 & YP1	WP1 & YP1	BP2 & WP2	BP2 & YP2	WP2 & YP2	BP2 -BP1	WP2-WP1	YP2-YP1	
1	DOWN	DOWN	UP	DOWN	DOWN	UP	2 to 1	+	2 to 1	+ No water Movement
2	"	"	"	"	"	"	"	2 to 1	"	
3	"	"	"	"	"	"	+	"	"	
4	"	"	"	"	"	"	2 to 1	"	"	
5	"	"	DOWN	"	"	"	1 to 2	"	"	
6	"	"	"	"	"	"	+	"	"	
7	"	"	UP	"	"	"	2 to 1	"	"	
8	"	"	"	"	"	"	1 to 2	"	"	
9	"	"	DOWN	"	"	"	"	"	"	
10	"	"	"	"	"	"	"	"	"	
11	"	"	+	"	"	"	"	"	"	
12	"	"	DOWN	"	"	"	"	"	"	
13	"	"	"	"	"	DOWN	"	"	"	
14	"	"	"	"	"	"	"	"	"	
15	"	"	"	"	"	"	"	"	"	
16	"	"	"	"	"	"	"	"	"	
17	"	"	"	"	"	"	"	"	"	
18	"	"	+	"	"	"	"	"	"	
19	"	"	UP	"	"	"	"	"	"	
20	"	"	"	"	"	"	2 to 1	"	"	
21	"	"	"	"	"	"	"	"	"	
22	"	"	"	"	"	"	"	"	"	
23	"	"	"	"	"	"	"	"	"	
24	"	"	DOWN	"	"	"	1 to 2	"	"	
25	"	"	"	"	"	"	"	"	"	
26	"	"	+	"	"	"	"	"	"	
27	"	"	DOWN	"	"	"	"	"	"	
28	"	"	"	"	"	"	"	"	"	
29	"	"	"	"	"	"	+	"	"	
						"	"	"	"	

APPENDIX X

TABLE XI WATER RISE IN PIEZOMETERS UNIT:H1 MONTH OF: JANUARY, 1980

DATE	BLUE PIEZOMETERS		WHITE PIEZOMETERS		YELLOW PIEZOMETERS		REMARKS
	BP1 cm	BP2 cm	WP1 cm	WP2 cm	YP1 cm	YP2 cm	
1	0.000	0.000	40.624	63.484	50.084	55.704	
2	"	"	36.814	60.944	53.004	61.894	
3	"	"	33.004	59.674	47.924	54.274	
4	"	"	29.194	58.404	46.654	53.004	
5	"	"	25.384	55.864	42.844	50.464	
6	"	"	25.384	54.594	37.764	44.114	
7	"	"	20.304	53.324	36.494	41.574	
8	"	"	16.494	49.514	33.954	40.304	
9	"	"	12.684	45.704	30.144	37.764	
10	"	"	10.144	43.164	27.604	32.684	
11	"	"	7.604	41.894	27.604	32.684	
12	"	"	5.06[illegible]	38.034	22.524	30.144	
13	"	"	2.524	38.084	19.984	25.064	
14	"	"	0.000	35.544	17.444	22.524	
15	"	"	0.000	33.004	12.364	17.444	
[redacted]	[redacted]	[redacted]	[redacted]	30.464	13.634	17.444	
[redacted]	[redacted]	[redacted]	[redacted]	27.924	11.094	17.444	
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	6.014	9.824	
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	4.744	8.554	
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	3.474	6.014	
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	2.204	6.014	
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	0.000	3.474	
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	"	2.204	
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	"	0.934	
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	"	0.000	
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	"	"	
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	"	"	
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	"	"	
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	"	"	
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	"	"	

APPENDIX X

TABLE XII WATER FLOW DIRECTIONS IN SOIL, UNIT: H1 MONTH OF: JANUARY, 1980

DATE	VERTICAL FLOW						HORIZONTAL FLOW			REMARKS
	BP1 & WP1	BP1 & YP1	WP1 & YP1	BP2 & WP2	BP2 & YP2	WP2 & YP2	BP2 - BP1	WP2-WP1	YP2-YP1	
1	DOWN	DOWN	DOWN	DOWN	DOWN	DOWN	o	2 to 1	2 to 1	+ No Water Movement
2	•	•	•	•	•	•	•	•	•	o No Water in Piezometers
3	•	•	•	•	•	•	•	•	•	
4	•	•	•	•	•	•	•	•	•	
5	•	•	•	•	•	•	•	•	•	
6	•	•	•	•	•	•	•	•	•	
7	•	•	•	•	•	•	•	•	•	
8	•	•	•	•	•	•	•	•	•	
9	•	•	•	•	•	•	•	•	•	
10	•	•	•	•	•	•	•	•	•	
11	•	•	+	•	•	•	•	•	•	
12	•	•	DOWN	•	•	•	•	•	•	
13	•	•	•	•	•	•	•	•	•	
14	o	•	•	•	•	•	•	•	•	
15	•	•	•	•	•	•	•	•	•	
16	•	•	•	•	•	•	•	•	•	
17	•	•	•	•	•	•	•	•	•	
18	•	•	•	•	•	•	•	•	•	

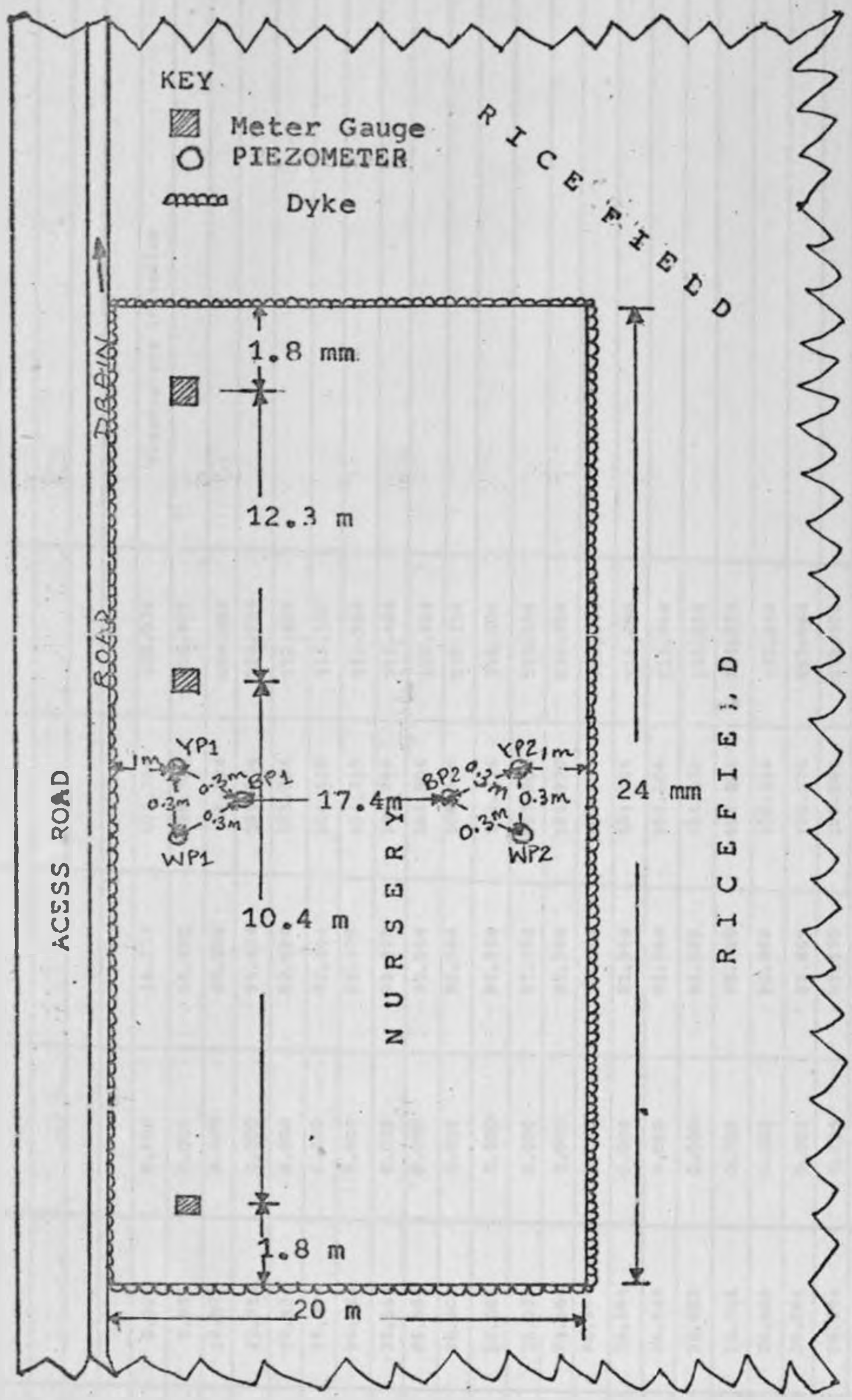

Fig II: H2 NURSERY LAYOUT

APPENDIX X

TABLE XII WATER RISE IN PIEZOMETERS. UNIT:H2 MONTH OF: AUGUST, 1979

DATE	BLUE PIEZOMETERS		WHITE PIEZOMETERS		YELLOW PIEZOMETERS		R E M A R K S
	BP1 cm	BP2 cm	WP1 cm	WP2 cm	YP1 cm	YP2 cm	
1							
2							
3							
4							
5							
6	0.000	0.000	0.000	34.274	101.264	105.074	Piezometers installed
7	0.000	3.804	0.000	66.659	98.724	106.979	
8	13.974	16.504	0.000	83.804	98.724	109.884	
9	21.584	22.854	0.000	91.424	103.804	113.964	
10	21.584	24.124	0.000	92.694	103.804	112.694	
11	20.314	25.394	0.000	92.694	104.439	113.329	
12	17.139	26.664	0.000	93.329	104.439	113.964	
13	13.329	26.664	0.000	93.329	101.264	111.424	
14	11.424	26.664	0.000	93.964	103.804	113.964	
15	10.789	26.664	0.000	93.964	106.344	115.234	
16	10.154	26.664	0.000	93.964	107.614	116.504	
17	7.614	26.029	0.000	93.964	103.804	113.964	
18	4.439	26.664	0.000	93.964	106.979	116.504	
19	5.074	26.664	0.000	93.964	102.534	112.059	
20	2.534	26.664	0.000	93.964	101.264	112.693	
21	5.074	26.644	0.000	93.964	103.804	113.964	
22	13.964	26.664	0.000	94.599	104.439	114.599	
23	20.314	26.664	0.000	95.869	105.074	114.599	
24	21.584	26.664	0.000	96.504	106.344	115.234	
25	22.854	26.664	0.000	95.869	105.074	113.964	
26	21.584	26.654	1.254	97.139	108.884	110.109	
27	19.044	26.664	1.254	[redacted]	106.344	115.869	
28	[redacted]	[redacted]	[redacted]	[redacted]	105.074	115.234	
29	[redacted]	[redacted]	2.524	[redacted]	105.074	114.599	
[redacted]	[redacted]	[redacted]	[illegible]	[redacted]	106.344	116.504	

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TABLE XIV WATER FLOW DIRECTIONS IN SOIL. UNIT: H2 MONTH OF: AUGUST, 1979

DATE	VERTICAL FLOW						HORIZONTAL FLOW			REMARKS
	BP1 & WP1	BP1 & YP1	WP1 & YP1	BP2 & WP2	BP2 & YP2	WP2 & YP2	BP2 -BP1	WP2-WP1	YP2-YP1	
1										
2										
3										
4										
5										
6 •	o	UP	UP	DOWN	UP	UP	◆◆	2 to 1	2 to 1	◆◆ No Water Flow
7	"	DOWN	"	"	"	"	2 to 1	"	"	o No Water in Piezometers
8	DOWN	"	"	"	DOWN	"	"	"	"	◆ No Water Movement
9	"	"	"	"	"	"	"	"	"	• Piezometers Installed
10	"	"	"	"	"	◆	"	"	"	
11	"	"	"	"	"	UP	"	"	"	
12	"	"	"	"	"	"	"	"	"	
13	"	"	"	"	"	"	"	"	"	
14	"	"	"	"	"	◆	"	"	"	
15	"	"	"	"	"	UP	"	"	"	
16	"	"	"	"	"	"	"	"	"	
17	"	"	"	"	"	◆	"	"	"	
18	"	"	"	"	"	UP	"	"	"	
19	"	"	"	"	"	DOWN	"	"	"	
20	"	"	"	"	"	"	"	"	"	
21	"	"	"	"	"	◆	"	"	"	
22	"	"	"	"	"	"	"	"	"	
23	"	"	"	"	"	DOWN	"	"	"	
24	"	"	"	"	"	"	"	"	"	
25	"	"	"	"	"	"	"	"	"	
26	"	"	"	"	"	UP	"	"	"	
27	"	"	"	"	"	DOWN	"	"	"	
28	"	"	"	"	"	"	"	"	"	
29	"	"	"	"	"	"	"	"	"	
					"	"	"	"	"	

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TABLE XV WATER RISE IN PIEZOMETERS, UNIT:M3 MONTH OF: SEPTEMBER, 1979

DATE	BLUE PIEZOMETERS		WHITE PIEZOMETERS		YELLOW PIEZOMETERS		R E M A R K S
	BP1 cm	BP2 cm	WP1 cm	WP2 cm	YP1 cm	YP2 cm	
1	24.759	26.664	3.794	98.409	108.249	117.139	
2	24.124	26.664	4.429	97.774	108.884	117.774	
3	24.759	26.664	5.046	96.504	105.074	113.964	
4	26.029	26.604	5.064	95.234	101.099	111.424	
5	25.394	26.664	5.064	93.964	101.264	110.154	
6	29.204	27.299	6.969	94.599	107.614	116.504	
7	29.839	26.654	6.969	95.234	106.344	115.234	
8	29.204	26.664	7.604	94.599	103.804	111.424	
9	26.664	26.664	8.874	92.694	105.074	112.694	
10	26.664	26.664	8.874	92.059	102.534	110.154	
11	26.664	26.664	8.874	92.059	102.534	110.154	
12	25.394	26.664	8.874	90.154	102.534	107.614	
13	24.124	26.664	10.144	90.154	101.264	108.884	
14	24.124	26.664	8.874	91.424	101.264	108.884	
15	25.394	26.664	10.144	90.789	99.994	107.614	
16	[illegible].474	26.664	11.414	91.424	102.534	110.154	
17	[illegible].014	26.664	12.684	91.424	105.074	112.694	
[illegible]	[illegible].014	26.664	12.684	91.424	99.994	108.884	
[illegible]	33.014	26.664	12.684	90.154	101.264	110.154	
[illegible]	[illegible].014	26.664	12.684	88.884	98.724	107.614	
[illegible]	[illegible].840	26.664	13.954	91.424	103.804	112.694	
[illegible]	[illegible].840	26.664	13.954	91.424	103.804	112.694	
[illegible]	39.840	26.664	15.224	91.424	99.994	108.884	
[illegible]	[illegible].840	26.664	15.224	91.424	103.804	112.694	
[illegible]	[illegible].040	26.664	15.224	91.424	99.994	108.884	
[illegible]	39.840	26.664	15.859	90.789	99.994	108.884	
[illegible]	38.570	26.664	16.494	90.154	99.994	108.884	
[illegible]	4.439*	26.664	16.4[illegible]	88.884	99.994	108.884	* Blockage Adjusted
[illegible]	4.439*	26.664	17.76[illegible]	[illegible]8.884	101.264	110.154	"
[illegible]	4.439*	26.664	17.764	[illegible].884	101.264	112.154	"

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TABLE XVI WATER FLOW DIRECTIONS IN SOIL. UNIT: H2 MONTH OF: SEPTEMBER, 1979

DATE	VERTICAL FLOW						HORIZONTAL FLOW			REMARKS
	BP1 & WP1	BP1 & YP1	WP1 & YP1	BP2 & WP2	BP2 & YP2	WP2 & YP2	BP2 - BP1	WP2-WP1	YP2-YP1	
1	DOWN	DOWN	UP	DOWN	DOWN	DOWN	2 to 1	2 to 1	2 to 1	+ No Water Movement
2	"	"	"	"	"	+	"	"	"	
3	"	"	"	"	"	DOWN	"	"	"	
4	"	"	"	"	"	"	"	"	"	
5	"	"	"	"	"	"	"	"	"	
6	"	"	"	"	"	UP	1 to 2	"	"	
7	"	"	"	"	"	+	"	"	"	
8	"	"	"	"	"	DOWN	"	"	"	
9	"	"	"	"	"	+	+	"	"	
10	"	"	"	"	"	DOWN	"	"	"	
11	"	"	"	"	"	"	"	"	"	
12	"	"	"	"	"	"	2 to 1	"	"	
13	"	"	"	"	"	"	"	"	"	
14	"	"	"	"	"	"	"	"	"	
15	"	"	"	"	"	"	"	"	"	
16	"	"	"	"	"	"	1 to 2	"	"	
17	"	"	"	"	"	UP	"	"	"	
18	"	"	"	"	"	DOWN	"	"	"	
19	"	"	"	"	"	+	"	"	"	
20	"	"	"	"	"	DOWN	"	"	"	
21	"	"	"	"	"	UP	"	"	"	
22	"	"	"	"	"	"	"	"	"	
23	"	"	"	"	"	DOWN	"	"	"	
24	"	"	"	"	"	UP	"	"	"	
25	"	"	"	"	"	DOWN	"	"	"	
26	"	"	"	"	"	"	"	"	"	
27	"	"	"	"	"	"	"	"	"	
28	"	"	"	"	"	+	2 to 1	"	"	
29	"	"	"	"	"	UP	2 to 1	"	"	
30	"	"	"	"	"	"	"	"	"	

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TABLE XVII WATER RISE IN PIEZOMETERS. UNIT:cm

MONTH OF: OCTOBER, 1979

DATE	BLUE PIEZOMETERS		WHITE PIEZOMETERS		YELLOW PIEZOMETERS		R E M A R K S
	BP1 cm	BP2 cm	WP1 cm	WP2 cm	YP1 cm	YP2 cm	
1	0.000	26.660	17.764	88.884	101.899	111.424	
2	0.000	26.660	17.764	88.884	97.454	106.979	
3	0.000	26.260	17.764	88.884	99.994	109.519	
4	0.000	26.260	19.034	90.154	99.994	110.154	
5	0.000	26.660	19.034	90.154	99.994	110.154	
6	0.000	26.660	19.034	89.519	97.454	106.344	
7	3.804	26.660	20.304	90.154	101.264	111.424	
8	3.804	26.660	20.304	90.154	99.994	110.154	
9	5.074	26.660	20.304	88.884	98.724	108.884	
10	5.074	26.660	20.304	88.884	98.724	108.884	
11	5.074	26.030	20.304	88.881	96.184	106.344	
12	6.344	26.660	20.304	90.154	98.724	110.154	
13	7.614	26.660	22.209	88.884	99.994	110.154	
14	8.244	26.660	22.944	90.154	99.994	110.154	
15	8.884	26.030	22.844	90.154	98.724	109.519	
16	10.154	26.030	22.844	90.154	98.089	107.614	
17	11.4[redacted]	[redacted].030	24.114	88.884	98.089	107.614	
18	11.424	[redacted].030	24.114	88.884	[redacted]6.184	106.344	
19	12.0[redacted]	[redacted].010	24.749	88.884	[redacted].819	108.884	
20	12.69[redacted]	[redacted].030	25.3[redacted]	[redacted]	[redacted].454	108.249	
[redacted]	[redacted]	[redacted].660	25.38[redacted]	[redacted]	96.184	107.614	
[redacted]	[redacted].96[redacted]	[redacted].030	25.38[redacted]	[redacted]	[redacted].184	107.614	
[redacted]	13.96[redacted]	[redacted].660	27.924	[redacted]	[redacted].089	108.249	
[redacted]	13.96[redacted]	[redacted].030	26.6[redacted]	[redacted]	93.644	103.804	
[redacted]	[redacted]3.96[redacted]	[redacted].660	27.92[redacted]	[redacted]	[redacted].644	105.074	
[redacted]	15.23[redacted]	[redacted].299	27.2[redacted]	[redacted]	94.314	105.709	
[redacted]	[redacted]6.50[redacted]	[redacted].934	[redacted].924	[redacted]	96.[redacted]	[redacted].344	
[redacted]	[redacted]	[redacted]	27.924	[redacted]	97.45[redacted]	[redacted].614	

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TABLE XVIII WATER FLOW DIRECTIONS IN SOIL. UNIT: H2 MONTH OF: OCTOBER, 1979

DATE	VERTICAL FLOW						HORIZONTAL FLOW			REMARKS
	BP1 & WP1	BP1 & YP1	WP1 & YP1	BP2 & WP2	BP2 & YP2	WP2 & YP2	BP2 -BP1	WP2-WP1	YP2-YP1	
1	DOWN	UP	UP	DOWN	DOWN	UP	2 to 1	2 to 1	2 to 1	+ No water Movement
2	•	DOWN	•	•	•	DOWN	•	•	•	
3	•	+	•	•	•	UP	•	•	•	
4	•	•	•	•	•	+	•	•	•	
5	•	•	•	•	•	•	•	•	•	
6	•	DOWN	•	•	•	DOWN	•	•	•	
7	•	•	•	•	•	UP	•	•	•	
8	•	•	•	•	•	+	•	•	•	
9	•	•	•	•	•	•	•	•	•	
10	•	•	•	•	•	•	•	•	•	
11	•	•	•	•	•	DOWN	•	•	•	
12	•	•	•	•	•	+	•	•	•	
13	•	•	•	•	•	UP	•	•	•	
14	•	•	•	•	•	+	•	•	•	
15	•	•	•	•	•	DOWN	•	•	•	
16	•	•	•	•	•	•	•	•	•	
17	•	•	•	•	•	•	•	•	•	
18	•	•	•	•	•	•	•	•	•	
19	•	•	•	•	•	+	•	•	•	
20	•	•	•	•	•	DOWN	•	•	•	
21	•	•	•	•	•	•	•	•	•	
22	•	•	•	•	•	•	•	•	•	
23	•	•	•	•	•	+	•	•	•	
24	•	•	•	•	•	DOWN	•	•	•	
25	•	•	•	•	•	•	•	•	•	
26	•	•	•	•	•	•	•	•	•	
27	•	•	•	•	•	•	•	•	•	

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TABLE XIX WATER RISE IN PIEZOMETERS, UNIT: H2 MONTH OF: NOVEMBER, 1979

DATE	BLUE PIEZOMETERS		WHITE PIEZOMETERS		YELLOW PIEZOMETERS		R E M A R K S
	BP1 cm	BP2 cm	WP1 cm	WP2 cm	YP1 cm	YP2 cm	
1	19.044	27.934	29.829	89.519	98.724	110.154	
2	19.044	27.934	30.464	90.154	98.724	110.154	
3	19.044	28.569	31.099	90.154	99.994	110.154	
4	19.679	28.569	31.734	89.519	98.724	107.614	
5	20.314	29.204	31.734	90.154	101.264	110.154	
6	21.584	29.204	34.909	90.154	101.264	110.154	
7	22.219	29.204	35.544	91.424	101.264	110.789	
8	22.394	29.204	35.544	91.424	103.804	111.424	
9	23.489	29.204	35.544	92.059	106.344	113.964	
10	25.394	29.204	36.814	92.694	101.264	108.884	
11	25.394	30.474	36.814	92.694	105.074	112.694	
12	25.394	29.839	36.814	93.329	103.804	111.424	
13	23.971	30.474	37.449	93.329	105.074	112.694	
14	26.664	30.474	38.084	93.964	107.614	113.964	
15	26.664	30.474	38.084	93.964	105.074	111.424	
16	26.664	30.474	38.084	93.964	105.709	112.694	
17	26.664	30.474	38.084	93.964	104.439	111.424	
[illegible]	26.664	29.204	39.354	93.964	106.344	113.964	
[illegible]	26.664	29.839	39.989	93.964	106.344	113.964	
[illegible]	[illegible].664	30.474	40.624	93.964	106.344	113.964	
[illegible]	[illegible].664	29.839	40.624	93.964	105.074	112.694	
[illegible]	[illegible].664	29.839	40.624	93.964	112.059	112.694	
[illegible]	26.654	29.204	40.624	93.329	103.804	112.694	
[illegible]	26.664	29.204	40.624	92.694	101.264	108.884	
[illegible]	26.654	29.204	40.624	92.694	10[illegible].264	108.884	
[illegible]	26.664	29.204	41.894	92.694	103.804	111.424	
[illegible]	26.664	29.204	43.164	91.424	106.344	113.964	
[illegible]	26.664	29.204	43.164	91.424	103.804	111.424	
[illegible]	26.662	29.204	43.164	93.964	103.249	116.504	
[illegible]	26.664	29.204	43.164	93.964	105.709	113.964	

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TABLE XX WATER FLOW DIRECTIONS IN SOIL, UNIT: H2 MONTH OF: NOVEMBER, 1979

DATE	VERTICAL FLOW						HORIZONTAL FLOW			REMARKS
	BP1 & WP1	BP1 & YP1	WP1 & YP1	BP2 & WP2	BP2 & YP2	WP2 & YP2	BP2 –BP1	WP2–WP1	YP2–YP1	
1	DOWN	DOWN	UP	DOWN	DOWN	UP	2 to 1	2 to 1	2 to 1	+ No Water Movement
2	"	"	"	"	"	+	"	"	"	
3	"	"	"	"	"	"	"	"	"	
4	"	"	"	"	"	DOWN	"	"	"	
5	"	"	"	"	"	+	"	"	"	
6	"	"	"	"	"	+	"	"	"	
7	"	"	"	"	"	DOWN	"	"	"	
8	"	"	"	"	"	+	"	"	"	
9	"	"	"	"	"	UP	"	"	"	
10	"	"	"	"	"	DOWN	"	"	"	
11	"	"	"	"	"	+	"	"	"	
12	"	"	"	"	"	DOWN	"	"	"	
13	"	"	"	"	"	"	"	"	"	
14	"	"	"	"	"	+	"	"	"	
15	"	"	"	"	"	DOWN	"	"	"	
16	"	"	"	"	"	"	"	"	"	
17	"	"	"	"	"	"	"	"	"	
18	"	"	"	"	"	+	"	"	"	
19	"	"	"	"	"	+	"	"	"	
20	"	"	"	"	"	+	"	"	"	
21	"	"	"	"	"	DOWN	"	"	"	
22	"	"	"	"	"	"	"	"	"	
23	"	"	"	"	"	"	"	"	"	
24	"	"	"	"	"	"	"	"	"	
25	"	"	"	"	"	"	"	"	"	
26	"	"	"	"	"	"	"	"	"	
27	"	"	"	"	"	UP	"	"	"	
28	"	"	"	"	"	+	"	"	"	
29	"	"	"	"	"	UP	"	"	"	
30	"	"	"	"	"	+	"	"	"	

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TABLE XXI WATER RISE IN PIEZOMETERS. UNIT: H2 MONTH OF: DECEMBER, 1979

DATE	BLUE PIEZOMETERS		WHITE PIEZOMETERS		YELLOW PIEZOMETERS		REMARKS
	BP1 cm	BP2 cm	WP1 cm	WP2 cm	YP1 cm	YP2 cm	
1	26.664	29.204	43.164	93.329	105.074	113.964	
2	26.664	29.204	45.069	92.694	104.439	113.964	
3	26.664	29.204	44.434	91.424	103.804	113.964	
4	23.971	29.204	44.434	93.329	103.169	112.694	
5	25.394	29.204	44.434	92.694	102.534	111.424	
6	27.934	29.204	45.069	92.694	105.074	112.694	
7	29.204	29.204	45.704	92.694	106.344	113.964	
8	29.204	29.204	45.704	92.694	101.264	111.424	
9	29.204	29.204	45.704	92.694	101.264	111.424	
10	29.204	29.204	45.704	92.694	102.534	111.424	
11	29.204	29.204	45.704	93.964	102.534	112.694	
12	27.934	29.204	46.339	93.964	102.534	112.694	
13	28.569	29.204	46.974	93.964	101.899	111.424	
14	27.934	29.204	46.974	93.964	102.535	112.694	
15	24.759	29.204	47.609	92.694	102.534	113.329	Water Drained
16	21.584	29.204	48.244	91.424	102.534	113.964	
[redacted]	16.504	28.569	46.974	92.059	98.089	108.884	
[redacted]	[redacted]9.044	29.204	48.244	91.424	98.724	108.884	
[redacted]	[redacted]1.584	29.204	48.244	91.424	99.994	110.154	
[redacted]	[redacted]1.584	29.204	48.244	91.424	101.899	111.424	
[redacted]	[redacted].584	29.204	48.244	91.424	102.534	112.059	
[redacted]	[redacted]0.949	29.204	48.244	91.424	103.804	112.694	
[redacted]	[redacted]0.314	28.569	49.514	91.424	102.534	111.424	
[redacted]	[redacted].504	28.569	49.514	91.424	102.534	110.789	
[redacted]	[redacted].804	27.934	49.514	88.884	101.264	110.789	
[redacted]	[redacted]1.264	27.934	49.514	88.884	99.994	110.154	
[redacted]	[redacted]0.000	27.934	49.514	88.884	98.724	107.614	
[redacted]	[redacted]00	28.569	49.514	88.884	[redacted]	106.344	
[redacted]	[redacted].000	27.934	49.514	87.619[redacted]	[redacted]	[redacted]	

TABLE XXII WATER FLOW DIRECTIONS IN SOIL. UNIT: H2O MONTH OF: DECEMBER, 1979

DATE	VERTICAL FLOW						HORIZONTAL FLOW			REMARKS
	BP1 & WP1	BP1 & YP1	WP1 & YP1	BP2 & WP2	BP2 & YP2	WP2 & YP2	BP2 -BP1	WP2-WP1	YP2-YP1	
1	DOWN	DOWN	UP	DOWN	DOWN	UP	2 to 1	2 to 1	2 to 1	+ No Water Movement
2	•	•	•	•	•	+	•	•	•	
3	•	•	•	•	•	UP	•	•	•	
4	•	•	•	•	•	DOWN	•	•	•	
5	•	•	•	•	•	•	•	•	•	
6	•	•	•	•	•	+	•	•	•	
7	•	•	•	•	•	UP	+	•	•	
8	•	•	•	•	•	DOWN	+	•	•	
9	•	•	•	•	•	•	+	•	•	
10	•	•	•	•	•	•	+	•	•	
11	•	•	•	•	•	•	+	•	•	
12	•	•	•	•	•	•	+	•	•	
13	•	•	•	•	•	•	+	•	•	
14	•	•	•	•	•	•	+	•	•	
15	•	•	•	•	•	UP	•	•	•	
16	•	•	•	•	•	•	•	•	•	
17	•	•	•	•	•	DOWN	•	•	•	
18	•	•	•	•	•	•	•	•	•	
19	•	•	•	•	•	•	•	•	•	
20	•	•	•	•	•	+	•	•	•	
21	•	•	•	•	•	UP	•	•	•	
22	•	•	•	[illegible]	•	•	•	•	•	
23	•	•	•	[illegible]	•	+	•	•	•	
24	•	•	[illegible]	[illegible]	•	DOWN	•	•	•	
25	•	•	[illegible]	[illegible]	[illegible]	UP	•	•	•	
26	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	•	•	•	•	
27	[illegible]	[illegible]	[illegible]	[illegible]	•	DOWN	•	•	•	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	•	•	•	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	•	•	•	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	•	•	•	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	•	•	

TABLE XXIII WATER RISE IN PIEZOMETERS, UNIT: H2 MONTH OF: JANUARY, 1980

DATE	BLUE PIEZOMETERS		WHITE PIEZOMETERS		YELLOW PIEZOMETERS		REMARKS
	BP1 cm	BP2 cm	WP1 cm	WP2 cm	YP1 cm	YP2 cm	
1	0.000	27.934	50.784	82.534	92.374	101.899	
2	"	27.934	50.784	78.724	91.104	101.264	
3	"	27.934	50.784	76.184	88.564	95.545	
4	"	26.664	50.784	73.644	88.564	96.184	
5	"	26.664	50.784	71.104	86.024	92.374	
6	"	26.664	49.514	68.564	83.484	87.929	
7	"	26.664	49.514	66.659	80.944	86.659	
8	"	26.664	49.514	64.754	79.674	84.754	
9	"	25.394	49.514	59.674	75.864	80.944	
10	"	25.394	48.244	55.864	73.324	78.404	
11	"	25.394	48.244	53.324	69.524	74.594	
12	"	24.124	48.244	52.054	69.514	74.594	
13	"	24.124	48.244	48.244	65.704	70.789	
14	"	24.124	48.244	46.974	63.164	68.244	
15	"	24.124	46.974	44.434	63.164	68.244	
16	"	22.854	46.974	43.164	60.624	65.704	
17	"	22.854	46.974	40.624	59.354	63.164	
18	"	22.854	46.974	39.354	54.274	59.354	
[illegible]	"	22.854	46.974	36.814	54.274	58.084	
[illegible]	[illegible]	22.219	45.704	35.544	53.639	56.814	
[illegible]	[illegible]	21.584	45.704	33.004	53.004	55.544	
[illegible]	[illegible]	20.314	45.704	31.734	50.464	55.544	
[illegible]	[illegible]	[illegible]9.044	45.704	30.464	50.464	55.544	
[illegible]	[illegible]	[illegible].774	45.069	2[illegible].924	46.654	53.004	
[illegible]	[illegible]	[illegible].504	44.434	26.654	45.384	51.734	
[illegible]	[illegible]	[illegible].234	43.799	25.384	44.114	50.464	
[illegible]	[illegible]	12.694	43.164	24.114	42.844	49.194	
[illegible]	[illegible]	10.154	43.164	22.844	[illegible]4.114	47.924	
[illegible]	[illegible]	[illegible]44	42.164	21.574	40.304	46.654	
[illegible]	[illegible]	[illegible]	43.164	20.304	39.034	45.384	
[illegible]	[illegible]	[illegible]	[illegible].464	19.034	37.764	44.114	

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TABLE XXVV WATER FLOW DIRECTIONS IN SOIL. UNIT: H2 MONTH OF: JANUARY, 1980

DATE	VERTICAL FLOW						HORIZONTAL FLOW			REMARKS
	BP1 & WP1	BP1 & YP1	WP1 & YP1	BP2 & WP2	BP2 & YP2	WP2 & YP2	BP2 -BP1	WP2-WP1	YP2-YP1	
1	DOWN	DOWN	UP	DOWN	DOWN	DOWN	2 to 1	2 to 1	2 to 1	+ No Water Movement.
2	•	•	•	•	•	UP	•	•	•	
3	•	•	•	•	•	DOWN	•	•	•	
4	•	•	•	•	•	UP	•	•	•	
5	•	•	•	•	•	•	•	•	•	
6	•	•	•	•	•	DOWN	•	•	•	
7	•	•	•	•	•	+	•	•	•	
8	•	•	•	•	•	+	•	•	•	
9	•	•	•	•	•	UP	•	•	•	
10	•	•	•	•	•	•	•	•	•	
11	•	•	•	•	•	•	•	•	•	
12	•	•	•	•	•	•	•	•	•	
13	•	•	DOWN	•	•	•	•	+	•	
14	•	•	•	•	•	•	•	1 to 2	•	
15	•	•	•	•	•	•	•	•	•	
16	•	•	•	•	•	•	•	•	•	
17	•	•	•	•	•	•	•	•	•	
18	•	•	•	•	•	+	•	•	•	
19	•	•	•	•	•	UP	•	•	•	
20	•	•	•	•	•	•	•	•	•	
21	•	•	•	•	•	•	•	•	•	
22	•	•	•	•	•	•	•	•	•	
23	•	•	•	•	•	•	•	•	•	
24	•	•	•	•	•	•	•	•	•	
25	•	•	•	•	•	•	•	•	•	
26	•	•	•	•	•	•	•	•	•	
27	•	•	•	•	•	•	•	•	•	
28	•	•	•	•	•	•	•	•	•	
29	•	•	•	•	•	•	•	•	•	
30	•	•	•	•	•	•	•	•	•	
31	•	•	•	•	•	•	•	•	•	

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TABLE XXV WATER RISE IN PIEZOMETERS, UNIT: H2 MONTH OF: FEBRUARY, 1980

DATE	BLUE PIEZOMETERS		WHITE PIEZOMETERS		YELLOW PIEZOMETERS		R E M A R K S
	BP1 cm	BP2 cm	WP1 cm	WP2 cm	YP1 cm	YP2 cm	
1	0.000	0.000	42.529	17.764	36.494	42.844	
2	"	"	41.894	16.494	35.224	41.574	
3	"	"	41.259	15.059	33.954	40.304	
4	"	"	43.164	15.224	32.684	40.304	
5	"	"	[redacted].164	13.954	32.684	40.304	
[redacted]	[redacted]	[redacted]	[redacted].164	13.954	32.684	40.304	
[redacted]	[redacted]	[redacted]	39.989	12.684	31.414	39.034	
[redacted]	[redacted]	[redacted]	[redacted].989	12.684	31.414	37.764	
[redacted]	[redacted]	[redacted]	39.354	11.414	30.144	36.494	
[redacted]	[redacted]	[redacted]	39.354	10.144	30.144	35.224	
[redacted]	[redacted]	[redacted]	[redacted]	[redacted].144	28.874	35.224	
[redacted]	[redacted]	"	38.71[redacted]	[redacted].870	28.874	33.954	
[redacted]	[redacted]	"	38.08[redacted]	[redacted]870	27.604	33.954	
[redacted]	[redacted]	"	38.08[redacted]	[redacted].600	27.604	32.684	
[redacted]	[redacted]	"	37.44[redacted]	[redacted].330	26.334	32.684	
[redacted]	[redacted]	[redacted]	37.449	[redacted].330	26.33[redacted]	31.414	
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	25.06[redacted]	[redacted].414	
[redacted]	[redacted]	[redacted]	36.81[redacted]	[redacted]	25.06[redacted]	[redacted].144	
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	23.79[redacted]	[redacted].874	

TABLE XXVI WATER FLOW DIRECTIONS IN SOIL. UNIT: H2 MONTH OF: FEBRUARY, 1980

DATE	VERTICAL FLOW						HORIZONTAL FLOW			REMARKS
	BP1 & WP1	BP1 & YP1	WP1 & YP1	BP2 & WP2	BP2 & YP2	WP2 & YP2	BP2 -BP1	WP2-WP1	YP2-YP1	
1	DOWN	DOWN	DOWN	DOWN	DOWN	UP	+	1 to 2	2 to 1	+ No Water Movement
2	"	"	"	"	"	"	"	"	"	
3	"	"	"	"	"	"	"	"	"	
4	"	"	"	2	"	"	"	"	"	
5	"	"	"	"	"	"	"	"	"	
6	"	"	"	"	"	"	"	"	"	
7	"	"	"	"	"	"	"	"	"	
8	"	"	"	"	"	"	"	"	"	
9	"	"	"	"	",	"	"	"	"	
10	"	"	"	"	"	"	"	"	"	
11	"	"	"	"	"	"	"	"	"	
12	"	"	"	"	"	"	"	"	"	
13	"	"	"	"	"	"	"	"	"	
14	"	"	"	"	"	"	"	"	"	
15	"	"	"	"	"	"	"	"	"	
16	"	"	"	"	"	"	"	"	"	
17	"	"	"	"	"	"	"	"	"	
18	"	"	"	"	"	"	"	"	"	
19	"	"	"	"	"	"	"	"	"	
20	"	"	"	"	"	"	"	"	"	
21	"	"	"	"	"	"	"	"	"	
22	"	"	"	"	"	"	"	"	"	
23	"	"	"	"	"	"	"	"	"	
24	"	"	"	"	"	"	"	"	"	
25	PIEZOMETERS UPROOTED, FINAL READINGS TAKEN									
26	PIEZOMETERS UPROOTED ALREADY									
27										
28										

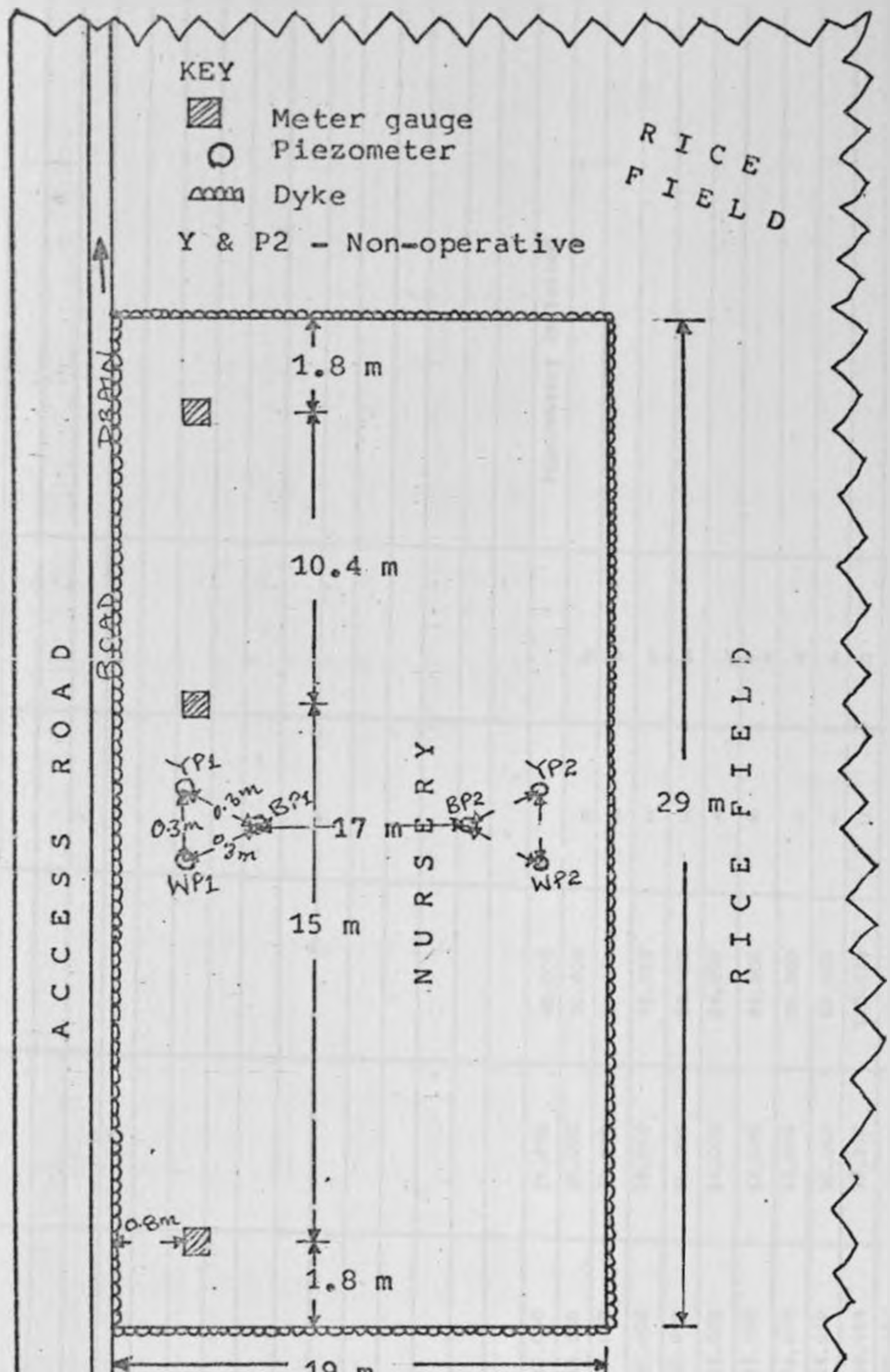

Fig. III: H3 Nursery Layout

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TABLE XXVII WATER RISE IN PIEZOMETERS, UNIT: H3 MONTH OF: July, 1979

DATE	BLUE PIEZOMETERS		WHITE PIEZOMETERS		YELLOW PIEZOMETERS		REMARKS
	BP1 cm	BP2 cm	WP1 cm	WP2 cm	YP1 cm	YP2 cm	
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
[redacted]							
							Piezometers Installed
					E	E	
					V	V	
					I	I	
					T	T	
					A	A	
					R	R	
					E	E	

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TABLE XXVII WATER FLOW DIRECTIONS IN SOIL. UNIT: M3 MONTH OF: JULY, 1979

DATE	VERTICAL FLOW						HORIZONTAL FLOW			REMARKS
	BP1 & WP1	BP1 & YP1	WP1 & YP1	BP2 & WP2	BP2 & YP2	WP2 & YP2	BP2 - BP1	WP2-WP1	YP2-YP1	
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17	DOWN			DOWN			2 to 1	2 to 1		
18	•			•			•	•		
19	•			•			•	•		
20	•			•			•	•		
21	•			•			•	•		
22	•			•			•	•		
23	•			•			•	•		
24	•			•			•	•		
25	•			•			•	•		
26	•			•			UP	•		
27	•			DOWN			•	•		* No water movement; Yellow piezometers were not
28	•			•			•	•		operating.
29	•			•			•	•		
30	•			•			•	•		
31	•			•			•	•		

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TABLE XXIX WATER RISE IN PIEZOMETERS, UNIT: M5 MONTH OF: AUGUST 1979

DATE	BLUE PIEZOMETERS		WHITE PIEZOMETERS		YELLOW PIEZOMETERS		REMARKS
	BP1 cm	BP2 cm	WP1 cm	WP2 cm	YP1 cm	YP2 cm	
1	27.934	26.029	73.644	91.424			
2	24.124	25.394	73.644	91.424			
3	21.025	26.029	73.374	90.154			
4	20.314	25.394	74.279	88.249			
5	28.565	25.394	77.454	93.329			
6	29.204	25.394	77.454	95.869			
7	29.204	25.394	74.914	95.869			
8	29.839	25.394	74.914	95.869			
9	30.474	26.029	76.184	96.504			
10	31.109	25.394	76.819	97.774			
11	31.109	25.394	76.819	97.774			
12	31.744	26.029	78.089	98.409			
13	31.744	26.664	76.184	97.774			
14	31.744	26.029	77.454	98.409			
15	31.744	26.029	78.724	99.044			
16	31.744	25.394	79.994	96.504			
17	31.744	26.029	77.454	96.504			
18	31.744	26.029	79.994	95.869			
19	31.744	26.664	77.454	93.964			
20	31.744	26.664	77.454	93.329			
21	30.474	26.664	77.454	92.694			
22	30.474	26.664	77.454	92.694			
23	29.839	26.664	76.184	91.424			
24	30.474	26.664	78.724	91.424			
25	31.744	26.664	78.724	91.424			
26	31.744	26.664	81.264	92.694			
27	34.284	27.299	81.264	92.694			
28	35.554	26.664	78.724	93.964			
29	35.554	27.934	78.724	93.964			
30	35.554	27.934	79.994	93.964			
31	39.840	29.204	77.454	90.789			

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TABLE XXX WATER FLOW DIRECTIONS IN SOIL, UNIT: H3 MONTH OF: AUGUST, 1979

DATE	VERTICAL FLOW						HORIZONTAL FLOW			REMARKS
	BP1 & WP1	BP1 & YP1	WP1 & YP1	BP2 & WP2	BP2 & YP2	WP2 & YP2	BP2 - BP1	WP2-WP1	YP2-YP1	
1	DOWN			DOWN			1 to 2	2 to 1		
2	"			"			2 to 1	"		
3	"			"			"	"		
4	"			"			"	"		
5	"			"			1 to 2	"		
6	"			"			"	"		
7	"			"			"	"		
8	"			"			"	"		
9	"			"			"	"		
10	"			"			"	"		
11	"			"			"	"		
12	"			"			"	1 to 2		
13	"			"			"	2 to 1		
14	"			"			"	"		
15	"			"			"	"		
16	"			"			"	"		
17	"			"			"	"		
18	"			"			"	"		
19	"			"			"	"		
20	"			"			"	"		
21	"			"			"	"		
22	"			"			"	"		
23	"			"			"	"		
24	"			"			"	"		
25	"			"			"	"		
26	"			"			"	"		
27	"			"			"	"		
28	"			"			"	"		
29	"			"			"	"		
30	"			"			"	"		
31	"			"			"	"		

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TABLE XXXIII WATER RISE IN PIEZOMETERS, UNIT: HB — MONTH OF SEPTEMBER, 1979

DATE	BLUE PIEZOMETERS		WHITE PIEZOMETERS		YELLOW PIEZOMETERS		REMARKS
	BP1 cm	BP2 cm	WP1 cm	WP2 cm	YP1 cm	YP2 cm	
1	47.460	29.839	77.454	88.884			
2	47.460	29.839	77.454	88.884			
3	47.460	29.204	74.914	86.979			
4	46.190	29.204	73.644	85.074			
5	47.460	29.204	71.103	83.804			
6	46.190	29.204	72.374	82.534			
7	44.920	29.204	67.294	77.454			
8	43.015	29.204	63.484	73.644			
9	42.380	29.204	69.834	69.834			
10	42.380	29.204	68.564	74.279			
11	42.380	29.204	68.564	78.724			
12	39.840	28.569	71.104	81.264			
13	42.380	29.204	73.009	83.804			
14	[redacted]	[redacted]	73.644	85.074			
15	[redacted]	[redacted]	77.454	86.344			
16	[redacted]	[redacted]	77.454	86.344			
17	[redacted]	[redacted]	77.454	86.344			
18	[redacted]	[redacted]	76.454	86.344			
19	[redacted]	[redacted]	76.184	86.344			
20	[redacted]	[redacted]	73.644	85.074			
21	[redacted]	[redacted]	76.184	85.074			
22	[redacted]	[redacted]	73.644	85.074			
23	[redacted]	[redacted]	[redacted]	83.804			
24	[redacted]	[redacted]	[redacted]	[redacted]			
25	[redacted]	[redacted]	[redacted]	[redacted]			
26	[redacted]	[redacted]	[redacted]	84.439			
27	[redacted]	[redacted]	[redacted]	83.804			

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TABLE XXXII WATER FLOW DIRECTIONS IN SOIL. UNIT: H3 MONTH OF: SEPTEMBER, 1979

DATE	VERTICAL FLOW						HORIZONTAL FLOW			REMARKS
	BP1 & WP1	BP1 & YP1	WP1 & YP1	BP2 & WP2	BP2 & YP2	WP2 & YP2	BP2 - BP1	WP2-WP1	YP2-YP1	
1	DOWN			DOWN			1 to 2	2 to 1		
2	.			.			.	.		
3	.			.			.	.		
4	.			.			.	.		
5	.			.			.	.		
6	.			.			.	.		
7	.			.			.	.		
8	.			.			.	.		
9	.			.			.	.		
10	.			.			.	.		
11	.			.			.	.		
12	.			.			.	.		
13	.			.			.	.		
14	.			.			.	.		
15	.			.			.	.		
16	.			.			.	.		
17	.			.			.	.		
18	.			.			.	.		
19	.			.			.	.		
20	.			.			.	.		
21	.			.			.	.		
22	.			.			.	.		
23	.			.			.	.		
24	.			.			.	.		
25	.			.			.	.		
26	.			.			.	.		
27	.			.			.	.		
28	.			.			2 to 1	.		
29	.			.			.	.		
[illegible]	.			.			.	.		

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TABLE XXXIII WATER RISE IN PIEZOMETERS. UNIT:H2 MONTH OF: OCTOBER, 1979

DATE	BLUE PIEZOMETERS		WHITE PIEZOMETERS		YELLOW PIEZOMETERS		R E M A R K S
	BP1 cm	BP2 cm	WP1 cm	WP2 cm	YP1 cm	YP2 cm	
1	19.044	29.204	73.644	82.534			
2	19,044	29.204	71.103	81.899			
3	21.584	29.204	76.184	83.804			
4	21.584	29.204	76.184	85.074			
5	21.584	29.204	76.184	85.074			
6	22.854	29.204	73.644	85.074			
7	22.854	29.204	76.184	85.074			
[redacted]	[redacted]2.854	27.934	74.914	83.804			
[redacted]	[redacted]2.854	28.569	73.644	82.534			
[redacted]	23.489	28.569	73.644	82.534			
[redacted]	23.489	28.569	72.374	82.534			
[redacted]	[redacted].489	28.569	73.644	83.534			
[redacted]	[redacted].124	29.204	72.374	81.264			
[redacted]	[redacted].489	28.569	73.009	81 264			
[redacted]	[redacted].489	27.934	72.374	79.994			
[redacted]	[redacted].124	28.569	71.103	79.994			
[redacted]	22.854	27.934	71.103	78.724			
[redacted]	22.854	28.569	71.103	79.994			
[redacted]	22.854	28.569	72.374	80.629			
[redacted]	23.48[redacted]	28.569	73.644	81.264			
[redacted]	[redacted]	[redacted].934	73.644	81.264			
[redacted]	[redacted]	[redacted].934	[redacted].644	81.899			

TABLE XXXIV WATER FLOW DIRECTIONS IN SOIL, UNIT: H3 MONTH OF: OCTOBER, [illegible]

DATE	VERTICAL FLOW						HORIZONTAL FLOW			REMARKS
	BP1 & WP1	BP1 & YP1	WP1 & YP1	BP2 & WP2	BP2 & YP2	WP2 & YP2	BP2 -BP1	WP2-WP1	YP2-YP1	
1	DOWN			DOWN			2 to 1	2 to 1		
2	•			•			•	•		
3	•			•			•	•		
4	•			•			•	•		
5	•			•			•	•		
6	•			•			•	•		
7	•			•			•	•		
8	•			•			•	•		
9	•			•			•	•		
10	•			•			•	•		
11	•			•			•	•		
12	•			•			•	•		
13	•			•			•	•		
14	•			•			•	•		
15	•			•			•	•		
16	•			•			•	•		
17	•			•			•	•		
18	•			•			•	•		
19	•			•			•	•		
20	•			•			•	•		
21	•			•			•	•		
22	•			•			•	•		
23	•			•			•	•		
24	•			•			•	•		
25	•			•			•	•		
26	•			•			•	•		
	•			•			•	•		

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TABLE XXXV WATER RISE IN PIEZOMETERS, UNIT: ND MONTH OF: NOVEMBER, 1979

DATE	BLUE PIEZOMETERS		WHITE PIEZOMETERS		YELLOW PIEZOMETERS		REMARKS
	BP1 cm	BP2 cm	WP1 cm	WP2 cm	YP1 cm	YP2 cm	
1	28.569	28.569	78.089	88.249			
2	28.569	29.839	78.724	88.884			
3	38.094	30.474	81.264	90.154			
4	36.189	31.109	80.629	90.154			
5	35.554	31.109	82.534	91.424			
6	35.554	29.839	84.439	92.694			
7	34.284	37.300	83.804	93.964			
[redacted]	33.649	38.570	85.074	95.234			
[redacted]	[redacted]3.014	39.840	[illegible]	96.504			
[redacted]	[redacted]9.840	43.650	85.074	96.504			
[redacted]	[redacted]4.919	39.840	87.614	97.774			
[redacted]	[redacted]3.014	41.110	87.614	99.044			
[redacted]	[redacted]2.379	41.110	88.249	99.679			
[redacted]	[redacted]0.474	41.110	88.884	[illegible]			
[redacted]	[redacted]3.014	40.380	87.614	99.044			
[redacted]	[redacted]3.014	[redacted]	[redacted]	99.679			
[redacted]	[redacted]	[redacted]	[redacted]	[redacted].044			
[redacted]	[redacted]	[redacted]	[redacted]	[redacted].044			
[redacted]	[redacted]	[redacted]	[redacted]	[redacted].044			
[redacted]	[redacted]	[redacted]	[redacted]	[redacted].314			
[redacted]	[redacted]	[redacted]	[redacted]	100.314			
[redacted]	[redacted]	[redacted]	[redacted]	[redacted].679			

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TABLE XXXVI WATER FLOW DIRECTIONS IN SOIL, UNIT: M3 MONTH OF NOVEMBER, 1979

DATE	VERTICAL FLOW						HORIZONTAL FLOW			REMARKS
	BP1 & WP1	BP1 & YP1	WP1 & YP1	BP2 & WP2	BP2 & YP2	WP2 & YP2	BP2 -BP1	WP2-WP1	YP2-YP1	
1	DOWN			DOWN			•	2 to 1		
2	•			•			2 to 1	•		
3	•			•			1 to 2	•		
4	•			•			•	•		
5	•			•			•	•		
6	•			•			•	•		
7	•			•			2 to 1	•		
8	•			•			•	•		
9	•			•			•	•		
10	•			•			•	•		
11	•			•			•	•		
12	•			•			•	•		
13	•			•			•	•		
14	•			•			•	•		
15	•			•			•	•		
16	•			•			•	•		
17	•			•			•	•		
18	•			•			•	•		
19	•			•			•	•		
20	•			•			•	"		
21	•			•			•	"		
22	•			•			1 to 2	"		
				•			[2 to 1]	"		

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TABLE XXXVII WATER RISE IN PIEZOMETERS, UNIT:H3 MONTH OF: DECEMBER,1979

DATE	BLUE PIEZOMETERS		WHITE PIEZOMETERS		YELLOW PIEZOMETERS		R E M A R K S
	BP1 cm	BP2 cm	WP1 cm	WP2 cm	YP1 cm	YP2 cm	
1	35.554	37.300	83.804	95.234			
2	34.919	38.729	82.534	93.964			
3	34.284	38.094	81.264	91.424			
4	34.284	36.824	79.994	90.789			
5	34.284	35.554	78.724	90.154			
6	33.014	34.919	77.454	87.614			
7	31.734	34.284	76.184	86.344			
8	31.734	33.014	72.374	85.074			
9	31.734	33.014	71.104	83.804			
10	30.474	32.379	68.564	81.264			
11	30.474	30.474	63.484	76.184			
12	29.204	28.569	58.404	68.564			
13	27.934	25.394	52.053	62.214			
14	26.664	21.584	48.244	57 134			
15	24.759	17.774	43.164	49.514			
16	22.854	13.964	38.084	45.704			
17	21.584	12.694	35.544	41.894			
18	21.584	11.424	46.974	45.704			
19	20.314	10.154	50.784	50.784			
20	20.314	10.154	53.424	53.324			
21	19.044	9.519	52.054	55.864			
22	18.409	8.884	49.514	58.404			
[illegible]	[illegible].409	8.884	50.734	5[illegible].404			

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TABLE XXXVII WATER FLOW DIRECTIONS IN SOIL, UNIT: H3 MONTH OF: DECEMBER, 1979

DATE	VERTICAL FLOW						HORIZONTAL FLOW			REMARKS
	BP1 & WP1	BP1 & YP1	WP1 & YP1	BP2 & WP2	BP2 & YP2	WP2 & YP2	BP2 - BP1	WP2-WP1	YP2-YP1	
1	DOWN			DOWN			2 to 1	2 to 1		
2	"			"			"	"		
3	"			"			"	"		
4	"			"			"	"		
5	"			"			"	"		
6	"			"			"	"		
7	"			"			"	"		
8	"			"			"	"		
9	"			"			"	"		
10	"			"			"	"		
11	"			"			+	"		+ No water movement
12	"			"			1 to 2	"		
13	"			"			"	"		
14	"			"			"	"		
15	"			"			"	"		
16	"			"			"	"		
17	"			"			"	"		
18	"			"			"	1 to 2		
19	"			"			"	+		
20	"			"			"	+		
21	"			"			"	2 to 1		
22	"			"			"	"		
23	"			"			"	"		
24	"			"			"	"		
25	"			"			"	"		
26	"			"			"	"		
27	"			"			"	"		
28	"			"			"	"		

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TABLE XXXIX WATER RISE IN PIEZOMETERS, UNIT:H3 MONTH OF: JANUARY, 1980

DATE	BLUE PIEZOMETERS		WHITE PIEZOMETERS		YELLOW PIEZOMETERS		REMARKS
	BP1 cm	BP2 cm	WP1 cm	WP2 cm	YP1 cm	YP2 cm	
1	10.789	0.000	33.639	40.624			
2	10.154	"	33.004	36.814			
3	8.884	"	27.924	31.734			
4	7.614	"	27.924	27.924			
5	0.000	"	27.924	24.114			
6	"	"	22.844	22.209			
7	"	"	22.209	22.209			
8	"	"	21.574	19.034			
9	"	"	20.304	17.764			
10	"	"	17.764	15.224			
11	"	"	16.494	13.594			
12	"	"	15.224	12.684			
13	"	"	13.954	11.414			
14	"	"	12.684	10.144			
15	"	"	8.874	7.604			
16	"	"	8,874	7.604			
17	"	"	8.874	6.334			
18	"	"	5.064	5.064			
19	"	"	4.429	4.429			
20	"	"	3.794	3.794			
21	"	"	2.524	2.524			
22	"	"	1.254	0.000			
23	"	"	0.000	"			
24	"	"	"	"			
25	"	"	"	"			
26	"	"	"	"			
27	"	"	"	"			
28	"	"	"	"			
29	"	"	"	"			
	"	"	"	"			

APPENDIX X

TABLE XL WATER FLOW DIRECTIONS IN SOIL. UNIT: H3 MONTH OF: JANUARY,1983

DATE	VERTICAL FLOW						HORIZONTAL FLOW			REMARKS
	BP1 & WP1	BP1 & YP1	WP1 & YP1	BP2 & WP2	BP2 & YP2	WP2 & YP2	BP2 - BP1	WP2-WP1	YP2-YP1	
1	DOWN			DOWN			1 to 2	2 to 1		
2	■			■			■	■		
3	■			■			■	■		
4	■			■			■	◆		◆ No water movement
5	■			■			◆	1 to 2		
6	■			■			◆	◆		
7	■			■			◆	◆		
8	■			■			◆	1 to 2		
9	■			■			◆	■		
10	■			■			◆	■		
11	■			■			◆	■		
12	■			■			◆	■		
13	■			■			◆	■		
14	■			■			◆	■		
15	■			■			◆	■		
16	■			■			◆	■		
17	■			■			◆	◆		
18	■			■			◆	◆		
19	■			■			◆	◆		
20	■			■			◆	◆		
21	■			■			◆	◆		
22	■			■			◆	◆		
23	■			■			◆	◆		
24	PIEZOMETERS WERE UPROOTED NO WATER WAS IN PIEZOMETERS									
25										
26										
27										

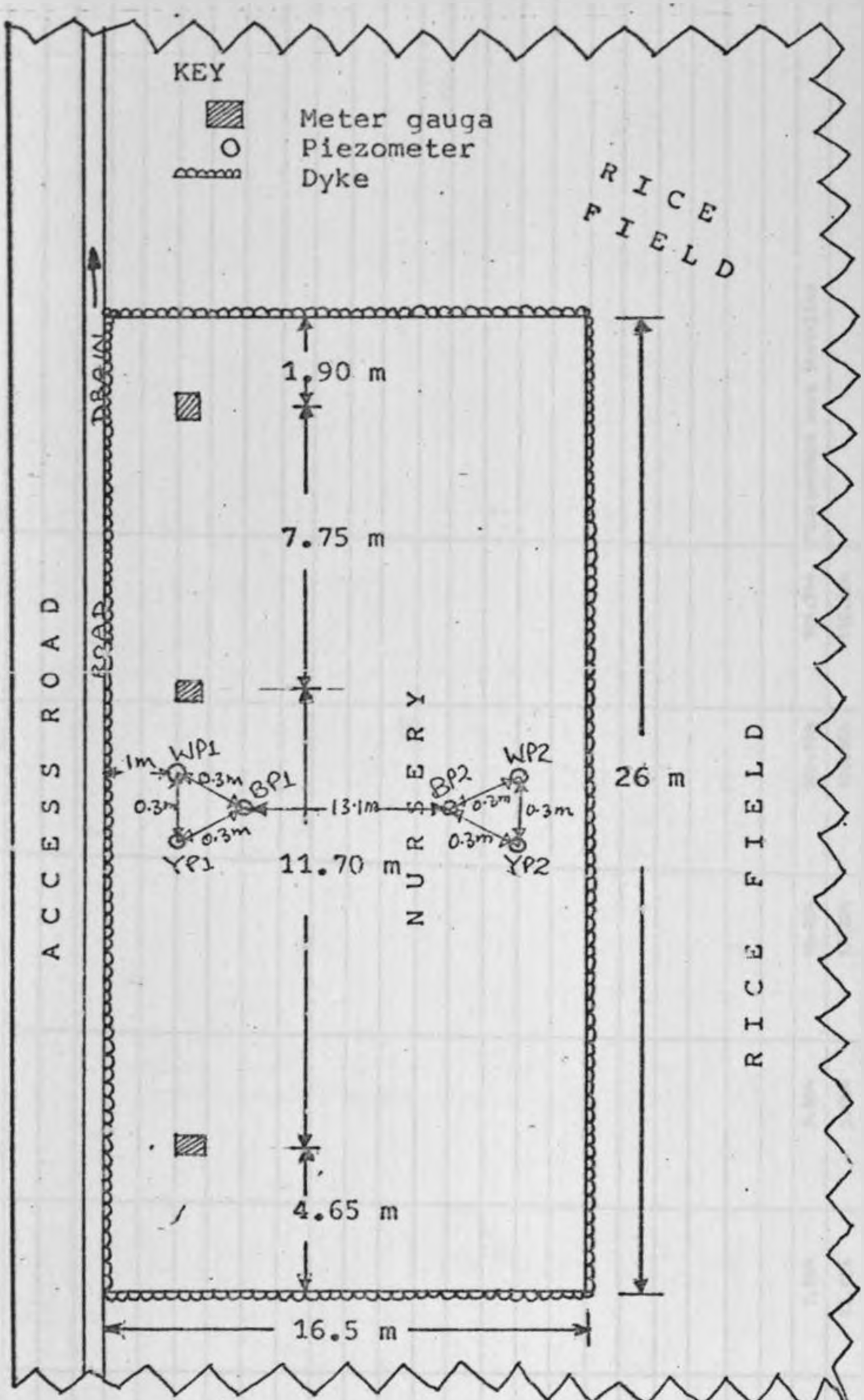

Fig. IV: H20 NUrseyy Layout

APPENDIX X

TABLE XLI WATER RISE IN PIEZOMETERS, UNIT: H20 MONTH OF: JULY.1979

DATE	BLUE PIEZOMETERS		WHITE PIEZOMETERS		YELLOW PIEZOMETERS		REMARKS
	BP1 cm	BP2 cm	WP1 cm	WP2 cm	YP1 cm	YP2 cm	
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24	[redacted]						
[redacted]							
[redacted]	[redacted]	[redacted]	3.604	10.224	103.804	106.344	Piezometers were installed
[redacted]	[redacted]	[redacted]	5.604	13.224	103.804	112.694	
[redacted]	[redacted]	[redacted]	7.604	15.224	105.074	115.234	
[redacted]	[redacted]	[redacted]	[redacted]684	22.644	103.804	111.424	
[redacted]	[redacted]	[redacted]	21.574	31.734	103.804	112.059	

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TABLE XLII WATER FLOW DIRECTIONS IN SOIL. UNIT: MZ3 MONTH OF: JULY 1979

DATE	VERTICAL FLOW						HORIZONTAL FLOW			REMARKS
	BP1 & WP1	BP1 & YP1	WP1 & YP1	BP2 & WP2	BP2 & YP2	WP2 & YP2	BP2 - BP1	WP2-WP1	YP2-YP1	
1.										
2.										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										

APPENDIX X

TABLE XLIII WATER RISE IN PIEZOMETERS, UNIT: [illegible]

MONTH OF: AUGUST, 1979

DATE	BLUE PIEZOMETERS		WHITE PIEZOMETERS		YELLOW PIEZOMETERS		REMARKS
	BP1 cm	BP2 cm	WP1 cm	WP2 cm	YP1 cm	YP2 cm	
1	23.489	25.394	34.274	48.244	104.439	112.694	
2	21.584	24.759	39.354	53.324	106.344	112.694	
3	21.025	24.124	44.434	58.404	103.169	110.789	
[illegible]	[illegible].314	22.854	53.324	67.929	103.804	111.424	
[illegible]	[illegible].889	21.504	53.324	67.929	103.804	112.059	
[illegible]	8.884	16.504	55.864	71.739	101.899	113.964	
[illegible]	8.249	15.869	57.769	73.009	98.724	107.614	
[illegible]	10.154	15.869	59.674	74.914	99.994	107.614	
[illegible]	24.124	22.854	62.214	78.724	102.534	110.154	
[illegible]	15.234	17.139	64.754	80.629	101.264	110.154	
[illegible]	19.044	20.949	67.294	82.534	101.89[illegible]	111.424	
[illegible]	24.124	22.854	69.199	83.804	102.534	112.059	
[illegible]	24.124	22.219	71.103	85.709	101.264	109.519	
[illegible]	24.759	22.854	73.644	86.344	102.534	111.424	
[illegible]	[illegible].394	24.124	74.914	101.584	103.804	112.694	
[illegible]	[illegible]6.664	25.394	77.45[illegible]	[illegible]0.474	105.074	113.964	
[illegible]	23.971	25.[illegible]	78.[illegible]	[illegible]0.474	102.534	110.154	
[illegible]	[illegible].664	24[illegible]	79.9[illegible]	109.204	105.074	113.964	
[illegible]	25.394	24[illegible]	[illegible]	107.934	102.534	108.804	

APPENDIX K

TABLE XLIV WATER FLOW DIRECTIONS IN SOIL, UNIT: H2O MONTH OF: AUGUST, 1979

DATE	VERTICAL FLOW						HORIZONTAL FLOW			REMARKS
	BP1 & WP1	BP1 & YP1	WP1 & YP1	BP2 & WP2	BP2 & YP2	WP2 & YP2	BP2 -BP1	WP2-WP1	YP2-YP1	
1	DOWN	DOWN	UP	DOWN	DOWN	UP	2 to 1	2 to 1	2 to 1	
2	"	"	"	"	"	"	"	"	"	
3	"	"	"	"	"	"	"	"	"	
4	"	"	"	"	"	"	"	"	"	
5	"	"	"	"	"	"	"	"	"	
6	"	"	"	"	"	"	"	"	"	
7	"	"	"	"	"	"	"	"	"	
8	"	"	"	"	"	"	"	"	"	
9	"	"	"	"	"	"	"	"	"	
10	"	"	"	"	"	"	"	"	"	
11	"	"	"	"	"	"	"	"	"	
12	"	"	"	"	"	"	1 to 2	"	"	
13	"	"	"	"	"	"	"	"	"	
14	"	"	"	"	"	"	"	"	"	
15	"	"	"	"	"	DOWN	"	"	"	
16	"	"	"	"	"	"	"	"	"	
17	"	"	"	"	"	"	2 to 1	"	"	
18	"	"	"	"	"	"	"	"	"	
19	"	"	"	"	"	"	1 to 2	"	"	
20	"	"	"	"	"	"	"	"	"	
21	"	"	"	"	"	"	"	"	"	
22	"	"	+	"	"	"	+	"	"	+ No water movement
23	"	"	+	"	"	"	+	"	"	
24	"	"	DOWN	"	"	"	1 to 2	"	"	
25	"	"	"	"	"	"	"	"	"	
26	"	"	+	"	"	"	"	"	"	
27	"	"	DOWN	"	"	"	+	"	"	
28	"	"	"	"	"	"	1 to 2	"	"	
29	"	"	"	"	"	"	"	"	"	
30	"	"	+	"	"	"	+	"	"	
31	"	"	DOWN	"	"	"	1 to 2	"	"	

APPENDIX X

TABLE. XLV WATER RISE IN PIEZOMETERS. UNIT: H2O   MONTH OF: SEPTEMBER, 1979

DAYS	BLUE PIEZOMETERS		WHITE PIEZOMETERS		YELLOW PIEZOMETERS		R E M A R K S
	BP1 cm	DP2 cm	WP1 cm	WP2 cm	YP1 cm	YP2 cm	
1	34.284	36.824	90.789	106.029	108.249	115.869	
2	33.014	38.094	91.424	106.664	107.614	116.504	
3	31.744	36.824	92.694	106.664	106.344	111.424	
4	31.109	36.824	93.694	105.394	106.344	111.424	
5	29.039	36.189	92.594	106.029	105.074	111.424	
6	30.474	36.189	92.694	105.394	106.344	116.504	
7	30.474	35.554	92.694	106.029	106.344	113.964	
8	28.569	34.284	93.964	105.394	103.804	110.789	
9	27.299	33.649	92.694	105.394	103.074	111.424	
10	27.299	33.649	92.694	104.759	104.439	108.884	
11	26.664	33.014	93.694	104.124	103.804	107.614	
12	26.664	32.379	93.964	104.124	103.804	107.614	
13	26.664	31.744	92.694	102.854	105.074	108.884	
14	25.394	31.744	92.694	102.854	103.804	108.884	
[illegible]	[illegible]	31.109	92.694	103.469	103.804	108.884	
[illegible]	[illegible]	31.109	92.694	104.124	106.344	112.694	
[illegible]	[illegible]	30.474	92.059	101.584	108.884	115.234	
[illegible]	[illegible]	27.934	92.694	101.584	106.344	113.964	
[illegible]	19.044	25.394	91.424	101.584	103.804	112.694	
[illegible]	[illegible]	26.664	91.424	101.584	102.534	108.604	
[illegible]	29.204	34.284	91.424	101.584	108.884	113.964	
[illegible]	29.204	34.284	91.424	100.949	106.34	115.234	
[illegible]	26.664	33.014	91.424	100.949	106.344	112.694	
[illegible]	[illegible]	[illegible]	91.424	101.534	106.344	115.234	
[illegible]	[illegible]	[illegible]	91.424	101.584	103.804	108.884	
[illegible]	26.664	[illegible]	91.424	101.584	104.439	110.154	
[illegible]	[illegible]	[illegible]	[illegible]	101.584	105.074	111.424	
[illegible]	[illegible]	[illegible]	91.424	101.504	105.074	111.424	
[illegible]	[illegible]	[illegible]	91.424	99.044	104.439	111.424	

APPENDIX X

TABLE XLVI WATER FLOW DIRECTIONS IN SOIL. UNIT: H2O MONTH OF: SEPTEMBER, 1979

DATE	VERTICAL FLOW						HORIZONTAL FLOW			REMARKS
	BP1 & WP1	BP1 & YP1	WP1 & YP1	BP2 & WP2	BP2 & YP2	WP2 & YP2	BP2 -BP1	WP2-WP1	YP2-YP1	
1	DOWN	DOWN	DOWN	DOWN	DOWN	DOWN	2 to 1	2 to 1	2 to1	
2	"	"	"	"	"	"	"	"	"	
3	"	"	"	"	"	"	"	"	"	
4	"	"	"	"	"	"	"	"	"	
5	"	"	"	"	"	"	"	"	"	
6	"	"	"	"	"	"	"	"	"	
7	"	"	"	"	"	"	"	"	"	
8	"	"	"	"	"	"	"	"	"	
9	"	"	"	"	"	"	"	"	"	
10	"	"	"	"	"	"	"	"	"	
11	"	"	"	"	"	"	"	"	"	
12	"	"	"	"	"	"	"	"	"	
13	"	"	"	"	"	"	"	"	"	
14	"	"	"	"	"	"	"	"	"	
15	"	"	"	"	"	"	"	"	"	
16	"	"	"	"	"	"	"	"	"	
17	"	"	"	"	"	"	"	"	"	
18	"	"	"	"	"	"	"	"	"	
19	"	"	"	"	"	"	"	"	"	
20	"	"	"	"	"	"	"	"	"	
21	"	"	"	"	"	"	"	"	"	
22	"	"	"	"	"	"	"	"	"	
23	"	"	"	"	"	"	"	"	"	
24	"	"	"	"	"	"	"	"	"	
25	"	"	"	"	"	"	"	"	"	
26	"	"	"	"	"	"	"	"	"	
27	"	"	"	"	"	"	"	"	"	
28	"	"	"	"	"	"	"	"	"	
29	"	"	"	"	"	"	"	"	"	
30	"	"	"	"	"	"	"	"	"	

APPENDIX X

TABLE XLVII WATER RISE IN PIEZOMETERS. UNIT:H2O MONTH OF: OCTOBER,1979.

DATE	BLUE PIEZOMETERS		WHITE PIEZOMETERS		YELLOW PIEZOMETERS		R E M A R K S
	BP1 cm	BP2 cm	WP1 cm	WP2 cm	YP1 cm	YP2 cm	
1	24.124	29.204	91.424	96.504	103.804	112.694	
2	21.584	29.204	90.154	96.504	101.264	107.614	
3	21.584	24.124	90.154	96.504	101.264	108.804	
4	25.394	29.304	90.154	96.504	103.804	110.154	
5	29.204	35.554	90.154	97.774	106.344	111.424	
6	31.744	39.840	91.424	98.409	105.074	107.614	
7	34.284	42.380	91.424	99.679	108.884	113.964	
8	33.649	42.380	91.424	100.314	106.344	109.519	
9	34.284	42.380	91.424	101.584	108884	113.964	
10	34.284	42,380	92.694	102.584	107.614	115.234	
11	34.284	42.380	92.694	103.489	107.614	112.694	
12	31.744	39.840	92.694	104.124	107.614	115.869	
13	31.109	37.300	92.694	104.759	107.614	115.869	
14	30.474	38.094	92.694	105.394	108.834	116.504	
15	28.569	36.189	92.694	105.394	107.614	115.869	
16	27.934	36.189	93.329	106.029	107.614	115.234	
17	29.204	36.824	93.964	106.029	107.614	113.964	
18	29.204	36.824	93.964	104.124	106.979	113.964	
19	26.664	35.554	93.329	106.029	106.979	113.964	
20	26.029	33.014	92.694	105.394	106.344	115.234	
21	25.394	33.014	93.964	105.394	107.614	114.599	
22	29.839	38.094	92.694	105.394	110.154	116.504	
23	33.649	41.110	93.329	105.394	112.694	118.409	
24	34.284	42.380	93.964	106.029	111.424	113.964	
25	35.554	42.380	93.964	106.664	112.059	114.599	
26	35.554	42.380	94.599	107.299	112.694	115.234	
27	35.554	42.380	55.234	107.934	112.694	116.504	
28	34.284	42.380	95.234	108.569	112.694	117.774	
29	34.919	42.380	95.869	108.569	111.424	116.504	
30	31.744	39.840	96.504	107.934	111.424	120.314	
31	34.284	41.110	96.504	109.204	111.424	116.504	

APPENDIX X

TABLE XLVI WATER FLOW DIRECTIONS IN SOIL. UNIT: H2O MONTH OF: OCTOBER, 1979

DATE	VERTICAL FLOW						HORIZONTAL FLOW			REMARKS
	BP1 & WP1	BP1 & YP1	WP1 & YP1	BP2 & WP2	BP2 & YP2	WP2 & YP2	BP2 -BP1	WP2-WP1	YP2-YP1	
1	DOWN	DOWN	DOWN	DOWN	DOWN	DOWN	2 to 1	2 to 1	2 to 1	
2	•	•	•	•	•	•	•	•	•	
3	•	•	•	•	•	•	•	•	•	
4	•	•	•	•	•	•	•	•	•	
5	•	•	•	•	•	•	•	•	•	
6	•	•	•	•	•	•	•	•	•	
7	•	•	•	•	•	•	•	•	•	
8	•	•	•	•	•	•	•	•	•	
9	•	•	•	•	•	•	•	•	•	
10	•	•	•	•	•	•	•	•	•	
11	•	•	•	•	•	•	•	•	•	
12	•	•	•	•	•	•	•	•	•	
13	•	•	•	•	•	•	•	•	•	
14	•	•	•	•	•	•	•	•	•	
15	•	•	•	•	•	•	•	•	•	
16	•	•	•	•	•	•	•	•	•	
17	•	•	•	•	•	•	•	•	•	
18	•	•	•	•	•	•	•	•	•	
19	•	•	•	•	•	•	•	•	•	
20	•	•	•	•	•	•	•	•	•	
21	•	•	•	•	•	•	•	•	•	
22	•	•	•	•	•	•	•	•	•	
23	•	•	•	•	•	•	•	•	•	
24	•	•	•	•	•	•	•	•	•	
25	•	•	•	•	•	•	•	•	•	
26	•	•	•	•	•	•	•	•	•	
27	•	•	•	•	•	•	•	•	•	
28	•	•	•	•	•	•	•	•	•	
29	•	•	•	•	•	•	•	•	•	
30	•	•	•	•	•	•	•	•	•	
31	•	•	•	•	•	•	•	•	•	

APPENDIX X

TABLE XLIX WATER RISE IN PIEZOMETERS. UNIT: H2O MONTH OF: NOVEMBER, 1979

DATE	BLUE PIEZOMETERS		WHITE PIEZOMETERS		YELLOW PIEZOMETERS		REMARKS
	BP1 cm	BP2 cm	WP1 cm	WP2 cm	YP1 cm	YP2 cm	
1	30.474	37.304	96.505	107.734	111.424	119.679	
2	35.554	42.380	96.504	109.039	113.964	119.679	
3	36.824	44.920	96.504	110.474	116.5[illegible]	119.044	
4	35.554	36.824	97.774	110.474	115.234	118.409	
5	36.189	38.570	97.774	111.109	116.504	122.219	
6	37.300	40.320	99.044	113.014	121.584	124.124	
7	38.570	40.380	99.044	113.649	117.774	122.854	
8	37.300	41.110	100.314	114.284	118.409	123.409	
9	38.094	39.840	100.314	114.284	119.044	124.124	
10	39.840	43.650	100.314	113.014	121.584	126.029	
11	33.014	39.840	101.584	114.284	124.124	127.299	
12	34.284	43.650	101.584	114.284	121.584	126.664	
13	34.284	41.110	102.854	114.284	120.949	126.664	
14	34.919	38.570	103.489	114.284	120.344	126.664	
15	34.284	39.840	102.584	114.284	119.044	123.489	
16	34.284	39.840	104.124	114.284	118.409	122.854	
17	33.014	[redacted]	[redacted]	[redacted]	116.504	121.584	
18	32.379	37.[redacted]	[redacted]	[redacted]	117.139	122.504	
19	31.734	36.824	[redacted]	[redacted]	117.774	124.124	
20	30.474	36.824	[redacted]	[redacted]	[redacted]	122.854	
21	32.379	37.300	[redacted]	[redacted]	115.869	120.949	
22	29.839	[redacted]	[redacted]	[redacted]	115.169	120.949	
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	116.[illegible]	121.504	

APPENDIX X

TABLE L WATER FLOW DIRECTIONS IN SOIL, UNIT: H2O MONTH OF: NOVEMBER 1979

DATE	VERTICAL FLOW						HORIZONTAL FLOW			REMARKS
	BP1 & WP1	BP1 & YP1	WP1 & YP1	BP2 & WP2	BP2 & YP2	WP2 & YP2	BP2 -BP1	WP2-WP1	YP2-YP1	
1	DOWN	DOWN	DOWN	DOWN	DOWN	DOWN	2 to 1	2 to 1	2 to 1	
2	•	•	•	•	•	•	•	•	•	
3	•	•	◆	•	•	•	•	•	•	◆ No water movement
4	•	•	DOWN	•	•	•	•	•	•	
5	•	•	•	•	•	•	•	•	•	
6	•	•	•	•	•	•	•	•	•	
7	•	•	•	•	•	•	•	•	•	
8	•	•	•	•	•	•	•	•	•	
9	•	•	•	•	•	•	•	•	•	
10	•	•	•	•	•	•	•	•	•	
11	•	•	•	•	•	•	•	•	•	
12	•	•	◆	•	•	•	•	•	•	
13	•	•	DOWN	•	•	•	•	•	•	
14	•	•	•	•	•	•	•	•	•	
15	•	•	•	•	•	•	•	•	•	
16	•	•	•	•	•	•	•	•	•	
17	•	•	•	•	•	•	•	•	•	
18	•	•	•	•	•	•	•	•	•	
[illegible]	•	•	•	•	•	•	•	•	•	

APPENDIX X

TABLE LI WATER RISE IN PIEZOMETERS. UNIT: H2O MONTH OF: DECEMBER, 1979.

DATE	BLUE PIEZOMETERS		WHITE PIEZOMETERS		YELLOW PIEZOMETERS		REMARKS
	BP1 cm	BP2 cm	WP1 cm	WP2 cm	YP1 cm	YP2 cm	
1	27.259	31.734	101.504	107.934	116.504	119.044	
2	26.664	31.109	100.949	107.299	115.869	119.044	
3	26.029	30.474	100.314	106.664	115.234	119.044	
4	27.934	31.734	100.314	106.664	114.599	118.409	
5	29.204	33.014	100.314	106.664	113.694	117.774	
6	26.664	30.474	99.679	106.029	113.329	117.774	
7	24.124	29.204	99.044	105.394	113.329	117.774	
8	24.124	29.204	99.044	105.394	111.424	116.504	
9	24.124	29.204	99.044	104.124	109.519	113.694	
10	24.124	29.204	99.044	104.124	106.834	111.424	
11	24.124	26.664	99.044	104.124	108.084	111.424	
12	23.469	26.664	98.409	104.124	108.884	111.424	
13	21.584	25.394	97.774	102.854	106.344	108.804	
14	18.114	20.314	97.774	101.584	102.534	106.979	
15	13.964	16.504	96.504	100.949	98.724	106.344	
16	10.154	7.614	95.234	100.314	93.644	103.004	
[redacted]	[redacted]	12.694	93.964	97.774	97.434	89.994	
[redacted]	[redacted]	21.584	92.694	96.504	99.994	97.454	
[redacted]	[redacted]	[redacted]	91.424	96.504	101.264	103.804	

APPENDIX X

TABLE LII WATER FLOW DIRECTIONS IN SOIL. UNIT: H20 MONTH OF: DECEMBER, 1979

DATE	VERTICAL FLOW						HORIZONTAL FLOW			REMARKS
	BP1 & WP1	BP1 & YP1	WP1 & YP1	BP2 & WP2	BP2 & YP2	WP2 & YP2	BP2 - BP1	WP2-WP1	YP2-YP1	
1	DOWN	DOWN	DOWN	DOWN	DOWN	DOWN	2 to 1	2 to 1	2 to 1	
2	•	•	•	•	•	•	•	•	•	
3	•	•	•	•	•	•	•	•	•	
4	•	•	•	•	•	•	•	•	•	
5	•	•	•	•	•	•	•	•	•	
6	•	•	•	•	•	•	•	•	•	
7	•	•	•	•	•	•	•	•	•	
8	•	•	•	•	•	•	•	•	•	
9	•	•	•	•	•	•	•	•	•	
10	•	•	•	•	•	•	•	•	•	
11	•	•	•	•	•	•	•	•	•	
12	•	•	•	•	•	•	•	•	•	
13	•	•	•	•	•	•	•	•	•	
14	+	•	•	UP	•	•	"	•	•	+ No water movement
15	UP	•	•	•	•	•	•	•	•	
16	•	•	•	•	•	•	1 to 2	•	•	
17	•	•	•	•	•	•	2 to 1	•	•	
18	DOWN	•	•	DOWN	•	•	•	•	1 to 2	
[illegible]	•	•	•	•	•	•	•	•	2 to 1	

APPENDIX 5

TABLE LIII WATER RISE IN PIEZOMETERS, UNIT I 1980 MONTH OF: JANUARY 1980

DATE	BLUE PIEZOMETERS		WHITE PIEZOMETERS		YELLOW PIEZOMETERS		REMARKS
	BP1 cm	BP2 cm	WP1 cm	WP2 cm	YP1 cm	YP2 cm	
1	0.00	0.000	81.264	81.264	75.864	88.564	
2	0.000	0.000	77.454	78.724	70.784	86.024	
3	"	"	76.184	76.184	65.704	78.404	
4	"	"	72.374	73.644	60.624	75.864	
5	"	"	69.834	71.104	56.814	70.784	
6	"	"	68.564	68.564	53.004	64.434	
7	"	"	64.754	64.754	50.464	59.354	
8	"	"	60.944	60.944	46.654	55.544	
9	"	"	57.134	57.134	44.114	53.004	
10	"	"	54.594	54.594	40.304	50.464	
11	"	"	52.054	52.054	37.764	45.384	
12	"	"	48.244	48.244	35.214	45.384	
13	"	"	45.704	45.704	32.684	41.574	
14	"	"	43.164	41.894	30.144	39.034	
15	"	"	39.354	38.084	28.874	37.764	
16	[redacted]	[redacted]	38.084	36.814	26.334	35.224	
[redacted]	[redacted]	[redacted]	35.544	33.004	17.444	30.144	
[redacted]	[redacted]	[redacted]	33.004	31.734	19.984	27.604	
[redacted]	[redacted]	[redacted]	30.464	26.654	19.349	26.969	
[redacted]	[redacted]	[redacted]	[redacted]	22.844	18.714	26.334	
[redacted]	[redacted]	[redacted]	[redacted]	20.304	17.444	25.034	
22	[redacted]	[redacted]	[redacted]	19.034	13.634	19.984	
23	[redacted]	[redacted]	[redacted]	15.224	14.904	19.984	
24	[redacted]	[redacted]	19.134	13.534	13.634	18.714	
[redacted]	[redacted]	[redacted]	17.764	12.684	12.364	17.444	
[redacted]	[redacted]	[redacted]	15.224	10.144	11.094	16.809	
[redacted]	[redacted]	[redacted]	[redacted]	7.604	10.459	16.174	
[redacted]	[redacted]	[redacted]	10.144	6.334	[illegible]	14.904	
[redacted]	[redacted]	[redacted]	7.604	5.064	9.824	12.364	
[redacted]	[redacted]	[redacted]	5.064	2.524	7.284	9.824	
[redacted]	[redacted]	[redacted]	[illegible]	0.000	4.744	7.284	

TABLE LIV WATER FLOW DIRECTIONS IN BOTH... UNIT: [illegible] APPENDIX [illegible] MONTH OF: JANUARY, 1990

DATE	VERTICAL FLOW						HORIZONTAL FLOW			REMARKS
	BP1 & WP1	BP1 & YP1	WP1 & YP1	BP2 & WP2	BP2 & YP2	WP2 & YP2	BP2 -BP1	WP2-WP1	YP2-YP1	
1	♦	DOWN	DOWN	DOWN	DOWN	DOWN	♦	♦	2 to 1	♦ No water movement
2	DOWN	"	"	"	"	"	♦	2 to 1	"	
3	"	"	"	"	"	"	♦	♦	"	
4	"	"	"	"	"	"	♦	2 to 1	"	
5	"	"	"	"	"	"	♦	"	"	
6	"	"	"	"	"	"	♦	♦	"	
7	"	"	"	"	"	"	♦	♦	"	
8	"	"	"	"	"	"	♦	♦	"	
9	"	"	"	"	"	"	♦	♦	"	
10	"	"	"	"	"	"	♦	♦	"	
11	"	"	"	"	"	"	♦	♦	"	
12	"	"	"	"	"	"	♦	♦	"	
13	"	"	"	"	"	"	♦	♦	"	
14	"	"	"	"	"	"	♦	1 to 2	"	
15	"	"	"	"	"	"	♦	"	"	
16	"	"	"	"	"	"	♦	"	"	
17	"	"	"	"	"	"	♦	"	"	
18	"	"	"	"	"	"	♦	"	"	
19	"	"	"	"	"	"	♦	"	"	
20	"	"	"	"	"	"	♦	"	"	
21	"	"	"	"	"	"	♦	"	"	
22	"	"	"	"	"	"	♦	"	"	
23	"	"	"	"	"	"	♦	"	"	
24	"	"	"	"	"	"	♦	"	"	
25	"	"	"	"	"	"	♦	"	"	
26	"	"	"	"	"	"	♦	"	"	
27	"	"	"	"	"	"	♦	"	"	
28	"	"	"	"	"	"	♦	"	"	
29	"	"	"	"	"	"	♦	"	"	
30	"	"	"	"	"	"	♦	"	"	
31	"	"	"	"	"	"	♦	"	"	

APPENDIX 9 MONTH OF: FEBRUARY, 1990

TABLE LV WATER RISE IN PIEZOMETERS, UNIT: [illegible]

DATE	BLUE PIEZOMETERS		WHITE PIEZOMETERS		YELLOW PIEZOMETERS		REMARKS
	BP1 cm	BP2 cm	WP1 cm	WP2 cm	YP1 cm	YP2 cm	
1	0.000	0.000	0.000	0.000	2.204	4.744	
2	"	"	"	"	0:000	2.204	
3	"	"	"	"	"	0.000	
4	"	"	"	"	"	"	
5	"	"	"	"	"	"	
6	"	"	"	"	"	"	
7	"	"	"	"	"	"	
8	"	"	"	"	"	"	
9	"	"	"	"	"	"	
10	"	"	"	"	"	"	
11	"	"	"	"	"	"	
12		"	"	"	"	"	
13	"	"	"	"	"	"	
14	"	"	"	"	"	"	
15	"	"	"	"	"	"	
16	"	"	"	"	"	"	
17	"	"	"	"	"	"	
18	"	"	"	"	"	"	
19	"	"	"	"	"	"	
20	"	"	"	"	"	"	
21	"	"	"	"	"	"	
22	"	"	"	"	"	"	
23	"	"	"	"	"	"	
24	"	"	"	"	"	"	
25	"	"	"	"	"	"	
26	"	"	"	"	"	"	
27	"	"	"	"	"	"	
28	"	"	"	"	"	"	

APPENDIX XI

PENMAN METHOD OF EVAPOTRANSPIRATION COMPUTATION

APPENDIX XI

PENMAN METHOD

FORMULA:[1]

$$E_T = \frac{\Delta H + 0.27\ Ea}{\Delta - 0.27}$$

With values of H and Ea given by:

$$H = RA(I - \gamma)(0.18\ .55n/N) - 6Ta^4\ (0.56 - 0.092\sqrt{ed})\ (0.10 + 0.90\ n/N).$$

$$Ea = 0.35(ea - ed)(1 + 0.0098 U_2)$$

Where H = daily heat budget at surface in mm H_2O/day

RA = Mean monthly extra terrestrial radiation in mm H_2O/day.

γ = reflection coefficient of surface

n = actual duration of bright sunshine

N = Maximum possible duration of bright sunshine

σ = Boltzmann constant

σT_a^4 = mm H_2O/Day

ed = Saturation vapour pressure at mean dew point (i.e. actual vapour in the air) mm Hg

Ea = evaporation in (mm) H_2O/day

ea = Saturation vapour at mean air temperature in mm Hg

U_2 = Mean windspeed at 2 metre above the ground (miles/day)[3]

E_T = evapotranspiration in mm H_2O/day

U_1 = measured windspeed in miles per day at height h in feet

Δ = slope of saturated vapour pressure curve of air at absolute temperature T_a in ^oF (mm H_g / ^oF)

3 Wind measurements taken at other heights can be corrected to the 2-metre elevation by use of the formula:

$$u_2 = u_1\left(\frac{\log 6.6}{\log h}\right)$$

---

1 P 241 Irrigation Principles by Israelsen.

Table I: VALUES FOR T_a^4

Temperature °C	σT_a^4 mm H_2O/day
18.33	14.52
18.40	.14.54
18.50	14.56
18.60	14.58
18.70	14.60
18.80	14.62
18.90	14.64
19.00	14.66
19.10	14.68
19.20	14.70
19.30	14.72
19.40	14.74
19.50	14.76
19.60	14.79
19.70	14.81
19.80	14.83
19.90	14.85
20.00	14.87
20.10	14.89
20.20	14.91

Table I: (Cont'd)

Temperature ^{o}C	σT_a^4 mm H_2O/day
20.30	14.93
20.40	14.95
20.50	14.97
20.60	14.99
20.70	15.02
20.80	15.04
20.90	15.06
21.00	15.08
21.1	15.10
21.2	15.12
21.3	15.14
21.4	15.16
21.5	15.18
21.6	15.20
21.7	15.22
21.8	15.24
21.9	15.26
22.0	15.28
22.10	15.30
22.20	15.32

Table I: (Cont'd)

Temperature ^{o}C	σT_a^4 mm H_2O/day
22.30	15.34
22.40	15.36
22.50	15.38
22.60	15.40
22.70	15.42
22.80	15.43
22.90	15.45
23.00	15.47
23.10	15.49
23.20	15.51
23.30	15.53
23.40	15.55
23.50	15.57
23.60	15.59
23.70	15.61
23.30	15.63
23.90	15.65
24.00	15.67

APPENDIX XI

Table II: Extra Terrestrial Radiation (Ra) expressed in equivalent evaporation in mm/day

Northern Hemisphere													Southern Hemisphere											
Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Lat	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
3.8	6.1	9.4	12.7	15.8	17.1	16.4	14.1	10.9	7.4	4.5	3.2	50°	17.5	14.7	10.9	7.0	4.2	3.1	3.5	5.5	8.9	12.9	16.5	18.2
4.3	6.6	9.8	13.0	15.9	17.2	16.5	14.3	11.2	7.8	5.0	3.7	48	17.6	14.9	11.2	7.5	4.7	3.5	4.0	6.0	9.3	13.2	16.6	18.2
4.9	7.1	10.2	13.3	16.0	17.2	16.6	14.5	11.5	8.3	5.5	4.3	46	17.7	15.1	11.5	7.9	5.2	4.0	4.4	6.5	9.7	13.4	16.7	18.3
5.3	7.6	10.6	13.7	16.1	17.2	16.6	14.7	11.9	8.7	6.0	4.7	44	17.8	15.3	11.9	8.4	5.7	4.4	4.9	6.9	10.2	13.7	16.7	18.3
5.9	8.1	11.0	14.0	16.2	17.3	16.7	15.0	12.2	9.1	6.5	5.2	42	17.8	15.5	12.2	8.8	6.1	4.9	5.4	7.4	10.6	14.0	16.8	18.3
6.4	8.6	11.4	14.3	16.4	17.3	16.7	15.2	12.5	9.6	7.0	5.7	40	17.9	15.7	12.5	9.2	6.5	5.3	5.9	7.9	11.0	14.2	16.9	18.3
6.9	9.0	11.8	14.5	16.4	17.2	16.7	15.3	12.8	10.0	7.5	6.1	38	17.9	15.8	12.8	9.6	7.1	5.8	6.3	8.3	11.4	14.4	17.0	18.3
7.4	9.4	12.1	14.7	16.4	17.2	16.7	15.4	13.1	10.6	8.0	6.6	36	17.9	16.0	13.2	10.1	7.5	6.3	6.8	8.8	11.7	14.6	17.0	18.2
7.9	9.8	12.4	14.8	16.5	17.1	16.8	15.5	13.4	10.8	8.5	7.2	34	17.8	16.1	13.5	10.5	8.0	6.8	7.2	9.2	12.0	14.9	17.1	18.2
8.3	10.2	12.8	15.0	16.5	17.0	16.8	15.6	13.6	11.2	9.0	7.8	32	17.8	16.2	13.8	10.9	8.5	7.3	7.7	9.6	12.4	15.1	17.2	18.1
8.8	10.7	13.1	15.2	16.5	17.0	16.8*	15.7	13.9	11.6	9.5	8.3	30	17.8	16.4	14.0	11.3	8.9	7.8	8.1	10.1	12.7	15.3	17.3	18.1
9.3	11.1	13.4	15.3	16.5	16.8	16.7	15.7	14.1	12.0	9.9	8.8	28	17.7	16.4	14.3	11.6	9.3	8.2	8.6	10.4	13.0	15.4	17.2	17.9
9.8	11.5	13.7	15.3	16.4	16.7	16.6	15.7	14.3	12.3	10.3	9.3	26	17.6	16.4	14.4	12.0	9.7	8.7	9.1	10.9	13.2	15.5	17.2	17.8
10.2	11.9	13.9	15.4	16.4	16.6	16.5	15.8	14.5	12.6	10.7	9.7	24	17.5	16.5	14.6	12.3	10.2	9.1	9.5	11.2	13.4	15.6	17.1	17.7
10.7	12.3	14.2	15.5	16.3	16.4	16.4	15.8	14.6	13.0	11.1	10.2	22	17.4	16.5	14.8	12.6	10.6	9.6	10.0	11.6	13.7	15.7	17.0	17.5
11.2	12.7	14.4	15.6	16.3	16.4	16.3	15.9	14.8	13.3	11.6	10.7	20	17.3	16.5	15.0	13.0	11.0	10.0	10.4	12.0	13.9	15.8	17.0	17.4
11.6	13.0	14.6	15.6	16.1	16.1	16.1	15.8	14.9	13.6	12.0	11.1	18	17.1	16.5	15.1	13.2	11.4	10.4	10.8	12.3	14.1	15.8	16.8	17.1
12.0	13.3	14.7	15.6	16.0	15.9	15.9	15.7	15.0	13.9	12.4	11.6	16	16.9	16.4	15.2	13.5	11.7	10.8	11.2	12.6	14.3	15.8	16.7	16.8
12.4	13.6	14.9	15.7	15.8	15.7	15.7	15.7	15.1	14.1	12.8	12.0	14	16.7	16.4	15.3	13.7	12.1	11.2	11.6	12.9	14.5	15.8	16.5	16.6
12.8	13.9	15.1	15.7	15.7	15.5	15.5	15.6	15.2	14.4	13.3	12.5	12	16.6	16.3	15.4	14.0	12.5	11.6	12.0	13.2	14.7	15.8	16.4	16.5
13.2	14.2	15.3	15.7	15.5	15.3	15.3	15.5	15.3	14.7	13.6	12.9	10	16.4	16.3	15.5	14.2	12.8	12.0	12.4	13.5	14.8	15.9	16.2	16.2
13.6	14.5	15.3	15.6	15.3	15.0	15.1	15.4	15.3	14.8	13.9	13.3	8	16.1	16.1	15.5	14.4	13.1	12.4	12.7	13.7	14.9	15.8	16.0	16.0
13.9	14.8	15.4	15.4	15.1	14.7	14.9	15.2	15.3	15.0	14.2	13.7	6	15.8	16.0	15.6	14.7	13.4	12.8	13.1	14.0	15.0	15.7	15.8	15.7
14.3	15.0	15.5	15.5	14.9	14.4	14.6	15.1	15.3	15.1	14.5	14.1	4	15.5	15.8	15.6	14.9	13.8	13.2	13.4	14.3	15.1	15.6	15.5	15.4
14.7	15.3	15.6	15.3	14.6	14.2	14.3	14.9	15.3	15.3	14.8	14.4	2	15.3	15.7	15.7	15.1	14.1	13.5	13.7	14.5	15.2	15.5	15.3	15.1
15.0	15.5	15.7	15.3	14.4	13.9	14.1	14.8	15.3	15.4	15.1	14.8	0	15.0	15.5	15.7	15.3	14.4	13.9	14.1	14.8	15.3	15.4	15.1	14.8

APPENDIX XI

Table III: Mean Daily Duration of Maximum Possible Sunshine Hours (N) for Different Months and Latitudes

Northern Lats	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Southern Lats	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
50	8.5	10.1	11.8	13.8	15.4	16.3	15.9	14.5	12.7	10.8	9.1	8.1
48	8.8	10.2	11.8	13.6	15.2	16.0	15.6	14.3	12.6	10.9	9.3	8.3
46	9.1	10.4	11.9	13.5	14.9	15.7	15.4	14.2	12.6	10.9	9.5	8.7
44	9.3	10.5	11.9	13.4	14.7	15.4	15.2	14.0	12.6	11.0	9.7	8.9
42	9.4	10.6	11.9	13.4	14.6	15.2	14.9	13.9	12.6	11.1	9.8	9.1
40	9.6	10.7	11.9	13.3	14.4	15.0	14.7	13.7	12.5	11.2	10.0	9.3
35	10.1	11.0	11.9	13.1	14.0	14.5	14.3	13.5	12.4	11.3	10.3	9.8
30	10.4	11.1	12.0	12.9	13.6	14.0	13.9*	13.2	12.4	11.5	10.6	10.2
25	10.7	11.3	12.0	12.7	13.3	13.7	13.5	13.0	12.3	11.6	10.9	10.6
20	11.0	11.5	12.0	12.6	13.1	13.3	13.2	12.8	12.3	11.7	11.2	10.9
15	11.3	11.6	12.0	12.5	12.8	13.0	12.9	12.6	12.2	11.8	11.4	11.2
10	11.6	11.8	12.0	12.3	12.6	12.7	12.6	12.4	12.1	11.8	11.6	11.5
5	11.8	11.9	12.0	12.2	12.3	12.4	12.3	12.3	12.1	12.0	11.9	11.8
0	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1

APPENDIX XI

Table IV: Values of Weighting Factor (W) for the Effect of Radiation on ETo at Different Temperatures and Altitudes

Temperature °C	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
W at altitude m																				
0	0.43	.46	.49	.52	.55	.58	.61	.64	.66	.68	.71	.73	.75	.77*	.78	.80	.82	.83	.84	.85
500	.45	.48	.51	.54	.57	.60	.62	.65	.67	.70	.72	.74	.76	.78	.79	.81	.82	.84	.85	.86
1 000	.46	.49	.52	.55	.58	.61	.64	.66	.69	.71	.73	.75	.77	.79	.80	.82	.83	.85	.86	.87
2 000	.49	.52	.55	.58	.61	.64	.66	.69	.71	.73	.75	.77	.79	.81	.82	.84	.85	.86	.87	.88
3 000	.52	.55	.58	.61	.64	.66	.69	.71	.73	.75	.77	.79	.81	.82	.84	.85	.86	.88	.88	.89
4 000	.55	.58	.61	.64	.66	.69	.71	.73	.76	.78	.79	.81	.83	.84	.85	.86	.88	.89	.90	.90

APPENDIX XI

Table V

VALUES OF σT_a^4 FOR VARIOUS TEMPERATURES WHEN COMPUTING EVAPO-TRANSPIRATION BY THE PENMAN METHOD (AFTER CRIDDLE)

Temperature	σT_a^4	Temperature	σT_a^4
°Abs	mm H_2O/day	°F	mm H_2O/day
270	10.73	35	11.48
275	11.51	40	11.96
280	12.40	45	12.45
285	13.20	50	12.94
290	14.26	55	13.45
295	15.30	60	13.96
300	16.34	65	14.52
305	17.46	70	15.10
310	18.60	75	15.65
315	19.85	80	16.25
320	21.15	85	16.85
325	22.50	90	17.46
		95	18.10
		100	18.80

Note: Heat of vaporization was assumed to be constant at 590 gal/gm of H_2O.

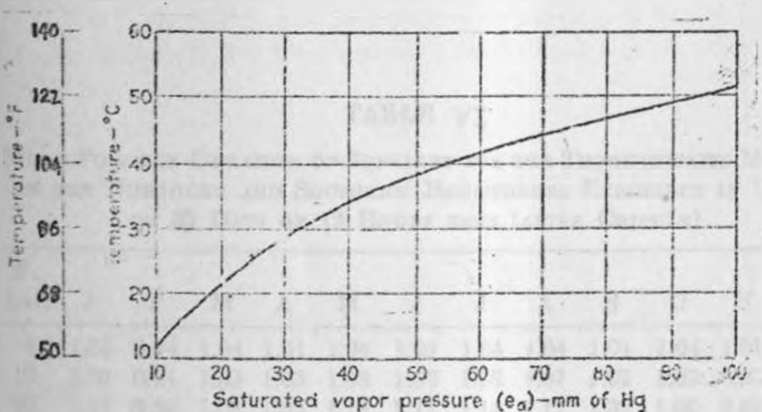

Fig. 1 Temperature vs. saturated vapor pressure. (After Criddle.)

APPENDIX XI

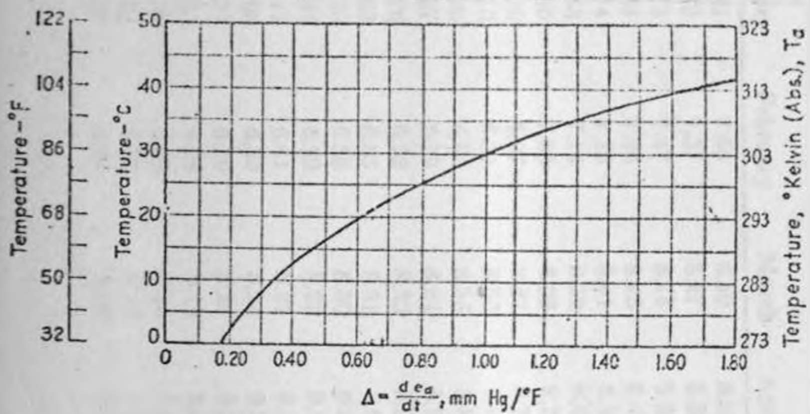

Fig. II Temperature vs. Δ

$\left(\frac{d \text{ Saturation Vapor Pressure, mm Hg.}}{d \text{ Temperature, °F}}\right)$ (After Criddle.)

TABLE VI

MEAN POSSIBLE DURATION OF SUNLIGHT FOR THE THORNTHWAITE METHOD IN THE NORTHERN AND SOUTHERN HEMISPHERES EXPRESSED IN UNITS OF 30 DAYS OF 12 HOURS EACH (AFTER CRIDDLE)

N. Lat.	J	F	M	A	M	J	J	A	S	O	N	D
0	1.04	0.94	1.04	1.01	1.04	1.01	1.04	1.04	1.01	1.04	1.01	1.04
10	1.00	0.91	1.03	1.03	1.08	1.06	1.08	1.07	1.02	1.02	0.98	0.99
20	0.95	0.90	1.03	1.05	1.13	1.11	1.14	1.11	1.02	1.00	0.93	0.94
30	0.90	0.87	1.03	1.08	1.18	1.17	1.20	1.14	1.03	0.98	0.89	0.88
35	0.87	0.85	1.03	1.09	1.21	1.21	1.23	1.16	1.03	0.97	0.86	0.85
40	0.84	0.83	1.03	1.11	1.24	1.25	1.27	1.18	1.04	0.96	0.83	0.81
45	0.80	0.81	1.02	1.13	1.28	1.29	1.31	1.21	1.04	0.94	0.79	0.75
50	0.74	0.78	1.02	1.15	1.33	1.36	1.37	1.25	1.06	0.92	0.76	0.70

APPENDIX XI

Table VII: Percent Day-Light hours - 46° South Latitude to 60° North Latitude

Latitude 0° North	January	February	March	April	May	June	July	August	September	October	November	December
0	8.50	7.66	8.49	8.21	8.50	8.22	8.50	8.49	8.21	8.50	8.22	8.50
5	8.32	7.57	8.47	8.20	8.65	8.41	8.07	8.60	8.23	8.42	8.07	8.30
10	8.13	7.47	8.45	8.37	8.81	8.60	8.86	8.71	8.25	8.34	7.91	8.10
15	7.94	7.36	8.43	8.44	8.98	8.80	9.05	8.83	8.28	8.26	7.75	7.88
20	7.74	7.25	8.41	8.52	9.15	9.00	9.25	8.96	8.30	8.18	7.58	7.66
25	7.53	7.14	8.39	8.61	9.33	9.23	9.45	9.09	8.32	8.09	7.40	7.42
30	7.30	7.03	8.38	8.72	9.53	9.49	9.67	9.22	8.33	7.99	7.19	7.15
32	7.20	6.97	8.37	8.76	9.62	9.59	0.77	9.27	8.34	7.95	7.11	7.05
34	7.10	6.91	8.36	8.80	9.72	9.70	9.88	9.33	8.36	7.90	7.02	6.92
36	6.99	6.85	8.35	8.85	9.82	9.82	9.99	9.40	8.37	7.85	6.92	6.79
38	6.87	6.79	8.34	8.90	9.92	9.95	10.10	9.47	8.38	7.80	6.82	6.66
40	6.76	6.72	8.33	8.95	10.02	10.08	10.22	9.54	8.39	7.75	6.72	7.52
42	6.63	6.65	8.31	9.00	10.14	10.22	10.35	9.62	8.40	7.69	6.62	6.37
44	6.49	6.58	8.30	9.06	10.26	10.38	10.49	9.70	8.41	7.63	6.49	6.21
46	6.34	6.50	8.29	9.12	10.39	10.54	10.64	9.79	8.42	7.57	6.36	6.04
48	6.17	6.41	8.27	9.18	10.53	10.71	10.80	9.89	8.44	7.51	6.23	5.86
50	5.98	6.30	8.24	9.24	10.68	10.91	10.99	10.00	8.46	7.45	6.10	5.65
52	5.77	6.19	8.21	9.29	10.85	11.13	11.20	10.12	8.49	7.39	5.93	5.43
54	5.55	6.08	8.18	9.36	11.03	11.38	11.43	10.26	8.51	7.30	5.74	5.18
56	5.30	5.95	8.15	9.45	11.22	11.67	11.69	10.40	8.53	7.21	5.54	4.89
58	5.01	5.81	8.12	9.55	11.46	12.00	11.98	10.55	8.55	7.10	4.31	4.56
60	4.67	5.65	8.08	9.65	11.74	12.39	12.31	10.70	8.57	6.98	5.04	4.22

APPENDIX XI

Table VII: Cont'd

Lat.	Jan.	Feb.	Mar.	April	May	June	Jul.
South							
0	8.50	7.66	8.49	8.21	8.50	8.22	8.50
5	8.68	7.76	8.51	8.15	8.34	8.05	8.33
10	8.86	7.87	8.53	8.09	8.18	7.86	8.14
15	9.05	7.98	8.55	8.02	8.02	7.65	7.95
20	9.24	8.09	8.57	7.94	7.85	7.43	7.76
25	9.46	8.21	8.60	7.84	7.66	7.20	7.54
30	9.70	8.33	8.62	7.73	7.45	6.96	7.31
32	9.81	8.39	8.63	7.69	7.36	6.85	7.21
34	9.92	8.45	8.64	7.64	7.27	6.74	7.10
36	10.03	8.51	8.65	7.59	7.18	6.62	6.99
38	10.15	8.57	8.66	7.54	7.08	6.50	6.87
40	10.27	8.63	8.67	7.49	6.97	6.37	6.76
42	10.40	8.70	8.68	7.44	6.85	6.23	6.64
44	10.54	8.78	8.69	7.38	6.73	6.08	6.51
46	10.69	8.86	8.70	7.32	6.61	5.92	6.37

Aug.	Sept.	Oct.	Nov.	Dec.
8.49	8.21	8.50	8.22	8.50
8.28	8.19	8.56	8.37	8.68
8.27	8.17	8.62	8.53	8.88
8.15	8.15	8.68	8.70	9.10
8.03	8.13	8.76	8.87	9.33
7.90	8.11	8.86	9.04	9.58
7.76	8.07	8.97	9.24	9.85
7.70	8.06	9.01	9.33	9.96
7.63	8.05	9.06	9.42	10.08
7.56	8.04	9.11	9.51	10.21
7.49	8.03	9.16	9.61	10.34
7.41	8.02	9.21	9.71	10.49
7.33	8.01	9.26	9.82	10.64
7.25	7.99	9.31	9.94	10.80
7.16	7.96	9.37	10.07	10.97

APPENDIX XII

SHORT RAINS CROPS PROGRAMME 1979/80 SEASON

(M.I.S.)

APPENDIX XII

Table I: TEBERE SECTION

APPROXIMATE ACREAGE						ROTAVATION				Date of Issue of Seed & S/A.	Date of Sowing	Date of Issue of S/A.	Date of Trans-planting	Approximate Date of First Harvest.
UNIT NO.	HOLDING	EXTRA FIELDS	TOTAL	GROUP TOTAL	GROUP ORDER	ACRES DAY/ TEAM	NO. OF DAYS	START (APPROX)	FINISH (APPROX)					
T7	228	33	261				12	5-3-79	17-3-1979	13-7-79	16-7-79	10-8-79	13-8-79	12-12-79
T8	320	71	391				18	19-3-79	7-4-79					
T22	160	12	172				8	9-4-79	19-4-79					
T23	96	17	113	1599	1	22	5	20-4-79	25-4-79					
T18	112	33	145				7	26-4-79	4-5-79					
T16	148	38	186				9	5-5-79	15-5-79					
T17	36	22	58				3	16-5-79	18-5-79					
T20	228	45	273				13	19-5-79	4-6-79					
T15	56	28	84				4	5-6-79	8-6-79					
T19	180	78	258	907	11	22	12	9-6-79	22-6-79-					
T21	140	51	191				9	23-6-79	3-7-79	27-7-79	30-7-79	24-8-79	27-8-79	26-12-79
T25	40	18	58				3	4-7-79	6-7-79					
T11	256	60	316				15	7-7-79	24-7-79					
T2	32	23	55	341	III	22	3	25-7-79	27-7-79	17-8-79	20-8-79	5-9-79	8-9-79	16-1-80
T5	248	38	286				13	28-7-79	11-8-79					
T13	148	24	172	312	IV	22	8	13-8-79	21-8-79	31-8-79	3-9-79	21-9-79	24-9-79	30-1-80
T6	116	24	140				7	22-8-79	29-8-79					
TOTAL	2544	615	3159	3159										

6 Tractors in Rotavation team.

Performance = 3.67 acres per tractor per day.

APPENDIX XII

Table II: MWEA SECTION

APPROXIMATE ACREAGE						ROTAVATION				Date of Issue of Seed & S/A.	Date of Sowing	Date of Issue of S/A.	Date of Trans-planting	Approximate Date of First Harvest
UNIT NO.	HOLDING	EXTRA FIELDS	TOTAL	GROUP TOTAL	GROUP ORDER	ACRES DAY/ TEAM	NO. OF DAYS	START (APPROX)	FINISH (APPROX)					
M2	92	8	100	1252	1	22	5	5-3-79	9-3-79	14-7-79	17-7-79	11-8-79	14-8-79	13-12-79
M4	263	64	327				15	10-3-79	27-3-79					
M9	105	21	126				6	28-3-79	3-4-79					
M10	59	22	81				4	4-4-79	7-4-79					
M12	154	34	188				9	9-4-79	20-4-79					
M13	148	20	168				8	21-4-79	30-4-79					
M14	212	50	262				12	2-5-79	15-5-79					
M16	216	110	326	1020	II	22	15	16-5-79	2-6-79	21-7-79	24-7-79	18-8-79	21-8-79	20-12-79
M5	124½	59½	184				9	4-6-79	13-6-79					
M7	69	51	120				6	14-6-79	20-6-79					
M8	60	3	63				3	21-6-79	23-6-79					
M1	188	9	197				9	25-6-79	4-7-79					
M3	69	61	130				6	5-7-79	11-7-79					
M6	148½	9½	158	502	111	22	7	12-7-79	19-7-79	4-8-79	7-8-79	1-9-79	4-9-79	3-1-80
M17	272	72	344				16	20-7-79	7-8-79					
M15	104	11	115	234	IV	22	6	8-8-79	14-8-79	25-8-79	28-8-79	22-9-79	25-9-79	24-1-80
M11	79	40	119				6	15-8-79	21-8-79					
TOTAL	2363	645	3008	3008										

6 Tractors in Rotavation team.

Performance = 3.67 acres per tractor per day.

APPENDIX XII

Table III: THIBA SECTION

APPROXIMATE ACREAGE						ROTAVATION				Date of Issue of Seed & S/A.	Date of Sowing	Date of Issue of S/A.	Date of Trans-planting	Approximate Date of First Harvest
UNIT NO.	HOLDING	EXTRA FIELDS	TOTAL	GROUP TOTAL	GROUP ORDER	ACRES DAY/ TEAM	NO. OF DAYS	START (APPROX)	FINISH (APPROX)					
H4	204	17	221	1146	1	22	10	5-3-79	15-3-79	16-7-79	18-7-79	13-8-79	15-8-79	14-12-79
H5	360	23	383				18	16-3-79	5-4-79					
H6	236	35	271				13	6-4-79	23-4-79					
H19	228	43	271				13	24-4-79	9-5-79					
H7	136	66	202	744	II	22	10	10-5-79	21-5-79	23-7-79	25-7-79	20-8-79	22-8-79	21-12-79
H18	262	13	275				13	22-5-79	6-6-79					
H3	260	7	267				13	7-6-79	21-6-79					
H20	248	36	284	518	III	22	13	22-6-79	6-7-79	30-7-79	1-8-79	27-8-79	29-8-79	28-12-79
H 8	196	38	234				11	7-7-79	19-7-79					
H 1	176	3	179	405	IV	22	9	20-7-79	30-7-79	13-8-79	15-8-79	10-9-79	12-9-79	12-1-80
H2	220	6	226				11	31-7-79	11-8-79					
TOTAL	2526	287	2813	2813										

6 Tractors in Rotavation team.
Performance = 3.67 acres per tractor per day.

Flooding = H1 11 days, H2 6 days, H3 10 days

Flooding Allowance = 7 days of flooding before rotavation starts.

APPENDIX XII

Table IV: WAMUMU SECTION

APPROXIMATE ACREAGE						ROTAVATION				Date of Issue of Seed & S/A.	Date of Sowing	Date of Issue of S/A.	Date of Trans-planting	Approximate Date of First Harvest.
UNIT NO.	HOLDING	EXTRA FIELDS	TOTAL	GROUP TOTAL	GROUP ORDER	ACRES DAY/ TEAM	NO. OF DAYS	START (APPROX)	FINISH (APPROX)					
W2 W4 W5	472 312 396	10 10¾ 6½	482 322¾ 402½	1207¼	I	22	22 15 19	5-3-79 30-3-79 19-4-79	29-3-79 18-4-79 11-5-79	17-7-79	19-7-79	14-8-79	16-8-79	15-12-79
W3 W6	384 496	10¾ 11	394¾ 507	901¾	II	22	18 23	12-5-79 4-6-79	2-6-79 29-6-79	24-7-79	26-7-79	21-8-79	25-8-79	22-12-79
W1	312	1¾	313¾	313¾	III	22	15	30-6-79	17-7-79	31-7-79	2-8-79	28-8-79	30-8-79	29-12-79
W7	292	-	292	292	IV	22	14	18-7-79	2-8-79	7-8-79	9-8-79	4-9-79	6-9-79	5-1-80
TOTAL	2664	51	2715	2715										

6 Tractors in Rotavation team.

Performance = 3.67 acres per tractor per day.

APPENDIX XII

Table V: KARABA SECTION

APPROXIMATE ACREAGE						ROTAVATION				Date of Issue of Seed & S/A.	Date of Sowing	Date of Issue of S/A.	Date of Trans-planting	Approximate Date of First Harvest.
UNIT NO.	HOLDING	EXTRA FIELDS	TOTAL	GROUP TOTAL	GROUP ORDER	ACRES DAY/ TEAM	NO. of DAYS	START (APPROX)	FINISH. (APPROX)					
K3	316	9	325				15	5-3-79	21-3-79					
K2	392	14	406	1240	I	22	19	22-3-79	12-4-79	18-7-79	20-7-79	15-8-79	17-8-79	16-12-79
K1	504	5	509				24	14-4-79	14-5-79					
K4	356	3	359	725	II	22	17	15-5-79	4-6-79	25-7-79	27-7-79	22-8-79	24-8-79	23-12-79
K5	360	6	366				17	5-6-79	23-6-79					
K7	312	6	318	318	III	22	15	25-6-79	11-7-79	1-8-79	3-8-79	29-8-79	31-8-79	30-12-79
K6	264	7	271	271	IV	22	13	12-7-79	26-7-79	8-8-79	10-8-79	5-9-79	7-9-79	6-1-80
TOTAL	2504	50	2554	2554										

6 Tractors in Rotavation team.

Performance = 3.67 acres per tractor per day.

APPENDIX XIII

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