9. IMPROVEMENT OF IRRIGATION AND DRAINAGE SYSTEM OF RICE FIELDS IN THAILAND

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I. Present Status and Problems of Irrigation and Drainage Systems of Rice Fields in Thailand

Most of irrigation and drainage systems in rice fields in Thailand have been improved to the Inter-Farm Level. It is worthwhile to discuss the existing problems of such the improvements.

Improvement at the Inter-Farm Level

With the completion of the major water control works, full water control on micro-level will be guaranteed, but there still remains a highly unsatisfactory situation on micro-level, i.e. on farm and inter-farm levels.

The Royal Irrigation Department installed ditches at approximately 400 meter intervals along the main supply channels. This was to be achieved by adding to the existing network of distribution canals and laterals a partial network of small ditches that would convey the water closer to the individual farms.

This low-cost crash programme, the Ditches and Dikes project, was initiated in 1962 to improve the water distribution at inter-farm and farm levels. Before the ditches were constructed, the water had to flow from the laterals over the fields. In this way large amounts of water were wasted, many fields received too little water or no water at all and the water arrived too late at the lower end of the fields.

The ditches, excavated at mutual distance of 300 to 500 m., are connected to the laterals or to the main canal either directly or by means of a head ditch. As the ditches have been drawn as straight as possible according to the slope of the land, the pattern of the holdings and the boundaries of the parcels have, generally, not been taken into account. Thus many holdings are split up. Moreover, holdings situated between two ditches and not adjoining them cannot receive water directly from the ditch.

Although the ditches have a beneficial effect, the condition of the present irrigation system including the ditches gives rise to a considerable waste of water and an unequal distribution, resulting in shortages when water is scarce. Uneven land requires more water for rice cultivation, which aggravates the water shortage problem. Another difficulty in the present situation of water distribution is that many areas cannot be drained adequately; farmers in the lower-lying parts receive more water than they like, while at the same time the higher-lying fields along the same ditch have a shortage of water.

In the Table shown below, the inadequacies of the present infrastructure at farm level and inter-farm level are listed together with their consequences for water economy, water management and elasticity and efficiency of farm operations.

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Table showing the inadequacies of the present infrastructure and their consequences

Inadequacies	Consequence
– No regulation of ditch inlet.	Spill, resulting in excessive flooding on the one hand and irrigation shortages on the other.
– Poor alignment and poor maintenance of ditches.	Insufficient command, resulting in irrigation water shortages and making the farms more dependent on rainfall and flooding.
– No regulation of the distribution of the water supply among the farms.	Spill, resulting in excessive supply to some farms and insufficient supply to other farms.
– Not every farm has access to an irrigation ditch.	Poor supply, resulting in irrigation shortages.
– Uneven topography.	High water requirement to inuneven fields for paddy cultivation. Poor water control resulting in low yields.
– Irrigation ditches fragment properties.	At the present level of production negative effect is to be expected. In the future, fragmentation may have an advers effect on the efficiency of farm operations.
– Almost no drainage facilities.	Flooding, resulting in poor water management and, consequently, low yields. The farmers must adapt the farm operations to time and degree of flooding.
– Almost no farm roads.	Inaccessibility of the fields during the wet season, resulting in poor water management and poor crop attendance.
– Size and shape of plots.	The small size and the irregular shape of the plots have an adverse effect on the efficiency of farm operations.

II. Improvement of Irrigation and Drainage Systems of the Rice Fields in Thailand

The improvements at the Inter-Farm Level which were mostly constructed between 1962 and 1970 have proved insufficient. The next solution is the improvements at the on-farm level. The idea of the improvement at the on-farm level, in the other word, land consolidation, was introduced some seven years ago.

Improvement at the On-Farm Level

The improveemnt of water control may be divided into 3 categories: (1) for wet season production, (2) for dry season rice production, (3) for dry season production of upland crops. Implementing water control on-farm level should be carried with careful planning. In order to gain information and experience, two pilot projects, Land Consolidation and Sappya multipurpose cooperative, have been established in the northern Chao Phya area.

Some seven years ago "land consolidation" was introduced in the Northern Chao

Phya Area with the main objective of controlling water at farm level.

Land consolidation, as implemented in the Chanasutr pilot area, comprises:

—the construction of a minor irrigation system to deliver water to each farm;
—the construction of a minor drainage system to drain excess water from each field;
—the construction of farm roads along the irrigation ditches to improve the accessibility of the farmers' fields and to facilitate the operation and maintenance of the ditches;
—a re-arrangement of farm holdings in between the newly constructed irrigation ditches and drainage canals;
—the clearing and levelling of arable land to improve the on-field water control.

After completion of the land consolidation works every plot has an irrigation inlet, a drainage outlet and access to a farm road. Moreover, the plots are levelled and have a rectangular shape to allow for modern agricultural practices.

A total area of about 11,500 rai* has been implemented in the Chanasutr land consolidation project area between 1969 and 1972.

The Chao Phya Irrigated Agriculture Development Project

The policy of the Royal Thai Government is to promote a considerable expansion of double cropping in the Northern Chao Phya Plain.

Based on the encouraging results in the land consolidation pilot areas and on the favourable outcome of economic feasibility studies, the Royal Thai Government decided to extend the project on a larger scale, and credit was obtained from the International Development Association.

In order to arrive at maximum benefits from the investment from a national economic as well as from a farm-ecenomic point of view, it was decided to develop, simultaneously with the technical improvements, the necessary supporting agricultural services to the farmers.

The first stage of the project, which will serve about 106,000 rai in the Chanasutr and Boromdhart Irrigation Project, will involve some rehabilitation works of the main water control systems, as well as "land consolidation". It aslo includes the development of the supporting services. The project is scheduled to be completed in 1977. (see schedule and maps in Annex A and B enclosed).

The Project Area is inhabited by some 45,000 people of which about 90 percent or some 40,000 depend on agriculture for their living. Out of the agricultural population 40% or some 16,000 workers are available for crop production.

In view of the urgency to expand double cropping, a feasibility study for a second stage project covering some 300,000 rai will be carried out.

III. Procedure in implementing the improvement of irrigation and drainage systems of rice fields at the on-farm level (or land consolidation implementation)

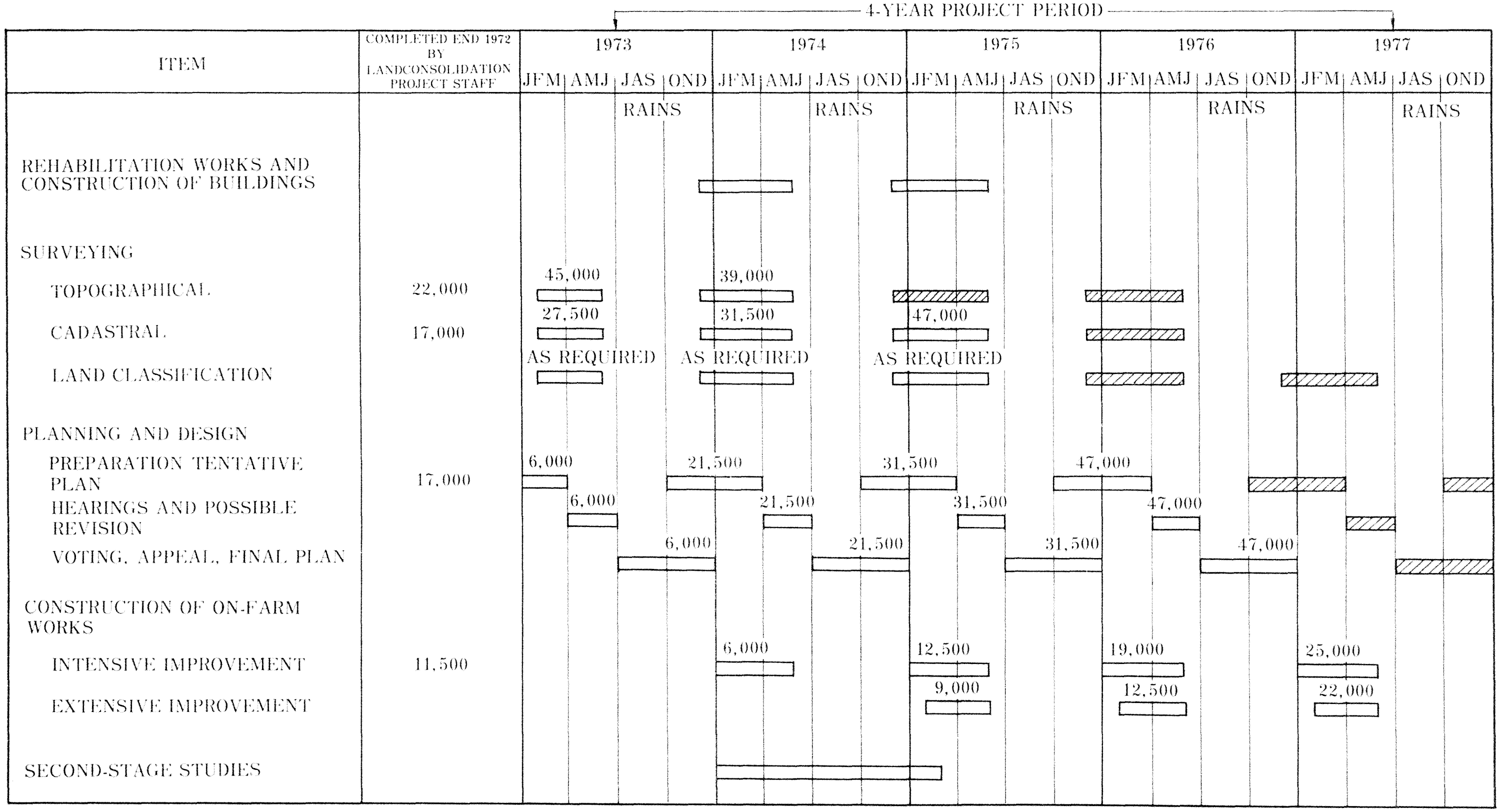
A. Surveys and Maps

1. Aerial Survey

Aerial surveys are needed to provide a basis for the topographical, cadastral and land classification surveys. The aerial photographs are prepared under the overall responsibility of the Royal Thai Army Survey Department. The flying is done at a height of 2,300 m. or 1,550 m. with an 80% end lap and a 42% side lap. The flight lines

* 1 hectare equal to 6.25 rai.

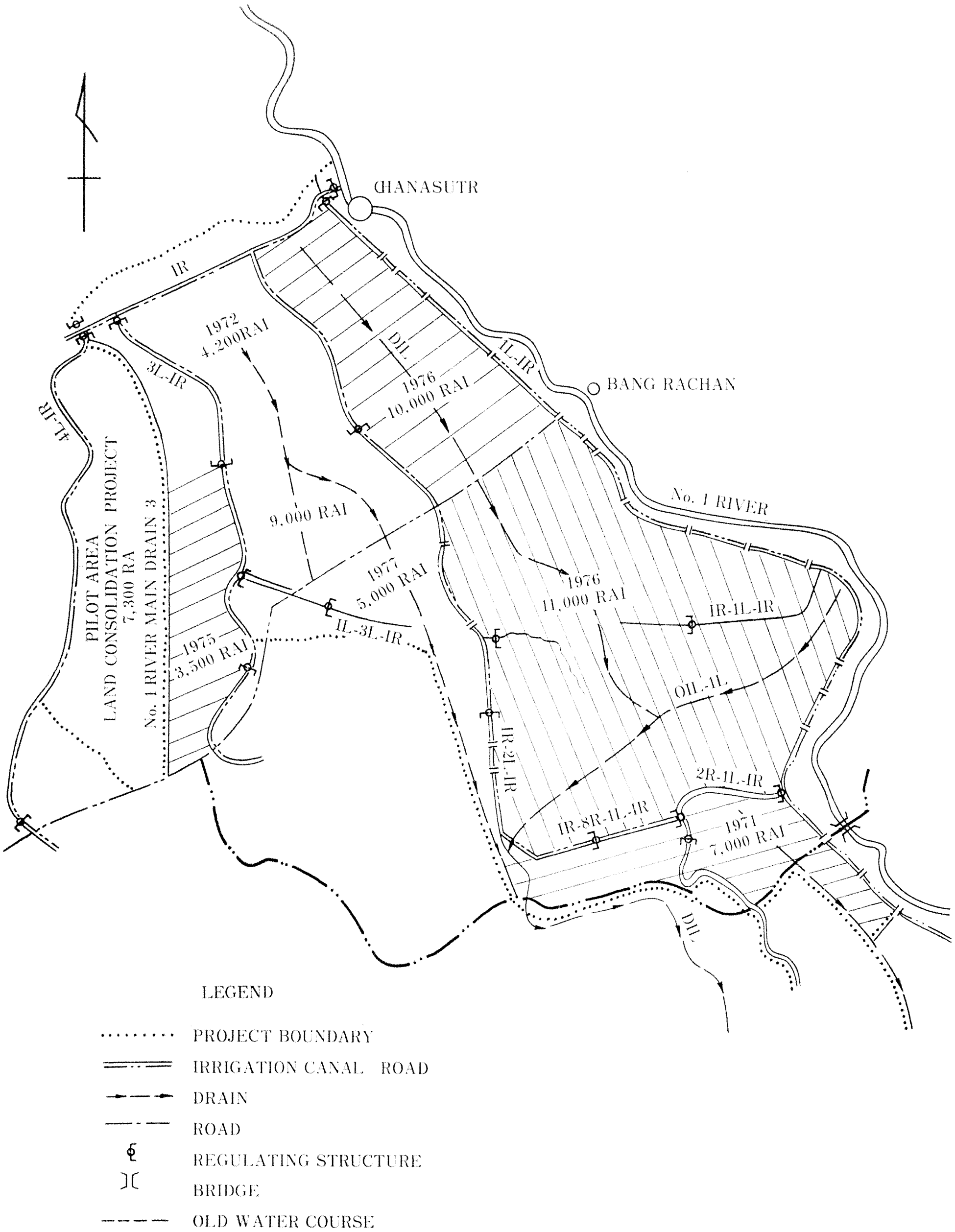
CHAO PHYA IRRIGATED AGRICULTURE DEVELOPMENT PROJECT 1973-1977 (HIRAI)
SURVEY AND IMPLEMENTATION SCHEDULE

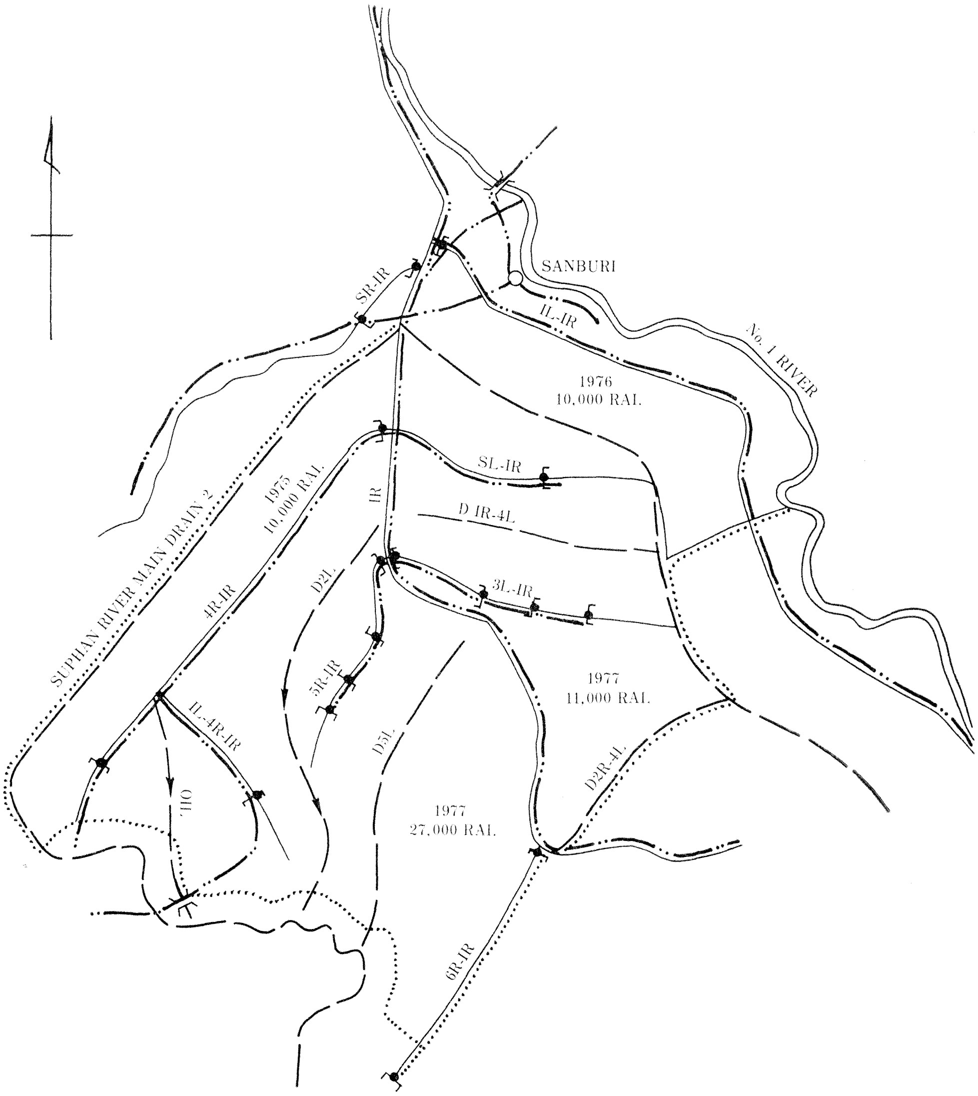


INCLUDING THE 17,000 RAI ALREADY SURVEYED IN 1971/1972, WHERE ADDITIONAL, SURVEY WORK HAS TO BE DONE

1st STAGE, 4-YEAR PROJECT PERIOD 1973-1977

(TO BE INCLUDED IN SECOND-PHASE PROJECT)


CHANASUTR
BANG RACHAN
No. 1 RIVER
IR
1L-IR
3L-IR
4L-IR
DIL
1972
4,200RAI
1976
10,000 RAI
9,000 RAI
1977
5,000 RAI
1976
11,000 RAI
IR-1L-IR
OIL-1L
IL-3L-IR
PILOT AREA
LAND CONSOLIDATION PROJECT
7,300 RA
No. 1 RIVER MAIN DRAIN 3
1975
3,500 RAI
IR-2L-IR
2R-1L-IR
IR-8R-1L-IR
1971
7,000 RAI
DIL
LEGEND
PROJECT BOUNDARY
IRRIGATION CANAL ROAD
DRAIN
ROAD
REGULATING STRUCTURE
BRIDGE
OLD WATER COURSE



LEGEND

...... PROJECT BOUNDARY

IRRIGATION CANAL+ROAD

DRAIN

ROAD

REGULATING STRUCTURE

BRIDGE

have a mutual distance of 2 km. The resulting photographs have a scale of 1:15,000 and 1:10,000 respectively and can be used for tentative surveying and locating of check points. The Royal Irrigation Department is responsible for the terrestrial survey of the check points, required to rectify the original aerial photographs. It is advised that modern rectifying methods should be used so as to reduce the necessary field-work. Care should be taken that the flying is done with a cloudless sky.

The rectified aerial photographs are enlarged and printed with a 10-cm. grid net at a scale of 1:4,000. The Royal Irrigation Department, the Land Department and the Land Development Department receive one set each for the topographical, cadastral and land classification surveys respectively. One set is printed at a scale of 1:2,000 to enable the Land Department to stake out the new situation accurately.

2. Topographical Survey

For the planning, design and implementation of irrigation and drainage works, accurate topographical maps with contour lines at 0.25 m. intervals are required. To set up a network of reference points and to facilitate regular maintenance surveying, bench-marks are to be placed at 1,000 m. intervals along all the canals of the main irrigation system. The bench-marks are to be checked by a closed circuit levelling.

The topographical survey is made by the Survey Division of the Royal Irrigation Department. One point is taken per rai in a 40 m. grid system. The contour lines are drawn at 0.25 m. intervals, which is sufficient for the planning of the minor irrigation and drainage systems. Finally, the maps are drawn at a scale of 1:4,000 based on rectified mosaics.

In the fields to be levelled a second topographical survey is carried out during the construction phase. This is done by the survey crews who also stake out the alignments of the roads and watercourses, under the responsibility of the Royal Irrigation Department's land consolidation office. The points are taken in a 20 m. grid system. At the same time stakes are placed at the levelling points. The topographical data are used to calculate the new field levels and to prepare earth-moving schedules. The stakes, on which the new surface levels are indicated, remain in the field to check the final levels of the fields after the land levelling work has eben completed. This final level, or levels in case the field is sloping, is indicated on a layout map, so no new topographical map needs to be prepared.

3. Cadastral Survey

A complete and up-to-date map of the actual cadastral situation is needed to be able to make a reallocation plan in the framework of land consolidation. This map can only be prepared if the necessary cadastral data of the areas concerned are available. Collecting and processing of these data is done by the Land Department.

A second cadstral survey is carried out after completion of the construction work. This survey will form the basis for the issue of title deeds.

4. Soil Suitability Classification

Semi-detailed soil surveys at a scale of 1:50,000 have been carried out in the project area by both the Land Development Department and the Royal Irrigation Department. Unfortunately, these surveys are not detailed enough to be very useful in the preparation of the reallocation plan. The Land Development Department survey teams are to make a detailed soil survey, on the basis of which maps (at a scale of 1:10,000) can be prepared indicating soil suitabilities for rice growing and upland crops.

Of course, the reallocation planner cannot reallocate land of inferior quality to a farmer who had good land before. He will need detailed soil data to make a proper reallocation plan. The land consolidation law will provide for a land valuation based among other things on detailed soil data.

B. Design

1. Layout

A recent cadastral map, scale 1:4,000, with 0.25 m. contour lines is needed as a basis for the design of the layout. Copies of the rectified aerial photographs are required to trace physical obstructions to the proposed rights-of-way of canals, drains and roads at an early stage.

If the topographical conditins permit to do so, irrigation canals and drains should be planned in a rectangular pattern. Modern, mechanized agriculture requires rectangular blocks, because they are easier and cheaper to work. Of course, rectanguarity cannot always be obtained. It should be aimed at, however, that at least two sides of the plot run parallel.

The distance between a drain and an irrigation canal should preferably be taken at 150–200 m. Incidentally, longer distance can be allowed if the natural slope of the terrain is sufficient.

firstly, the available average slope is very small. It varies from 10 to 40 cm. per kilometre only.

Secondly, where possible, the design should be made such, that the irrigation canal can supply water to both sides. Therefore, the alignment of irrigation canals and drains will be perpendicular to the contour lines, and the available slope between irrigation canal and drain very small.

The service unit, which is the area comanded by a canal, should vary between 400 and 1,000 rai. Larger service units with longer canals are very difficult to operate, especially in the downstream area.

Farm yards, orchards and fish-ponds should not be cut by irrigation canals, drains or farm roads.

Farm roads have to be planned along the irrigation canals; they facilitate operation and maintenance of the canal and provide access to all plots.

Existing irrigation structures have to be used where possible, especially check structures in the laterals, which are of great influence on the layout of the minor irrigation system. Existing culverts under roads along laterals have to be used if their capacity is large enough and if the level of the bottom of the structure is sufficiently low to allow proper operation of the inlet structure even with a limited irrigation water supply in the laterals.

Draw the proposed layout on the coloured top map as well. This map is passed on to the reallocation planner so he can make his first reallotment plan. When making the reallocation plan, the cadastral engineer regularly needs the help of the design engineer to make minor adjustments in the layout. Sometimes it will be necessary in this stage to make an alternative layout for part of the area.

Discuss the cadastral and technical layout in farmers' meetings. If necessary, make adjustments in th layout after these hearings. The technical plan must be up-to-date and completely finished before the final meeting with the farmers, during which the agreement is signed.

Making a proper layout of roads and watercourses for an area of approximately 10,000 rai takes about one month for a design engineer and a draughtsman. In addition, time is needed to attend the meetings with farmers.

2. Reallocation Design

Reparcelling only for the sake of remedying the present fragmentation is not justified in the project area.

In brief, the reasons for reparcelling are:

—to counterbalance the fragmentation caused by the construction of a simple and efficient system of irrigation canals, field drains and farm roads;

—to fashion property boundaries into straight lines with a view to farming operatoins;

—to remodel very elongated properties with a view to efficient farming;

and to a limited degree:

—to combine already fragmented properties.

With block reparcelling, properties are respected as much as possible. Topography permitting, irrigation canals, drains and roads are planned along present property boundaries wherever possible. Reparcelling only takes place if considered necessary to meet the above-mentioned criteria. Rearrangeemnt is effected with a limited number of parcels located in one block.

The farmers will obtain new parcels that are comparable to their original ones with respect to soil type, number of trees and distance to the village. In practice, most holdings in the land consolidation project are rearranged in such a way that new holdings overlap the old ones by some 50%.

A reallocation planner is responsible for the preparation of the reallocation plan. He is to fit the holdings into the new layout based on accurate data from the cadastral survey and the aerial mosaics. During his work he will have to maintain contact with the other designers, engaged in irrigation engineering and soil surveying.

Part of the original area has to be used for irrigation canals, drains and farm roads. Therefore, the planner may decrease the size of the property by a percentage of deduction not exceeding 5%.

The plots should be rectangular or have at least parallel sides.

Separated plots of one owner should be united unless the distance between two plots is great or the soil properties differ very much..

Plots of relatives should preferably be located next to each other.

One side of the plot should be connected to a drain and another side to an irrigation canal and farm road.

The plots of house-owners should, at least partly, be reallocated next to the house.

The total of the areas of the reallocated properties should be (about) the same as the total area of a block.

New plots should be allocated such that they partly cover the area of the original plots, preferably by about 50%.

3. Design of Service Units

3.1 Design Criteria

3.1.1 Irrigation Ditches

The ditches are designed with a minimum capacity of 0.17 l/sec/rai or about 9 mm./24 hours. The design capacity of the main irrigation system amount to 0.13 l/sec/rai.

The maximum area to be served per outlet is 25 rai. Larger holdings are given more than one outlet.

The minimum bed width should be 0.5 m.

The minimum slope should be 20 cm./km.

The maximum velocity allowed is 0.50 m./sec.

The dimensions of minor irrigation ditches have been designed according to the Chezy Manning formula for a uniform steady flow.

As the soils are fine-textured and the irrigation ditches are small, the side slopes have been taken at 1:1.

The design of the water level in a canal depends entirely on the water levels needed in the plots.

The design water level of the irrigation ditch should be such that it can cope with the full supply even if the supply canal runs at 70% of full supply.

The minimum free board in the irrigation ditch should be 0.3 m.

The bank level is the water level plus free board.

The bed level is the water level minus water depth.

The road level is the water level plus free board plus 0.10 m.

The diameter of the culverts should be not less than 0.40 m.

3.1.2 Drains

A drainage modulus of 46 mm./24 hours or 0.85 l/sec/rai has been adopted for areas not exceeding 2,00 ari. The drains in the service units belong to this category.

A roughness coefficient of $k_m=40$ has been adopted.

The minimum slope is taken at 20 cm. per kilometre.

The minimum bed width should be 0.50 m.

The depth of the drain must be at least 0.6 m. below the average surface level. In depressions the minimum drain depth to be allowed is 0.5 m.

The maximum velocity permitted is 0.50 m./sec.

3.1.3 Farm Roads

The road width should be 4.5 m., namely 3.5 m. top width and 0.5 m. shoulder at either side.

In order to obtain proper dewatering of the road, the top level of the road body must always be 0.1 m. higher than the bank level of the irrigation ditch. For the same reason, the road must be an average 0.6 m. above the surface level of the plots.

3.2 Design of Irrigation Ditches and Farm Roads

The design sequence is shown in Figures A through E and in Figure F.

Step 1—Draw the new cadastral layout on the spot height map.

Step 2—Draw the proposed future outlets to the plots of each ditch on the spot-height map, situating them opposite the highestlying parts of the plot. The demand level, which is the supply level required in the ditch to allog gravity irriagtion in the plot, is also noted down at every outlet. This map is used for the next step. (Fig. D)

Step 3—Make a longitudinal profile of the actual situation of the ditch under design on millimetre paper. Indicate the locations of the various outlet pipes in the longitudinal profile and indicate their related demand levels on the vertical axis. The proposed water level must now meet the demand levels. Drop structures, check structures, culverts and division boxes have to be taken into account because they also may influence the design of the water level.

Step 4—(see Fig. F)

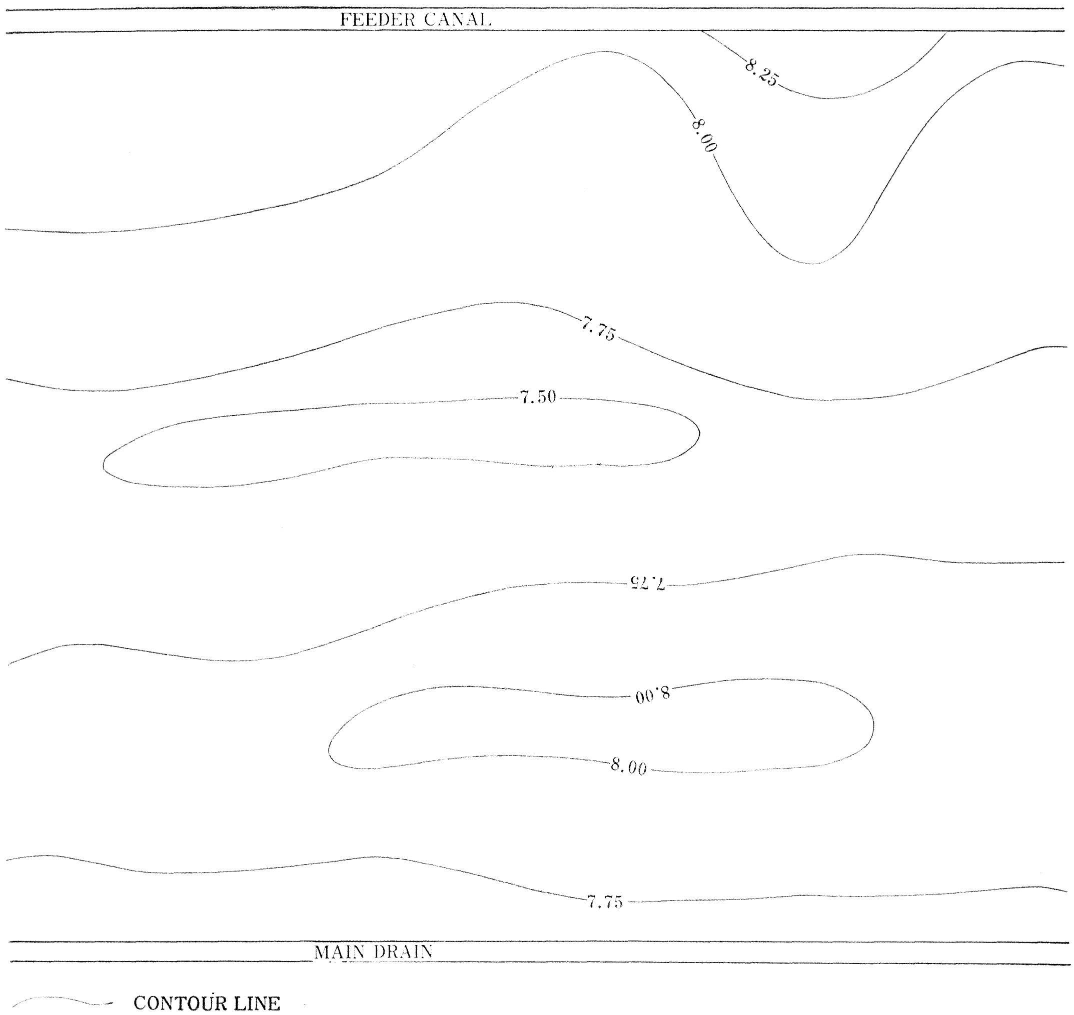
—The design water level of the ditch should be such that it can cope with the full supply if the lateral is operated at 70%. The means that the proposed water level plus minimum losses in the C.H.O. and culvert should not be higher than the water level of the lateral at 70% supply. The average minimum loss in the C.H.O. can be taken at 0.15 m. The constant head loss of the first gate is 0.06 m.

Often the criterion of 100% supply in the service unit with 70% in the lateral cannot be fulfilled. Therefore, it should be determined how large the area not under command with partial supply of the lateral will be, taking into account existing structures in the laterals. If this area is too large, there are two possibilities to solve the problems viz.:

a. always operate the lateral at full supply;
b. build an additional check structure in the lateral.

The designer should discuss this problem with the appropriate authorities to decide which is the best solution. If the area, not under command at partial supply of the lateral, is small, it is not strictly necessary for the designer to take immediate action. The area not commanded with partial supply being small or large, the designer must adapt the water level in the service unit to the

CONTOUR MAP
SCALE: APPROXIMATE 1:5000



Eig. A

LAYOUT
SCALE: APPROXIMATE 1:5000

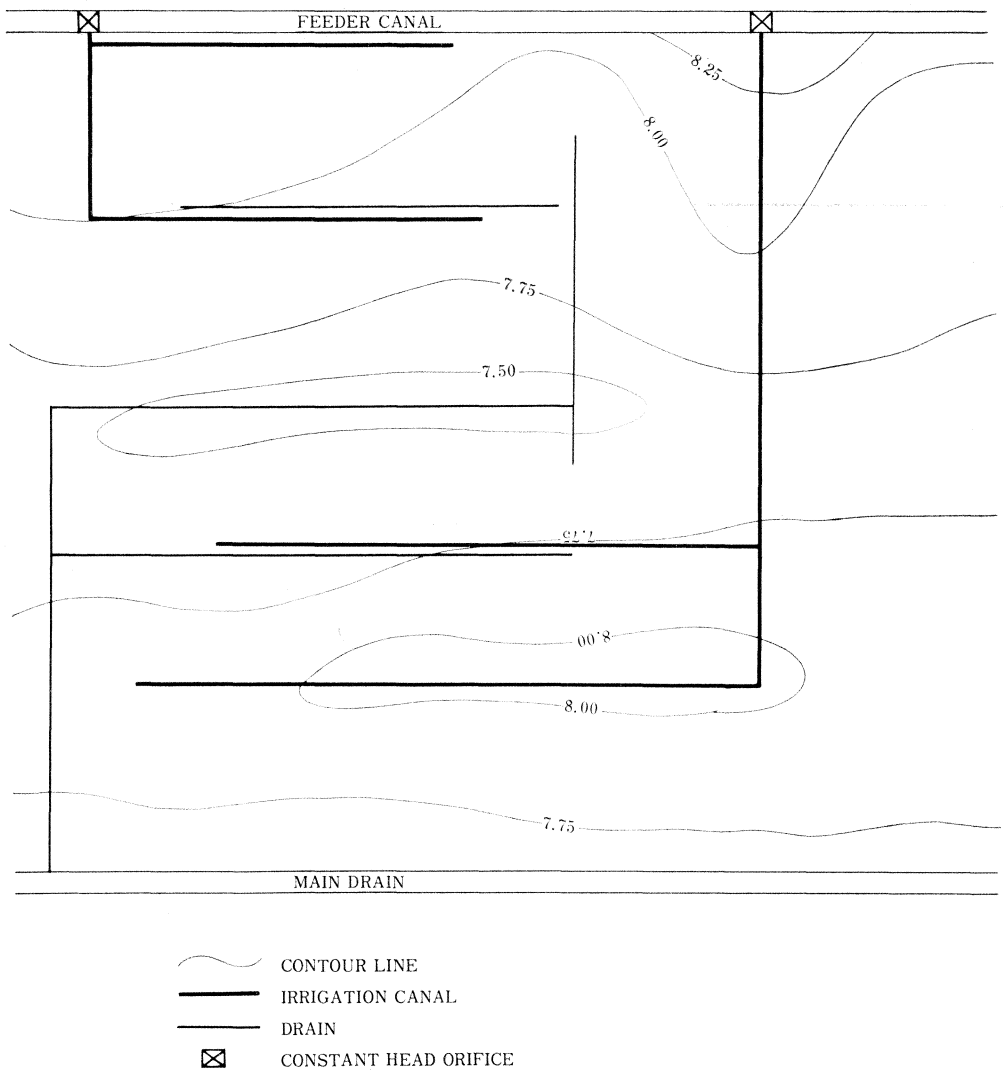


Fig. B

REALLOCATION PLAN
SCALE: APPROXIMATE 1:5000

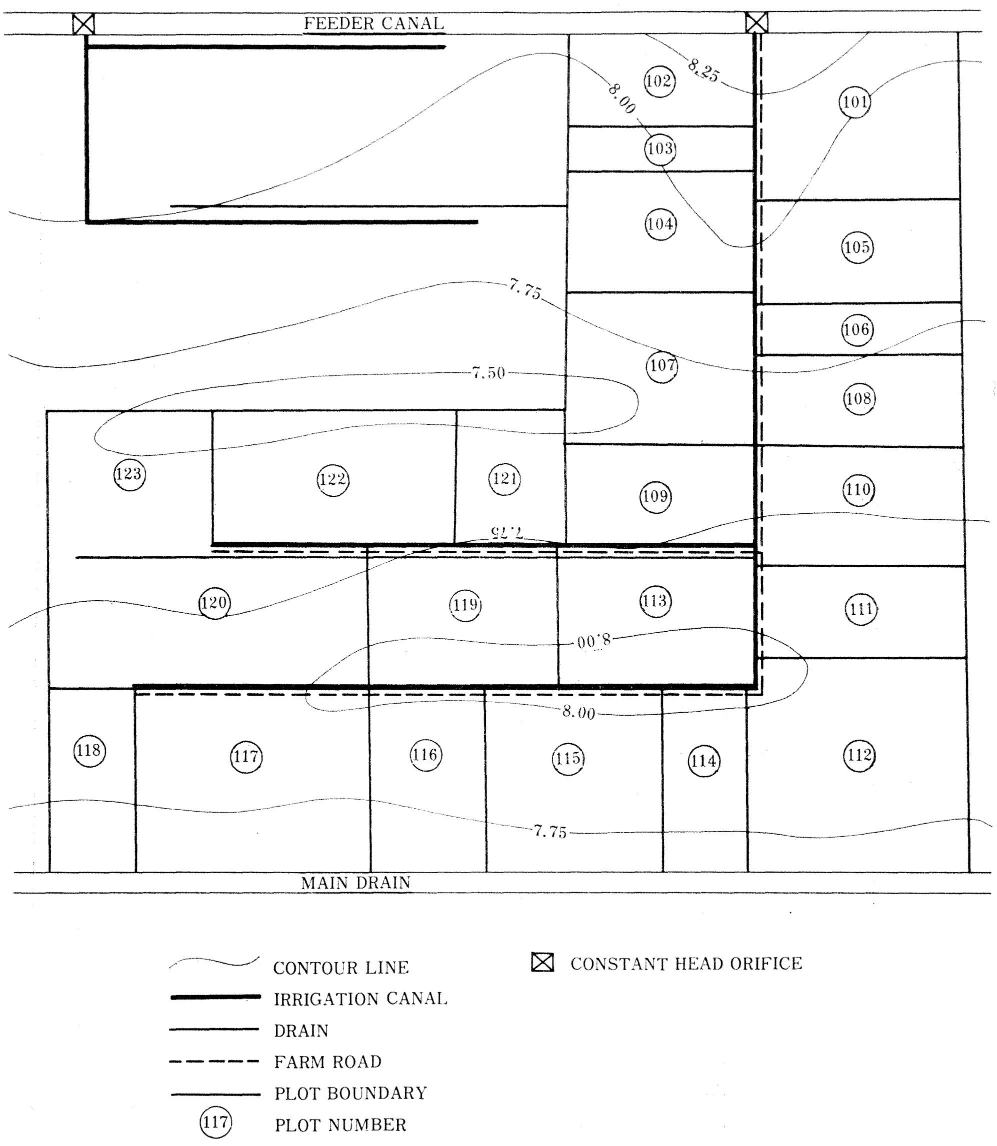


Fig. C

STEP 2. DESIGN OF IRRIGATION CANALR AND ROADS
DETERMINE THE LOCATION OF IRRIGATION INLETS AND THE DEMAND LEVELS
SCALE: APPROXIMATE 1:5000

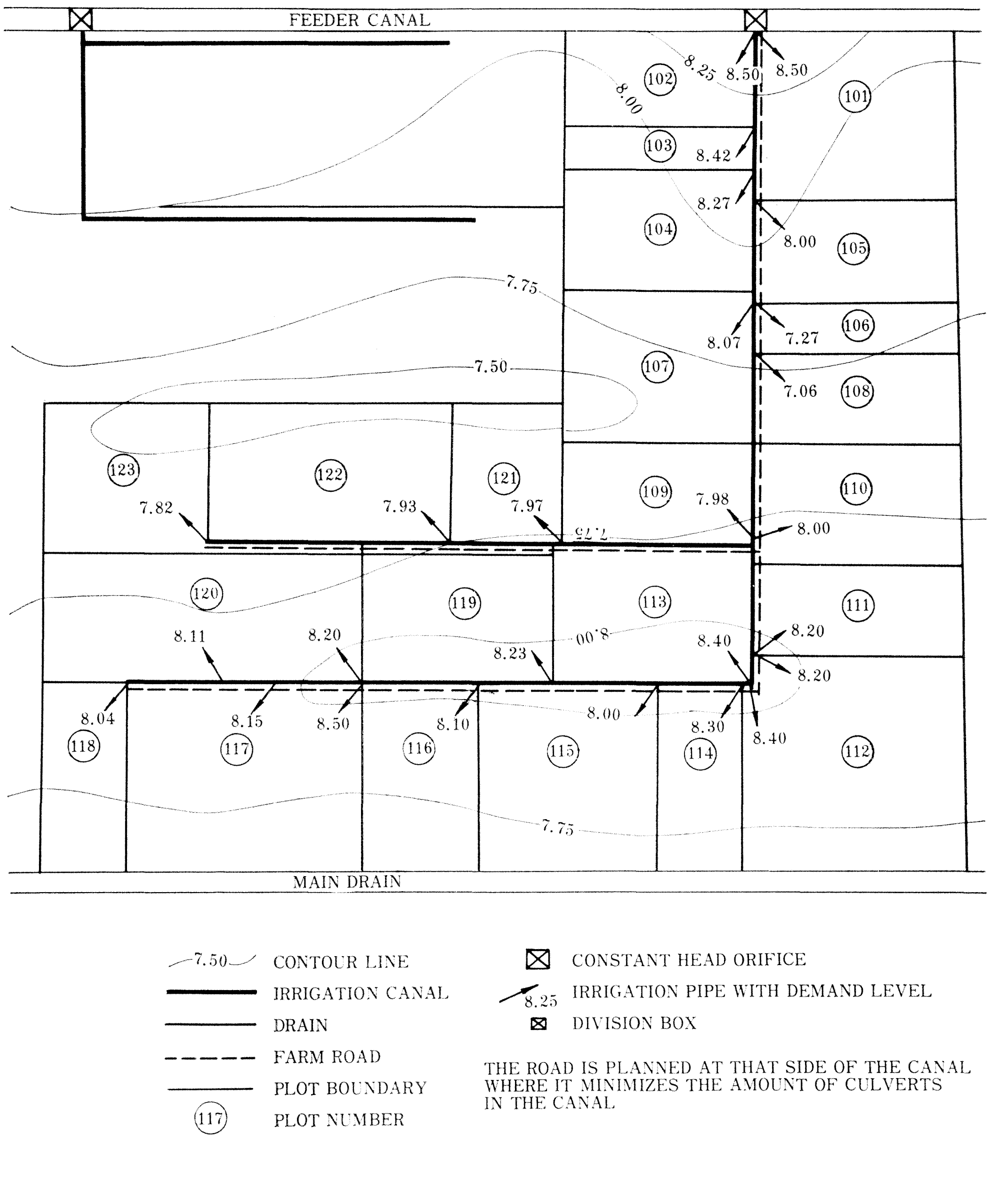


Fig. D

STEP 3. DESIGN OF IRRIGATION CANALS AND ROADS
DETERMINE THE LOCATION OF STRUCTURES
SCALE: APPROXIMATE 1:5000

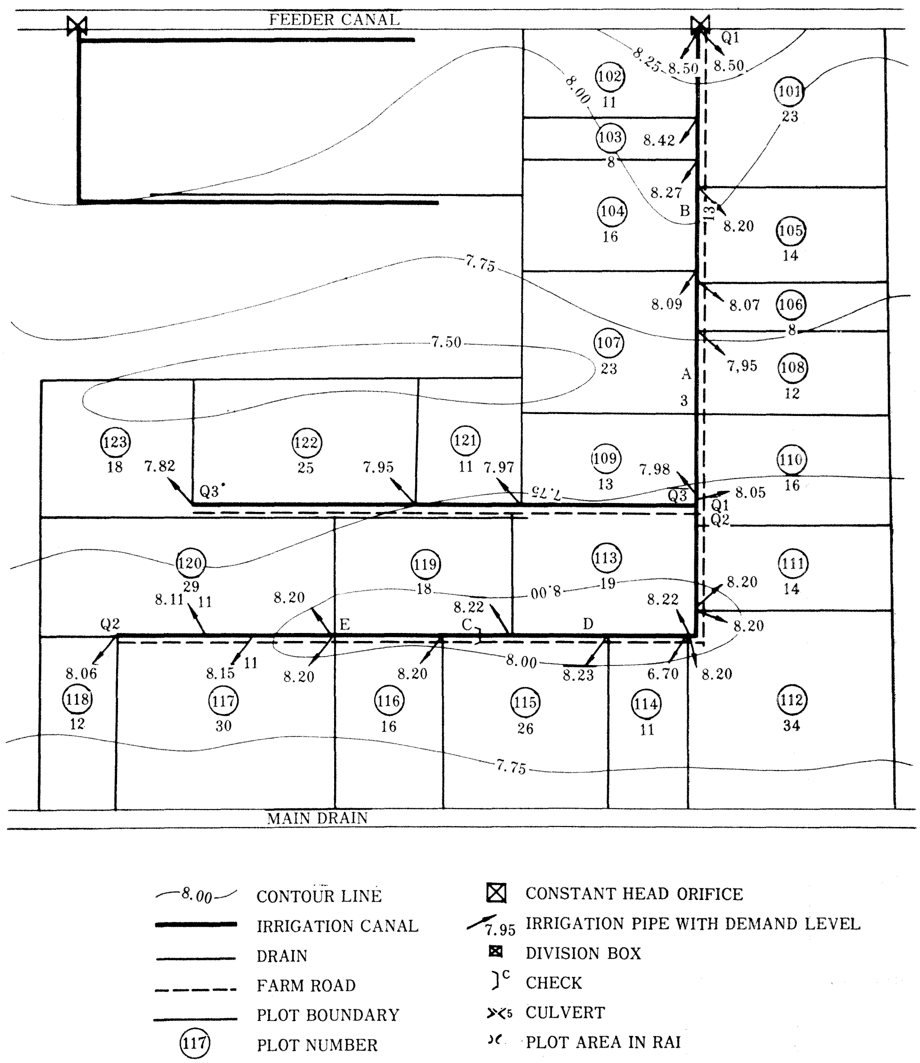


Fig. E

STEP 4. DESIGN OF IRRIGATION CANALS AND ROADS DEMAND LEVELS IN LONGITUDINAL PROFILE
SCALE: APPROXIMATE 1:5000

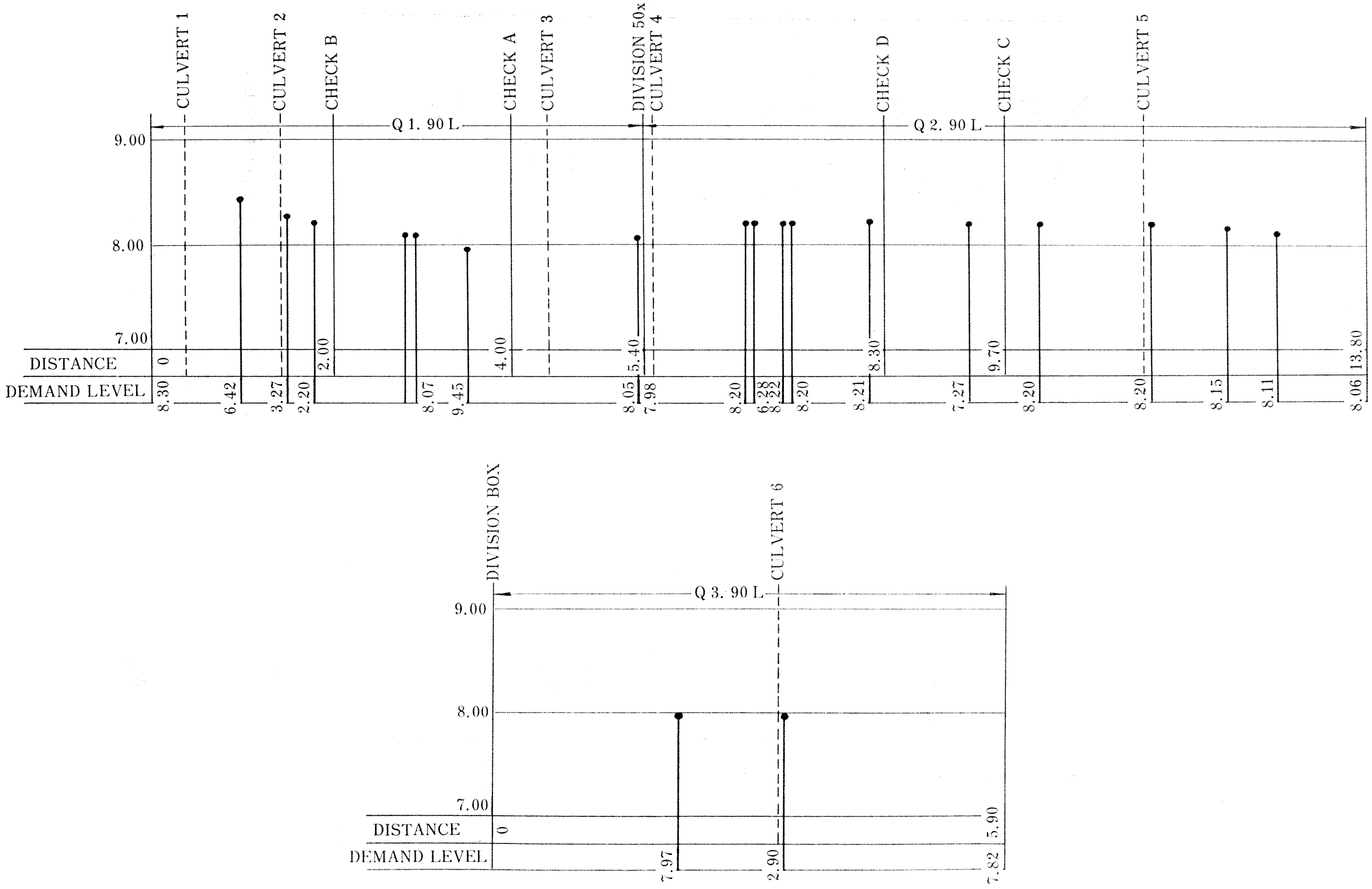


Fig. F

existing situation. In the first ditch section this means a designed water level just behind the C.H.O. equal to the water level in the lateral at 70% supply minus 0.15 m. losses. From the C.H.O. onwards the water level decreases with a minimum slope to the point where it intersects the desired water level determined earlier. After this point the water level is again determined.

Step 5—Next, the bed, bank and road levels are derived from the design water level according to the criteria.

Step 6—In addition to the farm roads along the ditches, connecting and maintenance roads along the main drain should be designed.

3.3 Design of Structures

The designs and drawings of all structures are made by personnel engaged in land consolidation according to the regulations and specifications of the Royal Irrigation Department.

3.3.1 Culverts

Culverts are necessary obstacles in a ditch to provide access to the plots. Normally, a culvert is located at the boundary between two plots giving access to both. Though one culvert causes only a few centimetres of head losses, many culverts together cause a considerable amount of head losses. Only half of the available slope in the canal should be used for head losses in the culverts.

3.3.2 Constant Head Orifices

The inlet structures supplying the irrigation ditches in the service units are constant head orifices (C.H.O.'s) as recommended in the Northern Chao Phya Study. With a C.H.O. the water flow is regulated and measured in the same structure. The C.H.O. consists of a stilling pool and two gates, viz. the orifice gate and the turnout gate placed on the upstream and downstream sides of the pool respectively.

3.3.3 Check Structure

Check structures are designed in the irrigation ditches in the service units to secure a full supply level at partial water supply of the laterals by backing up the water during irrigation. The influence of a check structure on the back water curve is estimated to be about 400 m. The location of check structures should not be based entirely on this distance.

3.3.4 Drop Structures

A drop structure in a canal is planned if the topographical conditions cause the demand levels in a certain area to be much lower than in the area traversed before. The water levels of ditch sections of different levels are designed separately. If the difference between the water levels is more than 0.30 m., a drop structure is justified. In case the difference is less than 0.30 m., it is better to design the lower water level by means of a steeper slope and thus to save a drop structure.

3.3.5 Division Boxes

In designing the layout of irrigation ditches a sub-division of the ditches cannot always be avoided. In that event a division box will be required. This structure is to divide the water flow into fixed, well-balanced parts without influencing the water flow into fixed, well-balanced parts without influencing the water level, which is rather difficult.

3.4 Design of Drains

Step 1—Subdivide the block in which a drain has to be designed into catchment units and calculate their areas. It is advised to subdivide as little as possible in order to avoid too many changes in the drain profile. Determine the discharge for every subdivision of the drain.

Step 2—Make a logitudinal profile of the actual situation on millimetre paper for every drain, as done for the irrigation ditches. If the centre line of a drain is located on a level point of the grid system, the actual level is known. If not, the actual level has to be interpolated from the surrounding level points.

Step 3—Design a water level, except for drains with a minimum profile where this is unnecessary. Irrespective of the designed water depth, the bed level must be at least 0.60 m. below the average surface level. In large drains, with water depths higher than 0.50 m., the water level is designed 0.10 m. below the average surface level. Often the bed level of the downstream part of a drain is lower than the bed level of the upstream and with a minimum profile. The difference in bed levels is due to either a steep slope in the upstream part or a large catchment resulting in a higher discharge and a higher water depth in the downstream part. In this case the bed level of the drain with a minimum profile can best be adapted to the level of the larger drain by giving it more slope. Of course this causes an over-dimension of the small drain. As, however, especially in the smaller drains maintenance is generally poor, the overdimension replaces a few maintenance passes. If the difference in bed levels between two parts is too wide to be covered by slope adaptation, a drop structure has to be designed. This can be a very plain structure. Protections of side slopes and bed, and a sill at the downstream end will suffice.

Step 4—Take care that the bed of the drain under design is situated about 0.10 m. higher than that the collector drain. If the bed level of the drain is 0.30 m. or more higher than that of the collector drain it is better to adapt the slope or build an end structure. This end structure can be a simple side slope bed protection.

Step 5—Have the designed drains drawn and meanwhile check the alignments in the field, if necessary. The necessity of checking can be derived from the aerial mosaics as follows. The centre lines of the drainage system are transferred to the mosaics. If they pass a suspected spot, a check in the field is required. Check also whether the main drain is not obstructed. It is senseless to design and construct an on-farm drainage system if the main drain does not operate properly.

C. Implementation

1. Staking Out

The implementation of the land consolidation plan started with staking out of the centre lines of the public land sections needed for roads and watercourses and of the boundaries according to the reallocation plan by officials of the Land Department. The centre lines were fixed very accurately, since this is of vital importance to the realization of a proper reallocation. As mentioned earlier, the plan was drawn on rectified aerial photographs enlarged to scale 1:2,000 in order to facilitate the work. The centre lines were staked out, based on the detailed dimensions as shown on the aerial photographs, thus allowing a double-check.

The alignments of the roads and watercourses were staked out by technicians of the Royal Irrigation Department. In order to calculate the final field levels, they also staked out the 20 m. grid after the fields to be levelled had been cleared from ant-hills, bushes and old boundary dikes. Care should be taken that stakes should never be aligned by 'extrapolating' a line. Aligning new stakes in between two fixed ones improves accuracy. Moreover, when stakes are to be given a certain elevation, a closed circuit levelling is necessary.

2. Earthwork

2.1 Clearing

The area was first cleared from trees, bushes, existing boundary dikes and ant-hills. The bulldozer drivers were instructed to move the soil in the direction of the lower-lying spots in the fields. Trees and bushes, if not carried away by the farmers, were burnt. Care was taken that the remaining trash was deposited along the new boundary dikes and not near irrigation canals, roads or drains. Many of the bigger trees, which had been marked by the landowners, were left standing in the fields. Farm yards and banana trees were left untouched.

2.2 Land Levilling

Under the conditions as prevalent in the pilot area, a cut deeper than 0.25 m. very seldom occurs. Thus the bulldozer blade will not be full if an earth-moving schedule is followed aiming at minimum transport, implying short runs criss-cross over the field. In practice, it proved to be more effective to make longer runs, with a fuller blade, parallel to the boundary dikes or canals. The bulldozer should always move from the lower side of the field near the drain to the higher side of the field near the irrigation canal. (Real high spots have already been removed for building up the road and irrigation canal bodies).

The slopes of the fields depend on the actual field level, the irrigation method, soil type, the crops to be grown and the dimensions of the irrigation fields.

The boundary dikes are constructed as part of the land levelling activities. Soil surpluses and trash can be pushed on to the boundary dikes.

It seems better to construct the roads and canals with a combination of bulldozers and motor scrapers. In that even the soil material can be gained immediately from alongside the drains or from elevated parts in the terrain and can be hauled to the roads by scraper.

After rough land levelling, heaps of loose soil and earth lumps are left behind on the field. Up till now, motor graders have been used to smooth out the irregularities and to construct small ridges between the level units. This activity has often been referred to incorrectly as 'final land levelling'. Final land levelling or rather 'precise land levelling and grading' with a tolerance of 2–3 cm. as opposed to rough land levelling with a tolerance of 6 cm. has so far not been practised on the project, because of lack of the appropriate equipment.

2.3 Irrigation Canals and Drains

In the course of the project period three methods have been applied for the excavation of irrigation canals and drains, namely:

a) excavation by ditcher;
b) excavation by backhoe;
c) excavation by manual labor.

2.4 Farm Roads

During the initial construction stages of the project the road bodies were built by bulldozers with cut from a 40 m. wide strip along the roads. As a results, the road body sometimes contained too much organic matter and could hence not be compacted adequately

Later, better-quality roads were constructed with motor scrapers, which hauled more suitable soil from high-lying spots and from the area near the drains resulting in a better compaction. Compaction has further been improved by regular spraying of the road body with water. No sheep-foot rollers have been used as yet.

3. Structures

Finally, the various structures such as inlet, check and drop structures, division boxes and culverts were constructed and the new plots—ready for the wet-season land preparation—were returned to the farmers.

4. Issue of Title Deeds

The procedure for the issue of title deeds is as follows. As soon as RID has finished the construction work, the Land Department starts preparing the title deeds. Concrete boundary marks are installed and the area between the marks is accurately measured in the field and mapped on the document of ownership. During a ceremony the title deeds are issued to the landowners, for whom the possession of the land title constitutes one of the incentives to cooperate voluntarily with the authorities.

Question and Answer

T. Saito, Japan: 1) Could you give me some information regarding the repayment system of consolidation work in your country.

2) What kind of method is employed on the levelling work there?

3) Are there any decreasing yields immediately after consolidation work? If any, could you give me some countermeasure usually employed there to prevent such demerits.

Answer: 1) Regarding the repayment system in Land Consolidation are, the Government have the policy for charging only 50–65% of the total cost for 20 years and 3 years for gracing period. And the Government allows them to loan them money from BAAC. (Bank of Agriculture and Cooperatives) in some amounts, which depends on how much their lands have to be constructed and the details of there works, i.e. they need land levelling or not, if their land quite smooth, no need to level.

The above mentioned only draft by the Committee. The IBRD. team will come to discuss on cost recovery by September 1975.

2) R.I.D. used their force for implementation and the Contractors for land levelling according to the programme.

3) This question if I understand correctly when the land already done for land levelling, top soils must be cutted, and low yield in some location will appear but it happen only one year and after agronomic practices by means of input heavy fertilizer it become normal condition.