TECHNICAL NOTE

NO. 8

POTENTIAL SALINITY PROBLEMS AT LAM NAM OON AND RESULTS OF INITIAL INVESTIGATIONS

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OF THE

KINGDOM OF THAILAND

Work Performed By

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FOREWORD

The Center for Rural Development, which is a Division of the Berger Group of companies, assists clients in planning and implementing programs and projects aimed to expand economic opportunities to improve the well-being of rural populations in many parts of the world.

Currently, in 1983, the Center supports ten major rural development projects which are funded by the World Bank, the U.S. Agency for International Development, the Asian Development Bank, and other international agencies in Asia, Africa, the Middle East, and Latin America.

As a part of its services to clients and the professional community of those engaged in rural development work, the Center releases technical notes on various aspects of individual projects. The notes are numbered by reference to the individual projects.

Technical Note No. 8 is issued as a part of that service.

For those interested, additional copies may be obtained from the Center for Rural Development, c/o Louis Berger International, Inc. 100 Halsted Street, East Orange, New Jersey New Jersey 07019, U.S.A.

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DESCRIPTION - RESEARCH AREA

The Lam Nam Oon Integrated Rural Development Project is now (1983) in it's third year of delivering irrigation water, on a managed basis, through a system of on-farm channels serving individual farms. Presently, about 16,000 rai (2,600 Hectare) are receiving managed irrigation water. By the end of 1985 the current construction program will have completed on-farm water delivery systems serving approximately 185,000 rai or about 31,000 Hectare at Lam Nam Oon.

This project is the only one in Northeastern Thailand to which the Land Consolidation Act of 1974 is being applied to the entire area. At the same time, it is the only one in which so many different Royal Thai Government agencies are seeking to integrate their planning and implementation so as to speed the necessary increases in productivity and economic income. Those increases are mandated under the Land Consolidation Act since, ultimately, the 12,500 benefitted farmers in the area will have to pay back to government up to 50% of the cost of installing the on-farm water delivery systems.

Research, planning, management, and training are all features of the Lam Nam Oon operations.

In the case of this particular Technical Note, the research operations are a consequence of installing special Pilot Areas in the Lam Nam Oon project. One of these, (the subject of this paper) is Pilot Area 2. It contains an experimental system for delivering water to farmer fields. The system features a quaternary-tertiary channel layout in three intensities of infrastructure. Unit 1 has the least amount of channel distribution and all-weather road access, Unit 2 is moderate, and Unit 3 has the highest or most intense distribution.

Other features include the use of gated, proportional, division boxes servicing the tertiary and quaternary layouts, a design modulus for channels based on rainfall analysis at Lam Nam Oon, and no land levelling of farmer fields (except upon request).

Based on the design criteria recommended in Technical Note Number 1 of the Louis Berger International, Inc. advisory team at Lam Nam Oon the Royal Irrigation Department completed construction of the 2,400 rai (400 Hectare) Pilot Area 2 in the summer of 1980. Units 1 and 2 were totally completed at that time. Farmer in those two Units have been equipped with the water resources to carry on irrigated Dry Season cultivation in the two Dry Seasons of 1981/82 and 1982/83. Those in Unit 3 have been similarly equipped since 1981 and for the Dry Season of 1982/83.

In designing this Pilot Area 2, the Louis Berger International, Inc. advisory team was also tasked to continue Operations Research aimed at examining a number of engineering, water use, and agro-economic factors in the area.

The first report on these matters, after a Dry Season of observations, appeared in Project Note No. 5, "Pilot Area 2 Operations Research Results - 1981/82 - Lam Nam Oon".

Technical Note Number 8, presented here, is based upon a series of detailed investigations in the same Pilot Area 2 location during the Dry Season of 1982/83.

Mr. William C. Bell, the author of Technical Note Number 8, designed, supervised, and analysed these special studies. He was assisted in this work by personnel of the Royal Irrigation Department. Support and encouragement provided by the Project Field Director, Vichai Snguanpaiboon; Banjong Tanagsuangnern, the Chief of Operations and Maintenance at Lam Nam Oon, and Nukool Thongtawee, Director of Operations and Maintenance at the Royal Irrigation Department, Bangkok is gratefully acknowledged.

CONCLUSION AND RECOMMENDATIONS

Lam Nam Oon, being in Northeast Thailand which has an inherent salinity problem, has a potentially serious problem of high water table and salinity that may regate or dimish considerbly present efforts at expanding dry season production.

Preliminary studies of Pilot Area 2 at Lam Nam Oon during the 1982-1983 dry season indicated about 60% of the area had a water table less than 1 meter below ground surface and about 40% of tested auger holes and wells had an EC x 10^3 of more that 2 millimhos.

The observed cause of high water table was, in main, due to excess water use and poor water management by the farmers and lack of sufficient drainage.

Salinization can proceed very rapidly under irrigated conditions during the dry season. In some areas the only alternative to irrigated upland crops and a salinization problem may be a dry season irrigated rice crop or not irrigating at all during the dry season.

An effective training program for farmers, extension workers and zoneman in the proper use and management of water is imperative.

An effective plan to monitor water table levels and salinity to determine to location and extent of problem areas is imperative.

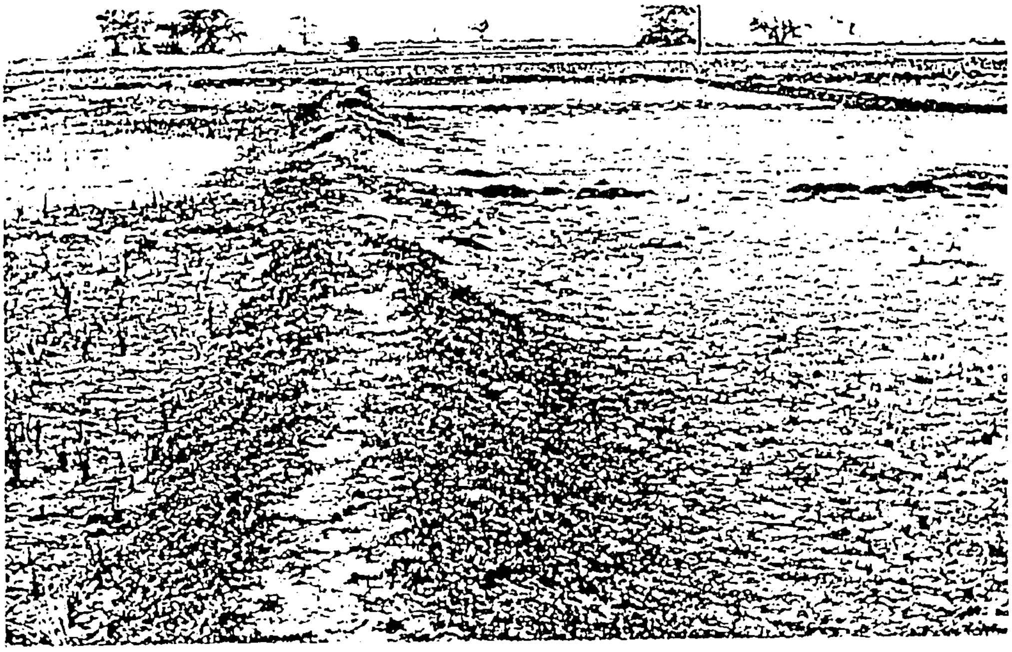
INTRODUCTION

Problems with salinity and waterlogging are inherent in all irrigation projects throughout the world, only the degree of the problem varies. These have been evident in the past as well as the present. There is strong evidence that some ancient civilizations declined due to the effect of salinity and waterlogging on their irrigated lands. The decrease in food supply weakened the population leading to their being overthrown by rivals or migrating to other lands.

This process of widescale salinization and waterlogging continues today. India's National Committee on Environmental Planning estimates that of 40 million hectares under irrigation, 10 million are in danger of becoming infertile, (1). One UN Document reports that about one-third of all the world's irrigated land faces salinity problems. Each year about 12 million hectares are being abandoned because of salinity, waterlogging, and alkalinity, (2). The San Joaquin valley in the U.S. has about 2 million hectares now irrigated of which 162,000 hectares have a drainage problem (water table within 1.5 meters of the soil surface) and it is expected that more than 400,000 will be affected. The rate at which the problem is expanding in some areas is very rapid. In one area the rate has been more than 1000 hectare/year over the past ten years, (2). The Nile Valley in Egypt, the Indus Basin in Pakistan, the Tigris-Euphrates in Iraq and the North China Plain in China are other examples of areas having salinity and waterlogging problems of major concern to those countries.

Thailand is not without its own salinity problems, especially in the Northeast. Saline-affected soils have been known for a long time. Most all project studies have encountered and reported salinity to greater or lesser extents. These include U.S. Bureau of Reclamations studies on the Nam Chi, (3) Nam Mum, (5); Pa Mong, (4); the ECI report for Lam Nam Oon, (10): IRRI, (8); A.I.T., (9); and numerous others.

Lam Nam Oon is fairly typical of other parts of the Northeast in having an inherent salinity problem. In a recent questionaire administered at Lam Nam Oon more than one half of all farmers reported salinity as being something of a problem. In general the salinity now occurs in the project as scattered patches varying in size from several square meters to perhaps 5 rai. Photos 1 and 2. See figure 1 for general map of LNO and salinity areas as reported in previous Land Classification Studies (10). These scattered areas are usually intermixed with soils containing less salt. Where cropped, the severity affecting the plants ranges from reduced growth and yield to totally barren spots. In most cases the variability of salinity is distinctly obvious. Slightly higher spots are often more saline, old termite mounds usually have a fringe of saline soil along their base, and other irregularities such as higher strips along bunds may show a similar area of salinity. There can be a very sharp transition between salt-affected zones and non-affected. Rice growing on one side of a bund may grow with no apparent effects while on the other side it will not grow or do so only with difficulty. Photo 3.

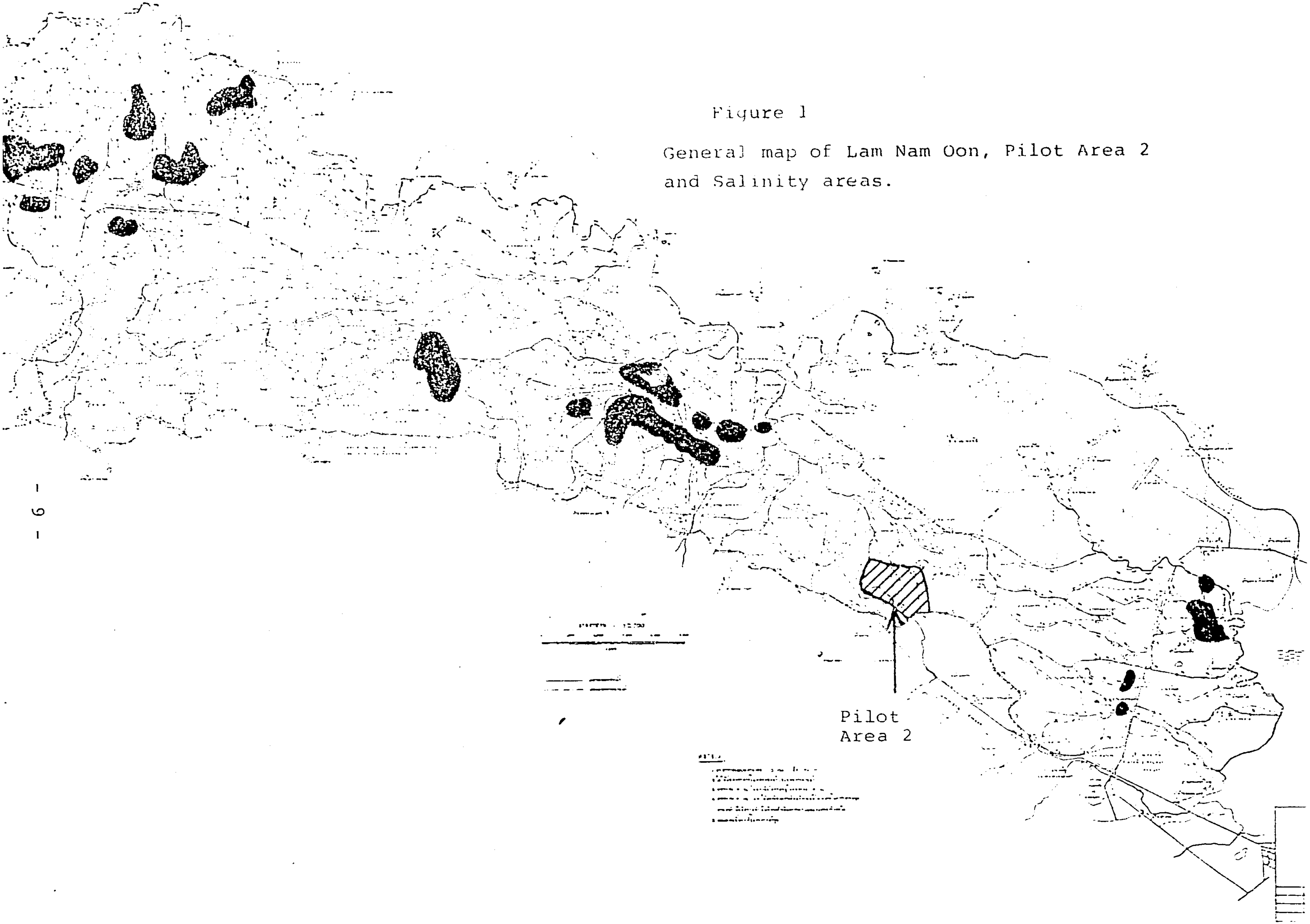


Photos 1 and 2

Shows the scattered nature of salinity as it occurs in Lam Nam Oon.

Figure 1

General map of Lam Nam Oon, Pilot Area 2 and Salinity areas.



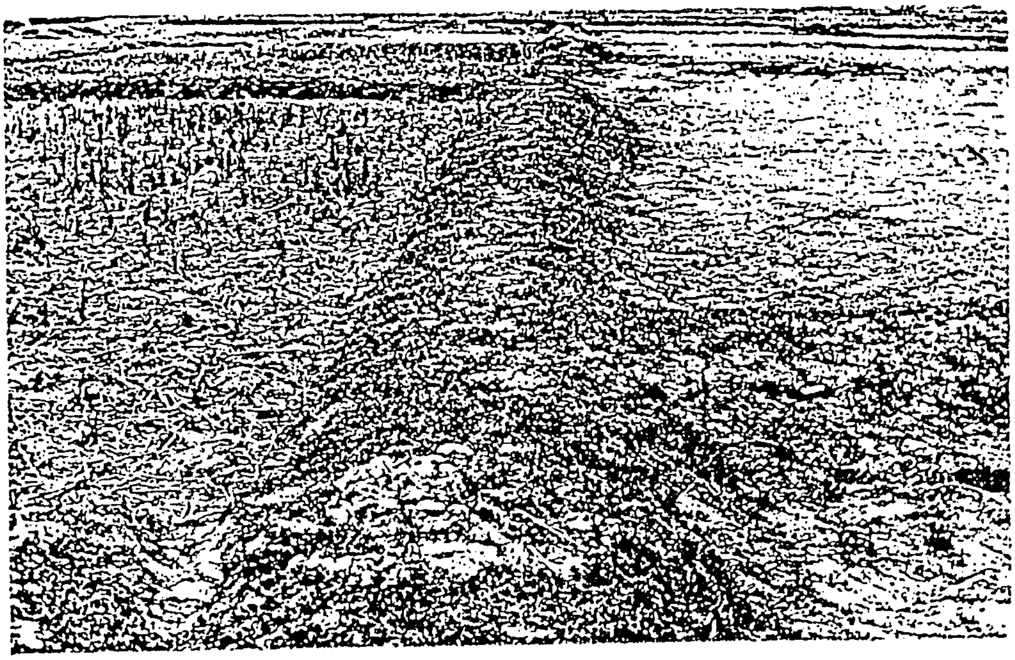


Photo 3

Transition between salt-affected areas and non-affected. Note rice stubble at left side of bund whereas on the right the soil is barren.

The mechanism of how and why salts move in the soil and accumulate as they do is a complex physical and chemical action. Movement of the groundwater, underlying geologic formations, parent soils, climate, topography and changes in landform all may affect the state of salinity in a particular place. One report (7) states that salt is released by erosion and weathering of some soil formations at or near the surface. IRRI (8) makes reference to interflow from salt-bearing rocks moving down to lower parts of the landscape where salts accumulate because of evaporation.

In general the salinity is caused by continual evaporation during the dry season. Salts move with the soil water to the surface where evaporation then leaves the salt concentrated there. If the water table stays within the capillary zone salts will continue to be deposited, if the water table drops below this zone then the soil will become dry and no more salt is deposited. Under the natural conditions of wet cycle - dry cycle (before irrigation) the saline state has reached a dynamic equilibrium. The Nam Chi Report (3) indicated that areas affected by salts had not changed or changed very little in the past 20-50 years. Those that did change were due in part to changing of landforms, i.e. roadways and borrow pits.

How rapid salinization occurs varies. As noted above, present conditions have, in most cases, reached dynamic equilibrium. However under dry season irrigated conditions this natural equilibrium is altered. It has been observed that in

Kalasin and in Senegal salinization has occured in one dry season (7). At Kalasin rice land was irrigated during the dry season for a variety of dryland crops. In the Senegal salinization occurred due to capillary rise form saturated subsoil within a few months.

Given the above facts and examples of what can, and ultimately, will occur it behooves those responsible to put in effect immediately the necessary actions to monitor closely what is happening to the salinity dynamics in Lam Nam Oon as well as other Northeast Thailand irrigated projects. The unanswered question is how does the salinity equilibrium change under conditions imposed by an irrigation regime, and what are the likely affects? To quote from the IRRI book (8); "In irrigation projects in saline areas, the tendency is to practise multiple cropping with wet-season rice followed by one or more intermediate or dry-season dryland crops. For economical use of irrigation water, this approach seems logical. But the dynamics of salinity are definitely against such an approach".

LAM NAM OON TESTS

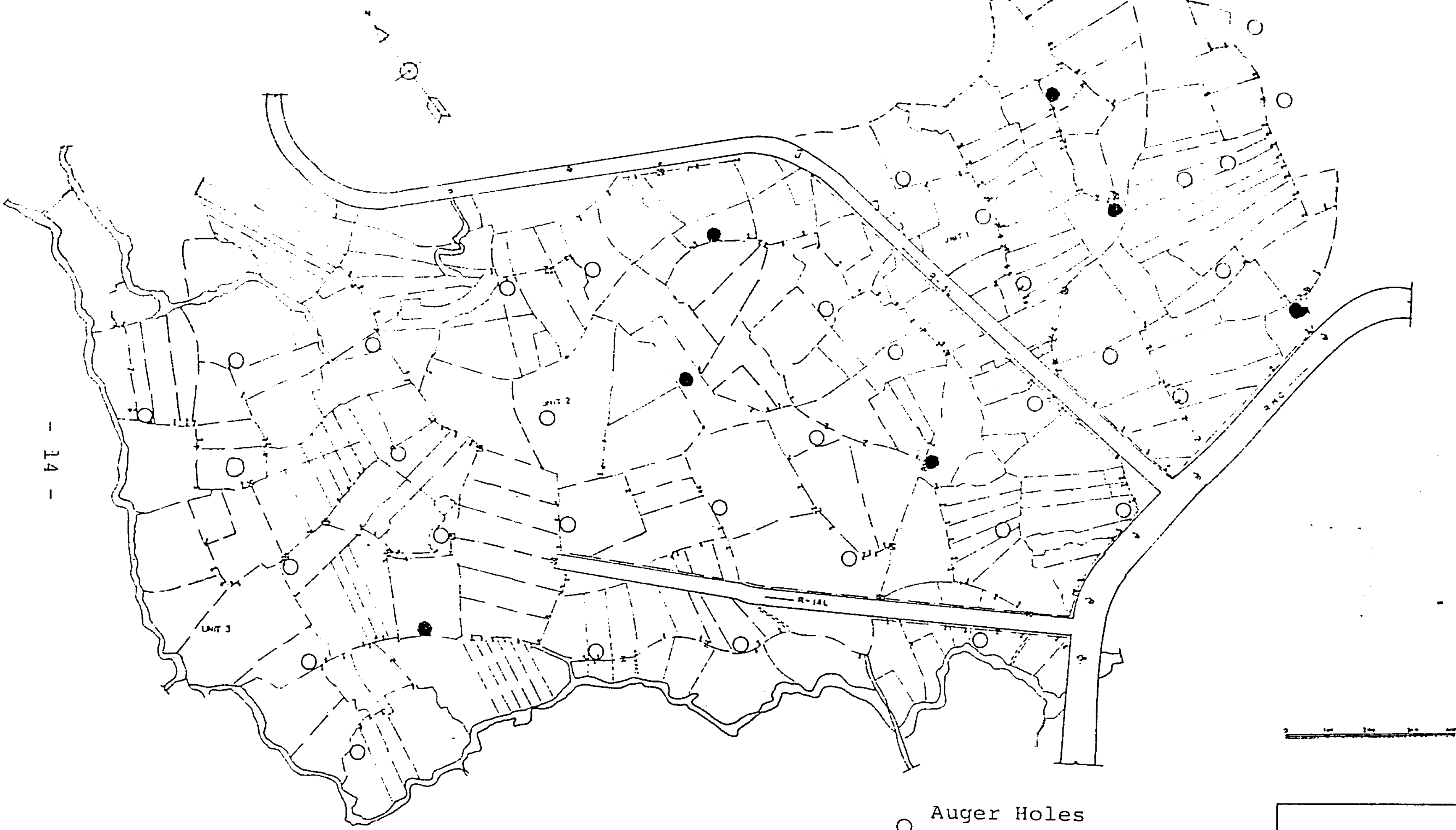
Having recognized the potential for salinity problems it was planned to make some water table observations and check salinity of ground water in Pilot Area 2 (see figure 1 for location) for the 1982-83 dry season crop. Seven observation wells were installed during the last week of December, 1982 in locations shown on Figure 2. These were read periodically and results are shown in Figures 3 and 4.

When the January, 1983 readings showed the water still relatively high it was decided to supplement the well readings with additional auger holes to observe water table levels over a wider area of Pilot Area 2. These holes were dug at two intervals during the dry season; during the week of 14 February, 1983 and week of 25 April, 1983. In addition to recording the depth to ground water level a sample of water from the hole was measured for salinity. The results of these readings are shown in Table 1.

Figure 5 is a plot of depth of ground water for the week of 14 February and Figure 6 a plot for 25 April. Table 2 shows the approximate areas for the various depths to water table. The area at less than 0.5 meters approximately doubled from about 5% to 10% of total area. Overall the area greater than one meter increased from about 32% to about 40%. This was mainly due to increases in Unit 3, probably because very little was irrigated in that area. In Unit 1, where the largest area

Figure 2

Location of observation wells and auger holes



○ Auger Holes

● Observation Wells

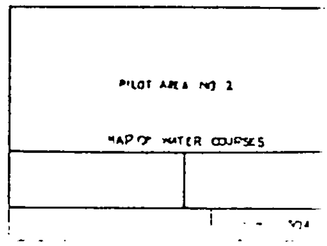


Figure 3

Depth to Water Table
Wells 1-4

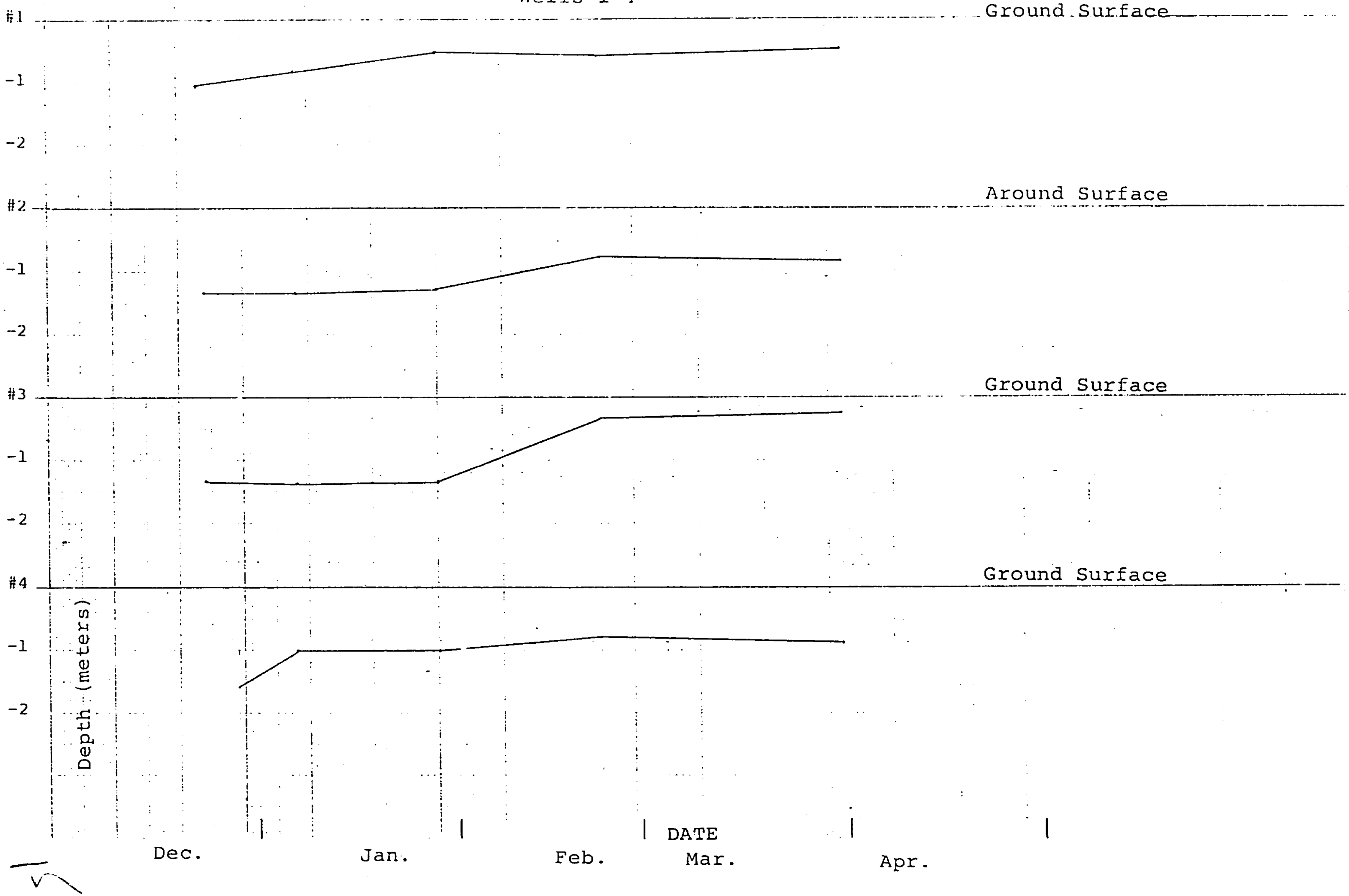


Figure 4

Depth to Water Table
Wells 3-7

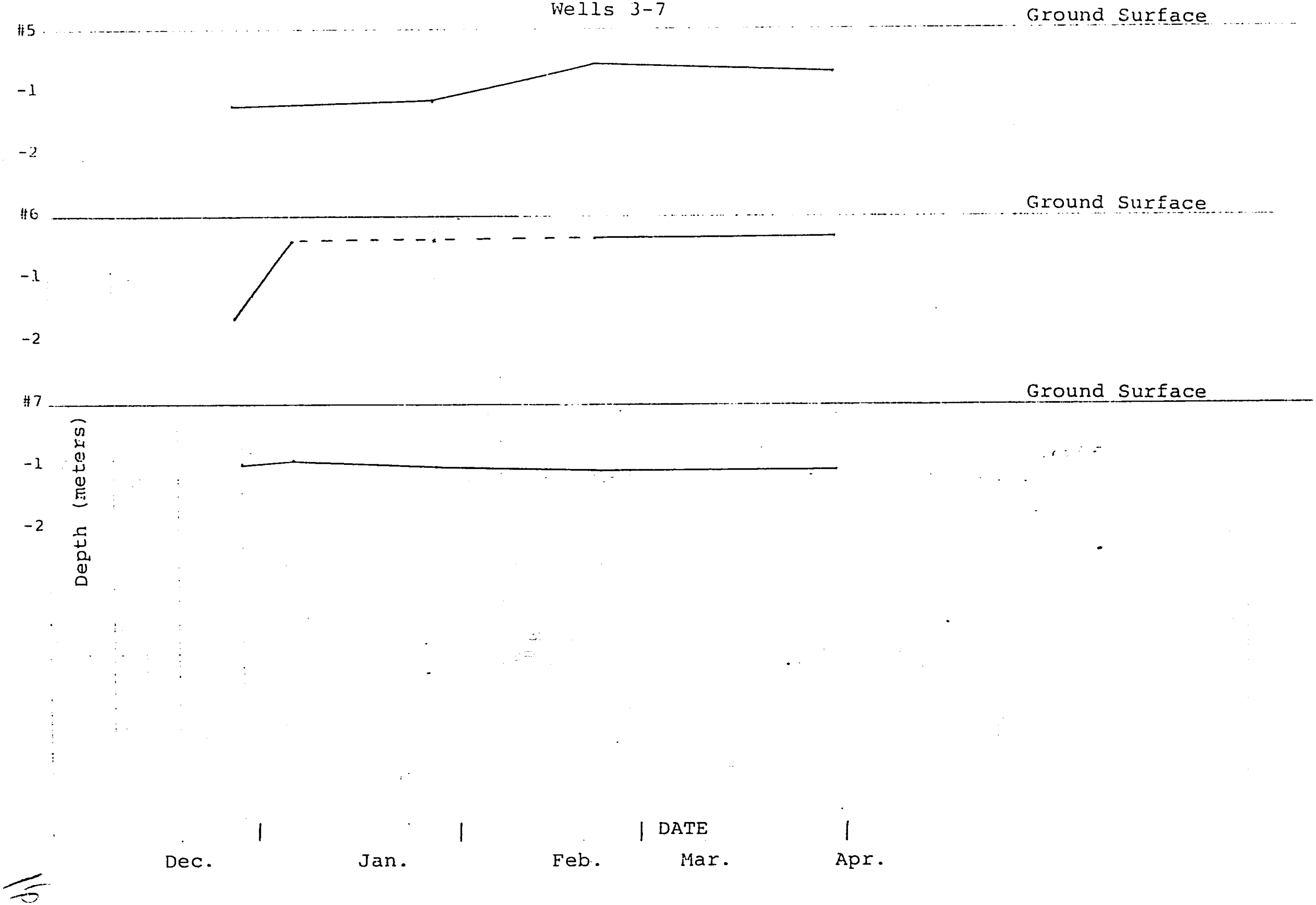


TABLE 1

WATER TABLE & SALINITY
Pilot Area 2
(Water table in meter below ground surface and salinity in Millimhos EC x 10^3)

	14 Feb 83	25 Apr 83	14 Feb 83	25 Apr 83		14 Feb 83	25 Apr 83	14 Feb 83	25 Apr 83
Hole #	WT	WT	EC	EC	Hole #	WT	WT	EC	EC
1	1.4	1.6	0.8	0.3	22	1.1	0.6	0.7	0.2
2	1.0	1.0	6.0	2.0	23	dry	dry	-	-
3	0.6	0.9	2.5	2.5	24	1.6	0.9	2.2	2.6
4	0.7	1.2	0.1	4.6	25	0.8	0.8	0.1	0.4
5	0.8	1.7	0.6	0.6	26	0.3	0.7	0.1	0.1
6	1.6	1.6	4.5	6.0	27	1.3	1.4	0.8	6.5
7	0.8	1.6	0.2	0.6	28	1.0	1.1	0.6	0.8
8	0.6	0.6	0.1	0.1	29	1.1	0.7	1.6	0.2
9	0.6	0.5	0.5	0.1	30	0.4	0.3	2.0	-
10	0.7	1.3	0.3	2.5	31	0.5	0.5	1.5	-
11	1.3	1.6	1.7	0.3	32	1.4	-	10.4	-
12	0.6	0.3	1.0	0.3	33	1.2	-	0.8	-
13	1.2	0.9	5.6	0.5	34	1.1	0.4	0.4	-
14	1.9	0.9	6.0	2.6	35	1.0	0.5	4.0	-
15	1.1	0.7	6.5	0.1					
16	0.5	1.1	0.1	0.4	Well #				
17	1.0	1.5	1.1	5.5	1	1.2	0.2	3.5	5.1
18	1.3	1.1	3.5	3.7	2	0.8	0.4	-	2.4
19	0.9	1.6	0.1	0.2	3	0.5	0.8	-	2.6
20	1.3	1.1	0.5	0.2	4	1.5	0.4	1.6	0.2
21	0.9	0.6	0.2	0.1	5	0.6	0.3	0.5	0.4
					6	0.5	0.6	-	3.0
					7	1.0	0.8	4.0	0.7

Figure 5

Ground Water Contours

14 Feb. 1983

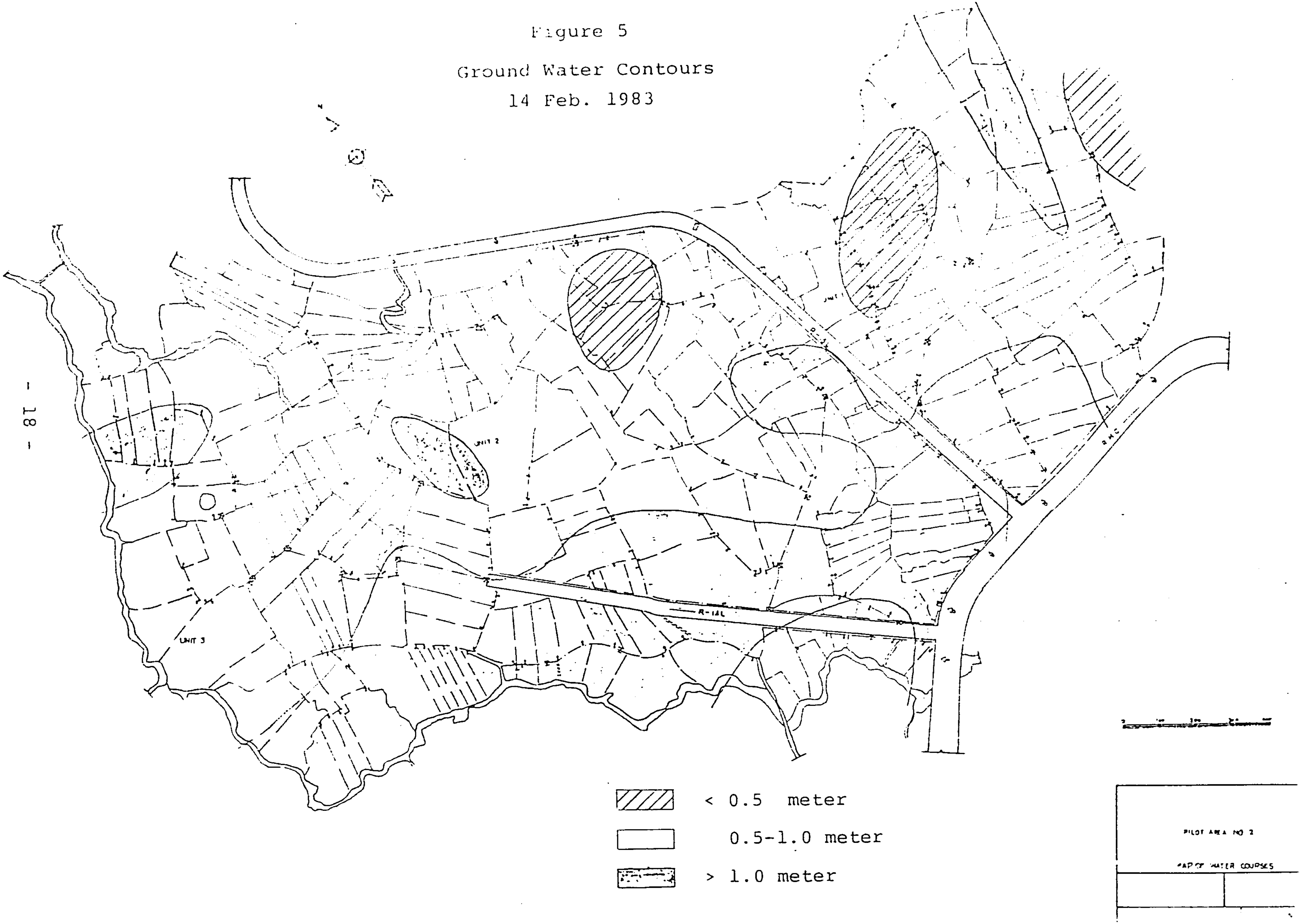


Figure 6

Ground Water Contours
25 April 1983

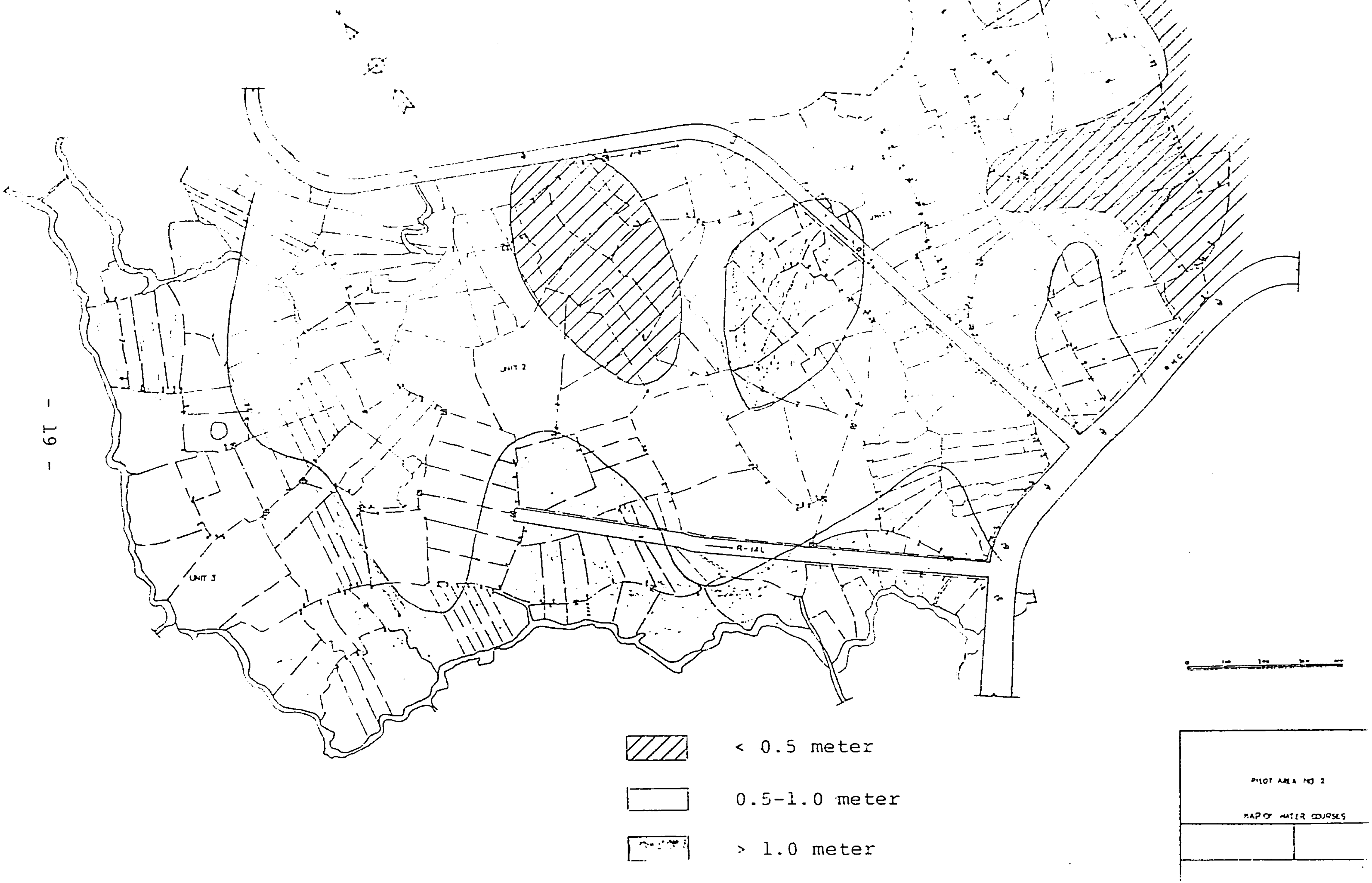


TABLE 2

Area of water table for various depths

14 February 1983

Depth	Unit 1	%	Total Area	%
≤ 0.5	67	12.3	110	4.9
0.6-1.0	309	56.6	1426	62.9
> 1.0	170	31.1	730	32.2

25 April 1983

Depth	Unit 1	%	Total Area	%
≤ 0.5	110	20.2	236	10.4
0.6-1.0	318	58.2	1114	49.2
> 1.0	118	21.6	916	40.4

was planted and where it seemed to have more water management problems, the situation deteriorated. Area with water table $\leq$ 0.5 meters increased from about 12% to about 20%. Area > 1.0 meter decreased from about 31% to about 22%. Area between 0.6 and 1.0 meters stayed approximately the same.

The percent of samples with water table at less than 0.5 meter increased during the period. The number of samples with EX x 10^3 of 2 or more also increased from the first reading. See Table 3. What this seems to indicate is that the water table and salinity situation continued to deteriorate, especially in Unit 1, during the growing season.

These conditions occurred in Pilot Area 2 with about 8% of the area under cultivation, Figure 7, the shaded area is the approximate scaled area planted. Unit 1 had the most with about 13.6% and it also had more of the area with high water table.

Even though the total area of crop was very small there were considerable areas throughout Pilot Area 2 where water stood in vacant paddies where nothing was growing. Field visits as well as an aerial view indicated this very clearly. It is difficult to estimate what this portion was but it must have been at least equal to that planted. If these results are indicative of what is happening, what will be the situation when larger areas are irrigated?

WATER TABLE & SALINITY

PA 2

WATER TABLE

Number and Percent at Various levels
(meter below ground surface)

Depth	14 Feb 83 #	14 Feb 83 %	25 Apr 83 #	25 Apr 83 %
≤ 0.5	6	14	10	24
> .5 - 1.0	18	43	15	38
> 1.0	18	43	15	38

SALINITY

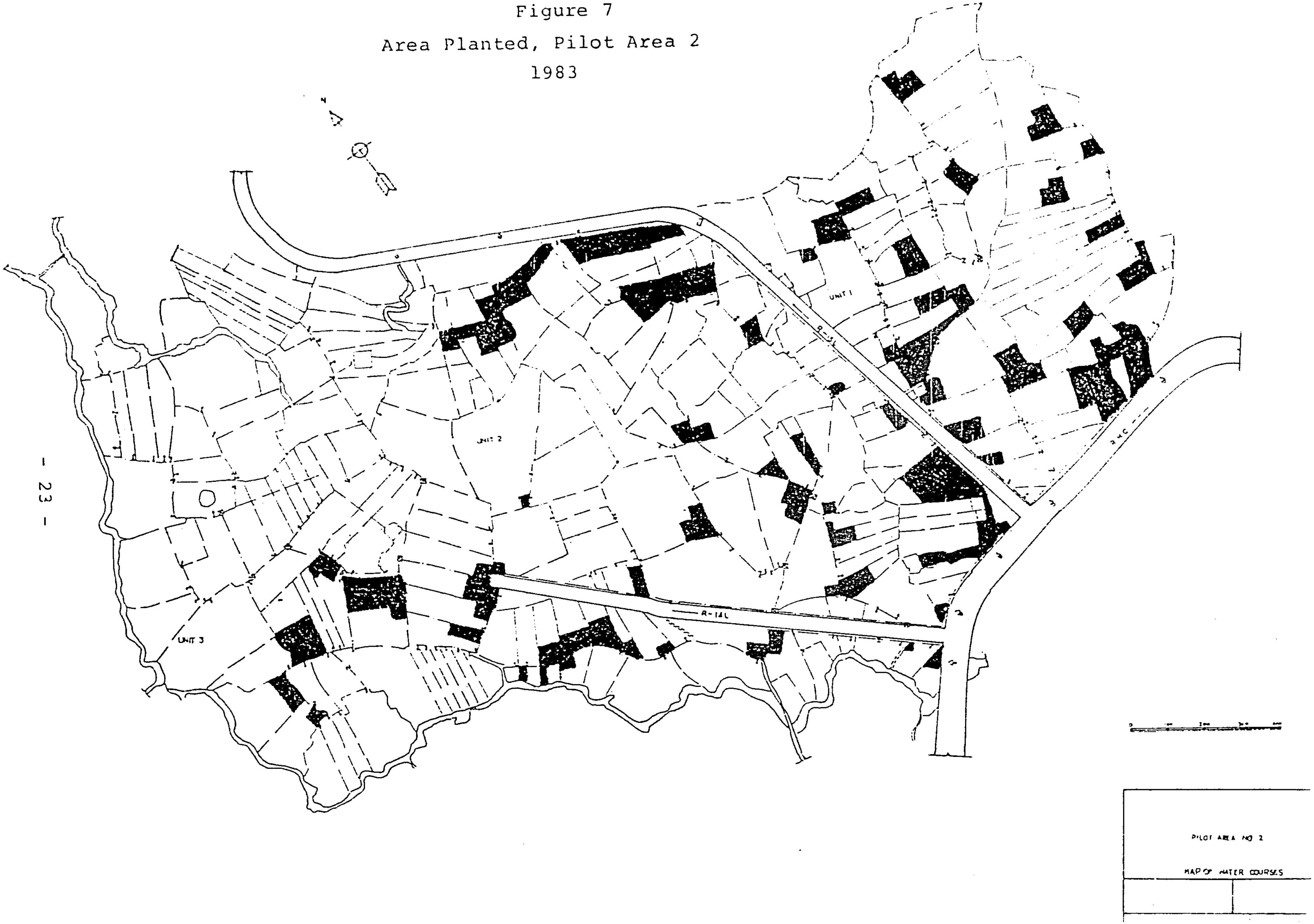
Number and percent above and below 2 millimhos

Millionhos	14 Feb 83 #	14 Feb 83 %	25 Apr 83 #	25 Apr 83 %
< 2	24	67	21	60
> 2	12	33	14	40

Figure 7

Area Planted, Pilot Area 2

1983

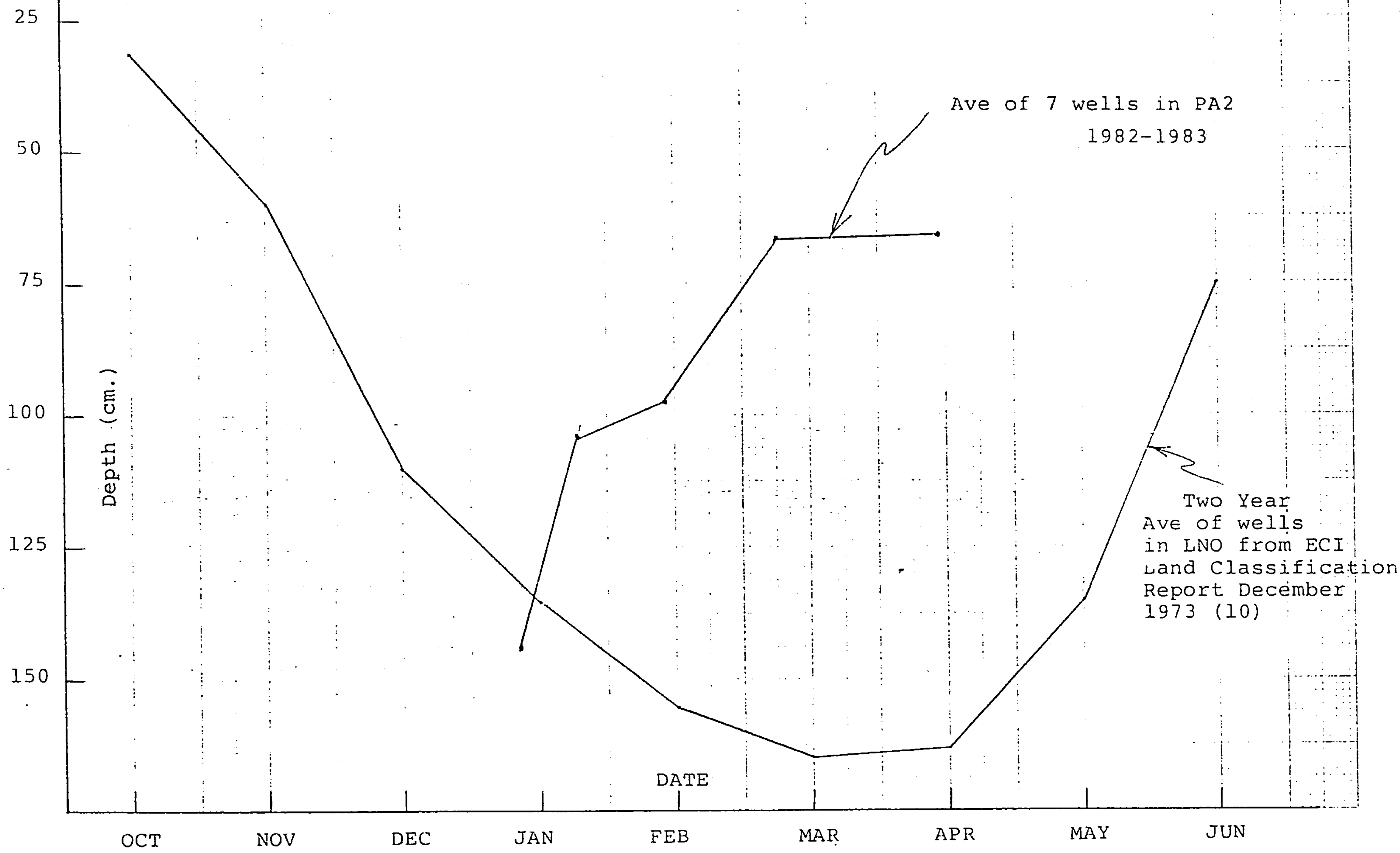


As noted previously, if the water table comes within the capilliary zone for that particular soil, then movement of salts from the ground water to the surface will take place. This depth is not known at Lam Nam Oon at this time; but, certainly, a water table maintained at less than one meter should be cause for concern.

Figure 8 shows a comparision of average water table changes. The two year average of wells in Lam Nam Oon show the generalized profile that normal dry season conditions have on water table levels. The other plot is an average of the seven wells in Pilot Area 2. Levels toward the end of December, 1982 are about the same. However, with irrigation water being diverted into Pilot Area 2 the water levels begin to rise and reach an average of about 0.6 meters below the surface, about one meter higher than what might normally be expected.

Figure 8

Comparsion of Average Water Table Levels



OBSERVED CAUSES OF THE HIGH WATER TABLE

A number of probable reasons for the building of the water table in the Pilot Area 2 can be sited, mainly drainage and irrigation practices. The main drain outlet from Units 2 and 3 is not deep enough to satisfactorily drain these areas, hence the increase in area with shallow water table from Figure 5 to Figure 6. Also drainage on a more micro-scale is not carried out by the farmers. Excess water from irrigation is not directed to the nearest drain (in most cases) but allowed to stand in the irrigated plot or adjacent vacant plot.

In general all the farmers over-irrigate, some to great extents. This is not uncommon, especially for these farmers who have only farmed rice in the rainy season. Their concept of irrigation is "water standing in the field for days on end". Another practice that leads to excess water running into unused fields is the fact that farmers along one ditch do not coordinate their irrigations. For example; maybe 5-6 farmers along one ditch have irrigated plots, one farmer may irrigate for 2-3 days, another for the next 2-3 days, etc. almost continuously. Each one uses only a portion of the water flowing in the ditch while the rest runs out the end into a vacant field, Photo 4. Other vacant fields are flooded due to inlets being open or only partially closed, and in places the ditch bank has been cut or eroded with the same effect. The practice of not constructing a small ditch from farm outlet to irrigated plot is common. The likely method is to allow water into bunded area(s) next to outlet until its high enough to irrigate the desired plot. Photo 5.

Photo 4

End of irrigation ditch. Large area of paddies under water with nothing cropped (about the same is off the photo to the right), this farmer had about 3 rai cropped in the upper left corner of photo. This condition persisted throughout most of the growing season.

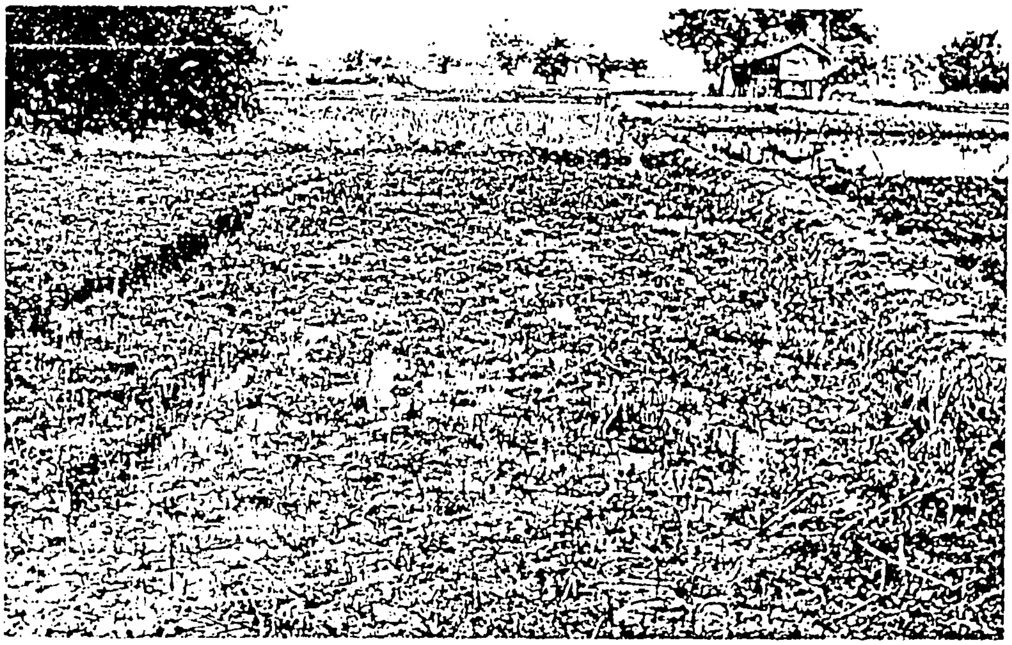


Photo 5

This farmer also irrigating by flooding adjacent areas. Note trench in center left, very unsuccessful attempt at constructing a ditch.

ACTIONS TO TAKE

The root cause of the problem of high water table then is over-use of water in the fields, improper management, and lack of drainage to remove the excess. More effective training (not just talking to) of zoneman, extension personnel, and farmers in the proper use of water is vitally important. The improvement of drainage both by the Royal Irrigation Department and at the Chak and zone level must be undertaken. The consequence of not doing so is to risk some areas becoming totally non-productive in a few years.

Even with better management of water and drainage there will likely be areas where high water tables will still occur under dry season irrigation. What to do about these areas will require some careful consideration in seeking to minimize damages. The high cost of drainage (either surface with a high cost of land and maintenance or subsurface with high initial cost) and the low value of outputs preclude this as a viable option. There may however, be small areas where drains could be used to help reclaim a small area.

Irrigated rice in the dry season is an option since the fresh water dilutes and suppresses the salinity to allowable levels for rice culture. To quote from the IRRI book(8); "...and the only economic solution appears to be a return to rice growing, using the available irrigation water for a smaller area. Many irrigation projects in the drier rice-growing areas suffer from the same lack of insight into the dynamics of salinity". Brinkman and Dieleman (6) state; "It might be most economic, and would minimize management problems, to concentrate dry-land cropping on the areas of better-drained soils of higher terraces occurring in many parts of North-east Thailand, and to assign irrigation projects to the low terrace to double cropping of paddy rice".

Another alternative may be not to irrigate anything during the dry season. How this may be accepted by those who have raised crops for several years with resulting better incomes in unknown. However, to continue would lead eventually to no production.

There have been various proposals and suggestions for dealing with the salinity problem. The use of resistant varieties, different planting techniques and soil amendments (such as rice hulls) have been noted. There is some merit to all of these (as may be others). However, all of these are only coping with the problem not eliminating it. Once salts are in the soil the only way to remove them is by leaching.

Given the conditions present at Lam Nam Oon and the potential for serious problems there is imminent need to establish a systematic plan to steadily monitor water table levels and salinity. A network of permanent observation wells in the Lam Nam Oon area must be spaced close enough to enable accurate determinations of water table levels. It is suggested that these wells be installed during and/or immediately after the on-farm works in each unit is completed. An initial network can be established from the design maps and added to or modified later as needed. They should be about 2 meters deep and a log of each one kept to accurately establish substrata conditions. They should be read at least once a month. At the time of reading the salinity should be measured. Hydraulic conductivity measurements should also be carried out at representative locations and for representative types of subsoil.

This data will enable the determination of location and extent of problem areas, and hopefully lend to satisfactory management of them.

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AUTHOR

William C. Bell has been a member of the Louis Berger International, Inc. advisory team at the Lam Nam Oon Integrated Rural Development Project in Changwat Sakon Nakhon, Thailand since October, 1979.

He is assigned as an Irrigation Systems and On-Farm Water Management Engineer. As such, he has assisted in installing a number of water management innovations at Lam Nam Oon including the broadcrested weir described in Technical Note Number 7 and micro-computer-based management of main canals and laterals.

He has also designed and supervised engineering-related Operations Research activities at Lam Nam Oon. The contents of this paper are derived from some of those activities.

Mr. Bell is a member of the American Society of Agricultural Engineers. He is a graduate of North Dakota State University and the University of Idaho with degrees in Agricultural Engineering.

He has worked in the United States as a supervisory hydraulic engineer with the U.S. Bureau of Reclamation. He has worked abroad as a irrigation systems and on-farm water managment engineer in Brazil, Indonesia, and currently - Thailand.

Mr. Bell's other papers published at Lam Nam Oon to date (June, 1983) include:

- Hand Book, Channel Design, with Tables for Varying Size Quaternary Canals Specific to Conditions at Lam Nam Oon.

- Project Note No. 2 - Lam Nam Oon Preliminary Water Space and Integrated Rural Development Planning.

- Project Note No. 4 - Dry Season Crop Production - 1981/82 - 1981/82 - Lam Nam Oon.

- Project Note No. 5 - Pilot Area 2 Operations Research Results - 1981/82 - Lam Nam Oon (In collaboration with Anthony Zola).

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