system.

The flow characteristics in the channel between BRH and the Tengi Headworks were further clarified by measuring water level and discharge at two points in the Tengi river: (1) downstream reach of the junction of the Feeder Canal with the Tengi river (the U/S site), and (2) 4 km upstream of the Tengi Headworks (the D/S site). For these observations, the diversion at BRH was stopped for three days. After that, the diversion was controlled to 8.8 cu.m/s for the next three days and then the diversion was stopped again. The results of these measurements are summarized in Fig. 38. Through these observations, the following points are made clear.

a. When the diversion at BRH is 8.8 cu.m/s, the traveling time of flow for the distance of 38 km from BRH to the Tengi Headworks is 25 hours. The mean flow velocity is about 0.5 m/s.

b. If the diversion is increased at BRH from 0 to 8.8 cu.m/s, the water level in the channel rises and part of the diverted water is stored in low-lying areas along the channel as well in the course of the river. The peak discharge is recorded at the D/S site on the third day after the diversion is increased.

The above findings indicate that if the amount of diversion is altered at BRH, the change in discharge at the Tengi Headworks would start after one day and the flow would become steady after three days.

4.4.3 Main Canal

The water levels in the Main Canal have been measured since January 1982. The records of water levels in 1985 at the following three places are summarized in Fig. 39.

Place	Tertiary Canal	FSL
1. Upstream reach	TASB 1	4.20 m (13.79 ft)
2. Middle reach	TASL 10	3.93 m (12.89 ft)
3. Downstream reach	TASN 17	3.51 m (11.53 ft)

As seen in Fig. 39, the water level in the Main Canal fluctuates frequently in all sections of the Main Canal. There was a severe water shortage during the period from June to September. During this time, water levels were below FSL in all the sections of the Main Canal. It is of utmost importance to maintain the water level at FSL in order to distribute the water properly to each tertiary canal. It would be necessary to increase the flow capacity of the Main Canal and at the same time to install one or two cross regulators on the Main Canal to keep the water level at FSL at all times.

4.4.4 Distribution network

Present water requirements are as follows:

a. Presaturation	2.10 lit/s/ha (30 acres/cusec)
b. Normal irrigation	1.05 lit/s/ha (60 acres/cusec)

When a compartment is under presaturation, all the tertiary canals in the compartment are filled to FSL for 20 days. During normal irrigation, canals are also filled to FSL, but the offtake is opened only for 12 hours a day. This means that during normal irrigation, it is necessary to repeat opening and closing of the offtake gate every 12 hours. This is impractical and nobody can follow this operation rule. Consequently, water is supplied continuously even during the normal irrigation period. Actual water management is quite different from design. It is necessary to establish a more practical operation rule which requires less man power. In order to assess the problems of water management in the distribution network, the flow characteristics of the concrete conduit were determined by both field trial operations and hydraulic simulation analyses.

(1) Trial Operations

Trial water management was carried out for nine concrete conduits selected from five compartments. First, the discharge at the head of a tertiary canal was regulated to the design discharge by adjusting the gates of CHO. Then, the discharge was decreased to half the design discharge. In both cases, the distance from the top of the conduit to the water level was measured upstream and downstream of each cross bund at intervals of 10 to 20 minutes. In the course of the trial operations, it was found that the top elevation of check gate was too high to control the water level in the conduit properly. The gates were removed and the same operation was repeated.

a. Flow characteristics under the design discharge

Prior to the trial operation, it was confirmed that no water leakage occurred from the canal and the check gates were fully opened. The gate of CHO was adjusted and the discharge at the head of canal was regulated to the designed discharge. For confirmation, the discharge was measured by a current meter. Data obtained through the trial operation in TAPB 2a are summarized in Fig. 40

With the check gates, the water depth above the offtake pipes considerably varied between the upstream and downstream reaches. The water depth in the upstream reaches was more than that downstream. As a result, the discharge from offtake pipes in the upstream reaches was about 50 % greater than that downstream. This was because the top elevation of the check gates were too high to properly control the water in the conduit. Under present conditions, the design discharge cannot be equally distributed to each farm lot.

The check gates were then removed and the trial operation repeated. As seen in Fig. 40 the flow pattern in the conduit was much improved. The water depth above the offtake pipes was almost constant in all reaches of the conduit. Consequently, there was no difference in the discharge from offtake pipes. The design discharge was equally distributed to each farm lot. The same phenomenon was observed in other concrete conduits.

It is concluded that even if the check gates are fully opened, the farm lots upstream get more water than those downstream. If the check gates are removed, the flow pattern in the conduit is much improved and an equitable distribution of water can be realized. This is because the top elevation of the check gates is so high that the gates prevent the proper control of water level in the conduit.

b. Flow pattern under the half of design discharge

In order to examine the flow characteristics under normal irrigation, the discharge at the head of canal was regulated to half the designed discharge. Data obtained through the trial operation in TAPB 2a are summarized in Fig. 41. The check gates significantly affected the water depth in the conduit. The water depth above the centre of offtake pipes was 10.2 cm (4.0 inches) on average in the upstream reach, but only 3.8 cm (1.5 inches) and 5.6 cm (2.2 inches) in the middle and downstream reaches, respectively. The discharge from offtake pipes in the upstream reach was about 40% greater than that in the middle and downstream reaches. The present check gates badly affect the equitable distribution of water.

The trial operation was repeated after the check gates were removed. As seen in Fig. 41, the water level in the upstream reach dropped and that in the downstream reach rose. No significant change was found in the water levels in the middle reach. As a result, the distribution of water was greater in the middle and downstream reaches and less in the upstream reach. The discharge from offtake pipes in the upstream reach was about half of that in the middle and downstream reaches.

Together with the results obtained under the design discharge, it is concluded that the check gate has a great influence on the flow pattern in the conduit. The top elevation of the present check gate is too high to properly maintain the water level. The water depth in the conduit is of course adjustable, if the check gate is suitably installed and properly operated.

(2) Hydraulic simulation analysis

In order to further examine the flow characteristics of the concrete conduit and to establish basic methods of water distribution, a hydraulic simulation analysis was carried out on six tertiary canals, using data obtained from the trial operations. For the simulation, a program was developed for the micro computer. The method of hydraulic simulation analysis and the program used are given in Annex D. The program could be used for determining the appropriate water level in the conduit for a given discharge as well as the location and the height of required slots without trial operations at the site. As a result of the simulation analysis, various constraints of concrete conduit became apparent. The followings are the main findings.

a. Manning's roughness coefficient "n"

Manning's roughness coefficient "n" of the existing concrete conduit is much higher than the designed value of 0.013. The actual values of "n" range from 0.016 to 0.024, as shown in the table below. The average coefficient gradually increases toward downstream. This is due to silt and rubbish deposited on the bottom of the canal. It is as if the side walls of the present conduit were made of concrete and the bottom of earth. The coefficient "n" naturally increases and the flow capacity of the conduit becomes less. The present flow capacity is estimated at about half of the designed one.

Manning's roughness coefficient "n"

Reach	TASL1	TASL2	TASL8	TASB3	TASB4	TAPB2a	Average
CB3 - CB2	0.017	0.018	0.016	0.017	0.018	-	0.017
CB2 - CB1	0.018	0.019	0.016	0.018	0.017	0.018	0.018
CB1 - END	0.018	0.024	0.020	0.018	0.018	0.020	0.019

Remarks: CB = Cross Bund

b. Discharge coefficient of offtake pipe

There are a lot of weeds and rubbish in the canal which even affect the discharge from offtake pipes. The coefficient of discharge of offtake pipe used for the simulation analysis is summarized below. The averaged coefficient is 0.70. This is about 13% smaller than the coefficient, 0.80, obtained through the trial operations. This indicates that some of offtake pipes were blocked by weeds or rubbish during the trial operations.

Coefficient of Discharge of Offtake Pipe

Reach	TASL1	TASL2	TASL8	TASB3	TASB4	TAPB2a	Average
CB3 - CB2	0.6	0.6	0.7	0.7	0.7	-	0.7
CB2 - CB1	0.7	0.6	0.7	0.6	0.7	0.6	0.7
CB1 - END	0.6	0.6	0.8	0.8	0.6	0.6	0.7

c. Installation of slots

The canal section gradually decreases towards downstream. The sections are determined on the basis of presaturation water requirements. When the discharge is decreased for normal irrigation, the drawdown of water level is greatest upstream and less downstream, while the field offtake pipe is constantly installed 30.5 cm (12 inches) below the top of conduit. The need of slots is highest in the upstream reach. The required number of slots derived from the simulation analysis is summarized in the table below. It is known that one or two slots will be necessary in the upstream reach of the cross bund 2. The result of simulation analysis indicates that the water level in the downstream reach of the cross bund 2 can be kept about 4.3 cm (1.7 inches) above the offtake pipes without slots during the normal irrigation period. It becomes parallel to the top of conduit. The amount of water discharged from the offtake pipe is sufficient and the distribution to each lot becomes even. Installation of slots is not necessary downstream of cross bund 2. On the other hand, the water level upstream of cross bund 2 becomes below the offtake pipes and the installation of slots becomes imperative.

Required Number of Slots

Reach	TASL1	TASL2	TASL8	TASB3	TASB4	TAPB2a
CB3 - CB2	0	1	0	2	2	0
CB2 - CB1	0	0	0	0	0	0
CB1 - END	0	0	0	0	0	0

d. Normal supply level

It would be convenient if normal irrigation could be practiced without frequent adjustment of CHO, checks and slots. For this, the water level in the Main Canal must be stable and at the same time, checks and slots on concrete conduit should be properly adjusted at the beginning of the normal season. Once the adjustment has been made properly, it should not be necessary to adjust checks and slots frequently. The water level in the canal would be constant at Normal Supply Level (NSL). The operation of CHO, if necessary, would be made only to keep the water level in the conduit close to NSL.

Each tertiary canal has different hydraulic characteristics. It would be difficult determine proper height of checks and slots and to settle NSL without trial operations which would take a long time. Hydraulic simulation would be helpful in determining proper height of checks and slots and in settling NSL.

4.4.5 Operation Manual

Now that direct seeding is employed widely in the project area, water management should follow the change in farming. In addition, the present operation manual includes regulations which are difficult to follow in practice. It should be modified or improved from time to time with accumulation of experiences. The main items to be improved are as follows:

(1) Distribution and language

The present operation manual is distributed to key personnel only. Staff who are in charge of the daily water management of the project do not understand the concepts of the water management. The operation manual is written in English. For the better understanding of Irrigation Inspectors and Irrigation Overseers, the operation manual should be written in Bahasa Malaysia and distributed to all the staff concerned.

(2) Measures to be taken during times of water deficit

In the present operation manual, it is simply stated that, in time of drought when the flow in the Bernam river is below 34 cu.m/s (1,200 cusec), the deficit is to be withdrawn from the Swamp. The result of the study on the Swamp reveals that the contribution from the Swamp is very small in the dry season. Detailed measures and procedures to be taken during the drought should be stipulated in the revised operation manual.

(3) Use of checks and slots

The trial operations have shown that use of checks and slots greatly influences the water flow in the tertiary canal. The proper use of the checks and slots should be determined through trial operations. The characteristics of tertiary canals differ from one another. Thus, the proper location and the height of checks and slots should be determined one by one. The use of checks and slots should be stipulated in the revised operation manual, and illegal use of them should be strictly prohibited.

(4) Operation during normal irrigation

In the present operation manual, it is stipulated that, when a compartment is under normal irrigation, all the tertiary canals are to be filled in the same way as during the presaturation period, but the offtakes are to be opened only for 12 hours a day. This may be theoretically satisfactory, because the water requirement for normal irrigation is just a half of that for presaturation, but such frequent intermittent irrigation is difficult to administer in practice. It is recommended that continuous irrigation water supply should be planned during the normal irrigation period.

4.4.6 Institutional aspects

(1) Structural deficiency of irrigation organization

It is observed that orders from two different sources reach to the Senior Irrigation Inspector and then to Irrigation Inspectors with regard to operation and maintenance in irrigation system. One is from the Chief Irrigation Inspector and another from the Engineers, Tanjong Karang and Sungai Besar. The whole irrigation area of Tanjong Karang scheme is stipulated as under the charge of the Chief Irrigation Inspector. At the same time, the scheme area is divided into two, each half is administered by the respective Engineers. There is no clear demarcation of responsibility between the Chief Irrigation Inspector and the Engineers. It is normally maintained that the Chief Irrigation Inspector is responsible mainly for operation aspects and that the Engineers have roles in maintenance works.

Organizationally, the Senior Irrigation Ispector and Irrigation Inspectors are attached to the respective Engineers. The Chief Irrigation Inspector has no staff under him except for BRH team, reporting directly to the Senior Engineer, Kuala Selangor. However, the Chief Irrigation Inspector issues orders actually for operation and maintenance of irrigation system.

Confusion of responsibility and discrepancy between the stipulation and actual performances have been derived from a structural deficiency of the organization. There is nothing else like this for the positions at the levels lower than the Senior Irrigation Inspector. Functions are well-defined in the duty lists according to the area of responsibility.

(2) Insufficient number and low-grade of existing Engineers

If compared to other irrigation areas, the number of Engineers seems too small in the State DID covering the PBLS area. Likewise, the grades of the existing Engineers are low. These facts are indicated in the comparison with the Engineering Division, Muda Agricultural Development Authority (MADA), as follows:

Grade	No. of Engineers	
	Engineering Div., MADA	DID, Kuala Selangor
Superscale 'E'	1 -	
Superscale 'F'	1 -	
Superscale 'G'	5 (1)	1 /1
Senior Timescale	6 (1) /4	1 /2
Timescale	13 (2)	4 /3
Total	26 (4)	6

Remarks:
/1 = Senior Engineer, Kuala Selangor
/2 = In charge of maintenance work in drainage areas of Blocks II and III, Kuala Selangor District (Seconded from the Federal DID, PBLS)
/3 = Composed of ;
1 Engineer (Development), Kuala Selangor
2 Engineers, Tg. Karang and Sg. Besar
1 Engineer (Pilot Project for TASB4, Seconded from the Federal DID, PBLS)
/4 = Figures parenthesized indicate number of Mechanical Engineer

Except those seconded from the Federal DID and PBLS, the original staff of the State DID involve only four Engineers. The head, Senior Engineer, Kuala Selangor, is of superscale 'G'. The Engineers, Tanjong Karang and Sungai Besar, are merely timescale in grade. Another Engineer (timescale) is in charge of development, who carries out tender supervision at the Kuala Selangor office.

The head of MADA, which covers an area of nearly five times PBLS irrigation area, is superscale 'C' in grade. The Kembu Agricultural Development Authority (KADA) has the area of authority (19,000 ha, approximately) almost equal to the PBLS irrigation area. The head of KADA is superscale 'F' in grade. These two Authorities are typical administration bodies for irrigation established under the Ministry of Agriculture.

In the PBLS area, DID, Kuala Selangor, administers not only irrigation areas (almost 20,000 ha in total) but outside drainage areas (82,000 ha). The present number of Engineers allocated to DID, Kuala Selangor, is apparently insufficient. The number of Engineers should be increased. Separation of matters between irrigation and drainage would be favourable.

For the purpose of strengthening Engineers' work force, it will be required to revise the grades of the existing Engineers. The grade of the Senior Engineer, Kuala Selangor, should be raised up, at least parallel with the head of KADA. In line with this lifting, those of the Engineers, Tanjong Karang and Sungai Besar, will have to be reconsidered also. Appointment of additional Engineers would be realized with these arrangements.

(3) Vacant S.I.I. for upstream compartments

There has been a vacant seat of the Senior Irrigation Inspector, Tanjong Karang, for a long time. This has caused the situation in irrigation administration that the whole Tanjong Karang Scheme area is divided into two. One half upstream has been administered by the Chief Irrigation Inspector, and the other half downstream is under the control of the Senior Irrigation Inspector, Sungai Besar. For the sake of stipulated responsibility of the Chief Irrigation Inspector, the vacancy should be filled.

(4) Operation and maintenance for the main conveyance system

There is a need for close connection in operation between BRH and the structures along the Main Canal such as cross regulators and spillways. These structures should be operated according to the volume of BRH discharge to meet field requirements.

Operation and maintenance of BRH have been carried out by a team stationed at BRH quarters: one special-grade Irrigation Overseer, two gatekeepers, one operator, one greaser, two drivers and three laborers. So far the operation aspect has not been remarkable, and a lot of their time is spent in maintenance works including clearing of the nearby areas.

The existing cross regulator located downstream a-a line is operated by an a-a line (secondary canal) gatekeeper under the Irrigation Inspector, Panchang Bedena. The end cross regulator is under the direct responsibility of the Irrigation Inspector, Panchang Bedena, due to its importance in controlling water for b-b line as well as for c-c line.

The Tengi Spillway and Headworks have been provided with the respective two operators, stationed at FDSc, Sawah Sempadan, while one operator for the Haji Dorani Spillway is working under the Irrigation Inspector, Panchang Bedena.

These are the present situations of operation and maintenance for BRH and structures in the main conveyance system. The staff are located at remote places, and not much effective coordination has been maintained with each other. Only the Chief Irrigation Inspector gives instructions separately to these staff from time to time. As a result, regulation of water level in the Main Canal has not been successful, leading to an uneven distribution of water between compartments.

(5) Operation and maintenance in irrigation compartments

Withdrawal of water from the Main Canal and water distribution along the tertiary canals are the tasks of the irrigation staff assigned in each compartment. Operation of control structures is done by irrigation gatekeepers who are instructed by Irrigation Overseers. Instruction of Irrigation Overseers is based on that from the Irrigation Inspector who is in change of the whole compartment. Distribution of duties among the staff (Irrigation Inspector-Irrigation Overseers-gatekeepers) is common to all the eight compartments. Both the Chief Irrigation Inspector and Senior Irrigation Inspector may coordinate Irrigation Inspectors and Irrigation Overseers for area-wide operation in four compartments, either upstream or downstream.

Maintenance of irrigation system, including repair of infrastructures such as farm roads and bridges, has been undertaken by the same irrigation staff in one compartment, but majority on a contract basis. Preparation of tender documents and supervision of contractors have thus been major roles of the staff. Both the Chief Irrigation Inspector and Senior Irrigation Inspector coordinate these activities, in terms of disbursement control. In case of patching of the damaged GRP flume and large-scale excavation for desilting work in drains and in the Main Canal, the personnel and machineries of the Store and Workshop of Tanjong Karang DID office have been employed. The Chief Irrigation Inspector arranges these departmental works for repairing and clearing through the Engineer, Tanjong Karang, according to the requirements judged.

As may be extracted from the above-stated, operation and maintenance are carried out separately in individual irrigation compartments. Proper coordination should be performed with the manning of Engineers superior to the Chief Irrigation Inspector who is to look after the practical aspects in controlling water. Another reason is that trials and application of common operation and maintenance methods of irrigation system should be undertaken smoothly. Furthermore, mechanical services in the project area should be strengthened, especially for departmental repair and clearing works. It calls for appointment of an Mechanical Engineer to the Store and Workshop.

5. THE PROJECT

5.1 Agricultural Development Plan

5.1.1 Land use plan

All the irrigation compartments covered by PBLS are planned for irrigated paddy. However, the PBLS Office has applied to the State Land Office to convert 449 ha in Sungai Leman and Pasir Panjang into tree crop areas. Due to the existence of Organic Clay and Muck Soils, irrigated paddy farming cannot be encouraged on these areas and most of them are left fallow. Of the total project area of 20,400 ha including 543 ha of the extension area and Sungai Panjang, the irrigated area will be 18,980 ha, comprising 18,320 ha for paddy and 660 ha for vegetables. The non-irrigated tree crop area will be 747 ha including the converted areas. The remaining 673 ha are reserves and home yards. The plan for future land use in the project area is summarized as shown in Table 22.

5.1.2 *Proposed farm operations*

(1) Planting methods

In order to overcome the labour shortage, direct seeding methods have been practiced in the project area, especially in Sawah Sempadan, Sungai Burong, Sekinchan and Sungai Leman. By converting from traditional transplanting to direct seeding methods, about 14 man-days of labour force can be saved per hectare. Considering the advantages in saving labour and reducing production costs, direct seeding methods are to be recommended.

One of the difficulties in applying direct seeding methods is proper control of weeds. If the wet direct seeding method is applied, the farm lot is presaturated for puddling. The water is then drained for seeding. After seeding, water is supplied again. Thus, the farm lot is filled with water twice during presaturation. This is very effective in controlling the growth of weeds. However, water consumption is high for the wet direct seeding method. In the dry direct seeding method, seeds are broadcasted onto a dry farm lot. Irrigation water is supplied gradually to match the growth of paddy. If the water is not supplied on time or the water depth is not properly controlled, the growth of weeds is faster than that of paddy plant. Precise on-farm water management is required for the dry direct seeding method. It is concluded that the wet direct seeding method has an advantage in controlling weeds, but it consumes much more water than the dry direct seeding method. Taking the above into account, the dry direct seeding method is proposed for the off-season (dry season) and the wet direct seeding method for the main season (wet season).

Transplanting will be continued as it will take a long time before direct seeding is extended to the whole project area. Mechanized transplanting saves considerable labour, but it should be introduced to the project area on a contract basis, because it is costly if individually introduced by farmers. Mechanized transplanting therefore is not recommended until it is practiced in the project area on a contract basis.

(2) Farming practices

a. Land preparation

Tillering activity of the rice plant should be promoted at the initial growth stage in order to increase the amount of effective tillers. For this purpose, land preparation works, rotavating or puddling, have to be carried out three times before seeding. The first land preparation should be done immediately after slashing and burning of paddy stalks of the preceding season. In the wet direct seeding metod, the second and the third land preparation should be conducted just before seeding. In the dry direct seeding method, the second land preparation should be done before seeding and the third one after seeding.

b. Seeds

Medium-term varieties such as MR52, MR71, MR77 and MR84 are recommended for the both planting methods. The growing period of these varieties is 130 to 135 days. The recommended seeding rate is 80 kg/ha.

c. Fertilizing

Fertilizer is applied by means of top dressing. The first top dressing is to apply mixed fertilizer of 100 kg/ha. It is made 20 days after the seeding. Same amount of mixed fertilizer is applied for the second top dressing, 35 days after the seeding. The third and fourth top dressings are done 55 and 75 days after seeding, respectively, applying Urea of 50 kg/ha.

d. Pests and rats control

In order to prevent outbreaks and spread of pests, especially of BPH, the cropping schedule should be so determined that the heading period of paddy never overlaps the one month from the middle of June. For rat control, an area-wise operation should be made in line with the recommendations of DOA.

e. Application of weedicides

Weedicides should be sprayed twice, 22 days and seven days, before seeding, in the dry direct seeding method. In the wet direct seeding method, weedicides are applied only once, 22 days before seeding. After seeding spraying of weedicides is also required for the both planting methods about 20 days after seeding.

The proposed farming practices in both the dry and wet direct seeding methods are summarized in Tables 23 and 24, respectively. The farm input requirements are shown in Table 25. The number of existing farm machinery in the project area will be sufficient, except rotavators and tractors for land preparations.

(3) Water management in the farm lot

Based on the recommendations by DOA on water depth in the farm lot and taking into account the prevailing farm operations in the project area, the proposed water management for each planting method is summarized below and illustrated in Fig. 42.

a. Wet direct seeding

The farm lot is presaturated for 15 days until the water depth becomes 75 mm (3 inches). After that, water supply should be stopped. After four days, i.e. on the 19th day from the start of presaturation, the farm lot is drained completely. Drainage should be completed within 24 hours. Pre-germinated seeds are then manually broadcasted on the 20th day. After broadcasting, water is again supplied for 20 days until the water depth reaches 100 mm (4 inches). The normal irrigation water supply then starts and continues for 85 days up to the 125th day from the start of presaturation.

b. Dry direct seeding

After land preparation, seeds are broadcasted on a dry farm lot. The start of water supply for presaturation depends on the condition of germination of seeds. Normally, the presaturation starts on the 6th day after seeding. The depth of water is gradually increased according to the growth of paddy for 20 days until the water depth become 100 mm. The water depth should be kept at 100 mm during the normal irrigation period. Normal irrigation lasts for 85 days.

(4) Measures to attain the proposed farm operations

With the completion of PBLS, the irrigation and drainage system has been improved. The targeted production, however, has not yet been achieved. The income level of farmers is still low. Aged farmers are increasing and the number of experienced farmers is decreasing. Under these conditions, the target of agricultural development of the Project should be to achieve irrigated double paddy cropping with the minimum project investment, inputs of manpower and production costs, and to achieve maximum output. In order to attain the target, the following measures should be necessary:

a. to improve farming practices by means of strengthening extension services;

b. to promote cooperative or contract farming to cope with the increase in aged farmers and decrease in experienced farmers;

c. to bring on key farmers to carry out intensive farming for irrigated double paddy cropping;

d. to improve on-farm drainage conditions for precise control of water on farm lots by excavating or repairing ditches;

e. to improve paddy field conditions for securing even growth of paddy and good performance of harvesting through levelling of land and removing of small patches;

f. to promote the above two physical improvements with provision of subsidies to be born from the Field Improvement Scheme's fund of the State DOA; and

g. to make paddy cultivation attractive to young members of farm households through integrated implementation of the above measures.

5.1.3 Proposed cropping schedule

The proposed cropping schedule is formulated as shown in Fig. 43, taking the followings into consideration.

a. Timing of harvest

Harvesting should be planned in dry months. Taking into account the seasonal rainfall pattern, harvesting should be avoided in wet months from April to May and from October to December.

b. Damages by brown plant hopper (BPH)

Occurrence of BPH is frequent from mid-June to mid-July. If the heading stage of paddy overlaps this period, outbreaks of BPH may become serious, leading to widespread damages out of control. Damages by BPH are significant in three compartments, Sungai Burong, Sekinchan and Sungai Leman. The cropping schedule for these three compartments should be so determined that the heading stage could not coincide with one month from the middle of june.

c. Best use of available water

In order to make the best use of available water resources, it is proposed to divide the project area into three irrigation schedule areas with 30 days allowance for undertaking the proposed farming practices in each area and 30 days staggering of water supply to these areas. In this way presaturation of the whole project area is completed within 90 days.

5.2 Irrigation Schedule and Water Demand

5.2.1 Irrigation schedules

(1) Main conveyance system

The proposed cropping schedule of the Project is recommended taking into accounts various hydrometeorological and agronomic factors. These factors include the best use of available water sources, annual and seasonal patterns of rainfall, farming practices, growing period of paddy, timing of harvesting and out-breaks of insects. The irrigation schedule is determined to match the proposed cropping schedule as follows:

a. The project area is divided into three Irrigation Schedule Areas (ISA).
b. Staggering period of presaturation in each ISA is 30 days.
c. Presaturation supply for ISA-1 is commenced on 21st February for off-season cropping and on 11th August for main season cropping.
d. Supply of water is stopped 25 days before harvesting.

The proposed irrigation schedule is illustrated in Fig. 44. The location of proposed ISAs is shown in Fig. 45. The area of proposed ISAs is given in detail in Table 26, and summarized below.

ISA-1 : 6,870 ha covering Sungai Burong, Sekinchan and Sungai Leman;
ISA-2 : 6,830 ha covering Sawah Sempadan, Pasir Panjang, Sungai Nipah, Panchang Bedena (secondary canal a-a line only), and

the extension area; and

ISA-3 : 5,280 ha in Panchang Bedena (secondary canals b-b and c-c lines), Bagan Terap and Sungai Panjang.

(2) Distribution network

The dry direct seeding method is proposed for off-season cropping and the wet direct seeding method for main season cropping. Schedules of water supply for the respective methods are explained in Section 5.1.2. For the normal irrigation period, the irrigation water is supplied continuously for 24 hours daily.

The intensity of irrigation during presaturation for the direct seeding method is higher than that for the traditional transplanting method. The flow capacity of concrete conduits is insufficient to cope with the water requirement during the presaturation as shown in Annex D. In order to meet the increased requirement without making any change in the present concrete conduits, introduction of rotational irrigation is proposed in the distribution network.

The area commanded by a tertiary canal is divided by the existing cross bunds into three blocks of similar area. Three rotation blocks are established on each tertiary canal as shown in Fig. 46. They are named from the block upstream as Rotation Block No.1, No.2 and No.3. The water is supplied from the upstream block at a rotation interval of about 10 days each. The presaturation for one tertiary canal can be completed within 30 days. The details of the proposed rotational irrigation method are given in Annex D.

The flow capacity of offtake pipes cannot meet the increase in water demand for presaturation. Consequently the use of syphons is imperative during the presaturation period.

5.2.2 Net irrigation requirements

(1) Presaturation requirement by paddy

Presaturation requirement is estimated applying the following equation.

$$PS = S + H + Ev + P$$

where, PS = Presaturation requirement (mm)
S = Water requirement for saturating soil (mm)
H = Standing water depth (mm)
Ev = Evaporation (mm)
P = Percolation loss (mm)

Water requirement for saturating soil is estimated at 100 mm in depth based on the field tests on the field capacity of soils in the project area. Required standing water depth varies depending upon the planting methods of paddy as follows:

Planting Methods	Required Depth (mm) 1st Supply	2nd Supply
Transplanting	100	-
Wet direct seeding	75	100
Dry direct seeding	50	50

Evaporation from paddy field is assumed at 5 mm/day on average. Percolation loss was measured in nine farm lots in the project area. The averaged percolation loss is 2 mm/day. Based on these assumptions and the observed data, the presaturation water requirement is estimated for the respective planting methods as follows:

Item		Trans-planting	Direct Seeding Wet	Dry
1st presaturation				
Supply period	(day)	20	15	10
Drainage period	(day)	-	5	-
Net supply amount	(mm)	320	265	210
	(mm/day)	16.0	17.7	21.0
2nd presaturation				
Supply period	(day)	-	20	10
Net supply amount	(mm)	-	240	120
	(mm/day)	-	12.0	12.0

In order to obtain reference information on presaturation supply, measurement of discharge was carried out in the tertiary canal, TASB 4, in Sungai Burong. In the area commanded by the canal, the dry direct seeding method prevailed in 85% of the area. The result of analysis shows that the presaturation requirement was about 210 mm at the offtake pipe, and about 260 mm at the head of the tertiary canal.

(2) Normal irrigation requirement of paddy

DID made water balance studies in Sawah Sempadan in 1984 and 1985. The estimated average evapotranspiration was 5.6 mm/day. Percolation was about 2 mm/day on average. The sum of these values, 7.6 mm/day, corresponds to the normal irrigation requirement.

In order to examine such values, the decrease in standing water depth in a farm lot was observed in 14 farm lots daily and the normal irrigation requirement was estimated. It was 7.4 mm/day on average. The normal irrigation requirements obtained from different sources being very close each other, the normal irrigation requirement was taken to be 7.6 mm/day.

(3) Crop water requirements of vegetables

Crop water requirements of vegetables were estimated using the method and assumptions suggested by FAO. The crop water requirement (ETcrop) is calculated by multiplying the reference crop evapotranspiration (ETo) by the crop coefficient (Kc). ETo was calculated by adopting the modified Penman method. It is 5.1 mm/day based on the meteorological data observed at the DID meteorological station at Sekinchan. The average Kc value is assumed at 0.95. Thus, ETcrop is estimated at 5 mm/day.

5.2.3 Water demand for irrigation use

(1) Irrigation efficiency

The irrigation efficiency of the Project is composed of conveyance and operation efficiency in the main conveyance system, and the distribution efficiency in tertiary canals. In addition, application efficiency in a farm lot should be taken into account for upland irrigation.

The right bank of the Main Canal is adjacent to the Swamp and the left bank is protected firmly by the road embankment. If the leakage from the Main Canal is stopped and proper water management is practiced, the conveyance and operation efficiency in the main conveyance system could be as high as 90%.

The distribution efficiency much depends on the location of field offtake pipes. The pipes are not always installed as designed. Pipes wrongly placed should be relocated. The more pipes that are relocated, the higher efficiency will be achieved. It is estimated that the distribution efficiency at present is as low as 60% with no pipes relocated. To grasp the relationship between the number of field offtake pipes to be relocated and the distribution efficiency, hydraulic simulation analysis was made using field survey data obtained in seven tertiary canals. The results of the study may be summarized in the following table.

	Number of Pipe Relocated		Attainable Distribut
Case	Number	% to Total	Efficiency (%)
1	231	20	85
2	166	14	80
3	91	8	75
4	47	4	70
5	35	4	65

Of the five cases above, the high irrigation efficiency is expected in Cases 1 and 2, but the number of offtake pipes to be relocated is more than 160. These are not practical and not recommended. In Cases 4 and 5, the distribution efficiency is below 70% and it is too low. These Cases are also not recommended. In Case 3, the distribution efficiency is high enough and the number of field offtake pipes to be relocated is limited to only 8% of the total field offtake pipes. By relocating 8% of field offtake pipes, the distribution efficiency of 75% can be achieved.

The application efficiency is assumed at 70% for upland irrigation. The irrigation efficiency of the Project is therefore determined as 67% for paddy and 47% for vegetables as calculated below.

Paddy	0.75 x 0.90	= 0.67
Vegetables	0.70 x 0.75 x 0.90	= 0.47

(2) Water demand required at the head of tertiary canal

After the introduction of rotational irrigation into a tertiary canal, the peak water requirement occurs when the water is supplied for the first presaturation (21 mm/day net) into Rotation Block No.3. At that time, the water is supplied for the second presaturation (12 mm/day net) into Rotation Block No.2 and normal irrigation (7.6 mm/day net) into Rotation Block No.1, respectively. During the presaturation period, the water demand required at the head of tertiary canal is determined based on this peak water requirement.

During normal irrigation period, water is diverted from the Main Canal continuously for 24 hours per day to supply the normal irrigation requirement into each lot. The supply should be 1.33 times (1/0.75) as much as the net irrigation requirements.

The water demand required at the head of tertiary canal differs from each other, because the commanded area and the land use vary for each canal. The unit water demands for both presaturation and normal irrigation periods are summarized below.

Presaturation: q_p = (21.0+12.0+7.6)/3 x 10/86,400/0.75
= 0.002091 cu.m/s/ha
= 2.091 lit/s/ha

Normal irrigation: q_n = 7.6 x 10/86,400/0.75
= 0.001173 cu.m/s/ha
= 1.173 lit/s/ha

Vegetables: q_v = 5.0 x 10/86,400/0.70/0.75
= 0.001102 cu.m/s/ha
= 1.102 lit/s/ha

(3) Water demand required at the head of main conveyance system

Irrigation water is supplied following the fixed irrigation schedule. The water demand at the head of main conveyance system can be obtained by dividing the total water demand required at the head tertiary canals by conveyance and operation efficiency; 90%. It is calculated as shown in Fig. 46 using the following unit water demand for each crop and season. The peak water demand occurs when the presaturation is practiced in ISA 3.

Presaturation: q_p = 2.091/0.9 = 2.338 lit/s/ha
Normal irrigation: q_n = 1.173/0.9 = 1.313 lit/s/ha
Vegetables: q_v = 1.102/0.9 = 1.231 lit/s/ha

5.2.4 Water demand for domestic and industrial use

(1) Present water demand

The Bernam river is the main water source for domestic and industrial (D&I) water supply in the northwestern region of the State of Selangor. For water supply to Sungai Besar town and villages in the District of Sabak Bernam, two pumping stations are in operation:

a. Sabak Bernam scheme on the Inlet channel of the Bagan Terap pumphouse with intake capacity of 5,460 cu.m/day; and
b. New Sabak Bernam scheme at BRH with an intake capacity of 27,300 cu.m/day.

In the State of Perak, there are two private oil palm plantations which have been taking water both for domestic and processing uses from a tributary of the Bernam river for many years. Present D&I water demand for these plantations is estimated to be 3,760 cu.m/day.

The total D&I water demand in the Bernam river basin is, therefore, estimated to be about 48,000 cu.m/day (0.55 cu.m/s) as shown in Table 27.

(2) Future water demand

There are some expansion plans and new development schemes for D&I water supply in the Bernam river basin. Increase in water demand upstream of BRH affects on the available discharge for the project area. Existing expansion plan of D&I water supply upstream of BRH is estimated at 9,580 cu.m/day as shown in Table 27. This amount is to be deducted from the available runoff at BRH in the succeeding water balance study.

In the project area, the Selangor State Waterworks Department scheme is under construction to tap water from the Main Canal at Sungai Burong. The proposed intake capacity is 27,300 cu.m/day (6 mgd). This amount is counted into water demand for the Project

5.2.5 Total water demand

Water demand in the project area consists of irrigation and D&I water uses. The diversion requirement at BRH varies seasonally depending on irrigation supply schedule. The total water demand by season is estimated as shown in Fig. 47. When presaturation is practiced in ISA-3, the diversion requirement becomes its peak value of 30.6 cu.m/s comprising 30.2 cu.m/s for irrigation demand and 0.4 cu.m/s for D&I water demand.

5.3 Water Balance Study

5.3.1 Methodology of the study

The water balance study of the Project was carried out to find the best method of water use as well as to identify the optimum irrigation development plan. The water balance study was based on the proposed land use, cropping schedule and water management plans. Among many factors, the amount of water released through the scour sluice at BRH has the greatest influence on the result of study. It is, therefore, necessary to establish alternative plans regarding the use of the released water.

(1) Release of water through scour sluice

When the gate is fully opened, a minimum of 6.2 cu.m/s (220 cusec) of water is released through the scour sluice, if the upstream water level of BRH is kept at FSL. During the dry period when the Bernam runoff falls below 18 cu.m/s (640 cusec), the upstream water level cannot be kept at FSL and the amount of released water decreases to about 4 cu.m/s (141 cusec). The released water can be used as an additional water source for the Project, but if the release is completely stopped the water quality downstream deteriorates and adversely affects the existing D&I water supply schemes downstream.

Even during the dry period, 2.5 cu.m/s (88 cusec) has been taken at the Bagan Terap pumphouse to irrigate the area of 1,520 ha, while 4 cu.m/s is released through the scour sluice. If pumping of water at Bagan Terap is stopped and the release from the scour sluice is reduced to a minimum of 1.5 cu.m/s (53 cusec), the water quality at Bagan Terap will not be affected.

(2) Alternative cases for the water balance study

Regarding the release of water from BRH, the following three alternative cases have been considered and tested in the water balance study for each case. Conditions of each case are explained below.

Case 1: The water is released as it is. Namely, the scour gate is always open and a minimum of 6.2 cu.m/s (220 cusec) is released through the scour sluice. The amount of released water will be reduced to 4 cu.m/s during the dry period, when the Bernam runoff becomes below 18 cu.m/s. At the Bagan Terap pumphouse, 2.5 cu.m/s of water is taken to irrigate the pumped irrigation area (1,200 ha in Bagan Terap and 320 ha of the Sungai Panjang area). The area commanded by BRH is 17,460 ha comprising 16,800 ha of paddy area and 660 ha of vegetable area.

Case 2 : The pumping of water at Bagan Terap is stopped. All the areas commanded by the Bagan Terap pumphouse at present are served by the Main Canal. The total irrigation area served by BRH is 18,980 ha. A minimum of 1.5 cu.m/s is released from BRH.

Case 3 : As in the Case 2, the pumping of water at Bagan Terap is stopped and BRH commands all the irrigable area of 18,980 ha. However, the scour gate is closed and no water is released downstream. Countermeasures are taken for compensating the existing D&I water supply schemes downstream.

(3) Procedure and assumptions for the study

The water balance study is made putting stress on the water balance during dry period and, therefore, discharges from the Swamp is neglected. Since the runoff of the Bernam river and rainfall in the project area have decreased in recent years, the study is made only for the recent 10 years, from 1975 to 1984.

The required dependability of irrigation water supply is set at 80%, namely water shortage should be accepted once in five years.

5.3.2 Results of study

The results of the water balance study are summarized below.

	Case 1	Case 2	Case 3
Conditions			
Irrigation area (ha)			
Served by BRH	17,460	18,980	18,980
Served by BT pumphouse	1,520	0	0
Minimum discharge released through scour sluice (cu.m/s)	4.0	1.5	0
Water deficit			
Frequency of occurrence	3/10	2/10	2/10
Amount of water deficit (million cu.m)			
- Biggest deficit	42	23	20
- 2nd biggest deficit	30	22	17
- 3rd biggest deficit	6	-	-
Need for countermeasures	Yes	No	No
Water source development (M$ million)			
- Alt.1 Storage dam	70	-	-
- Alt.2 Regulating pond	20	-	-
Reduction of irri. area (ha)	500	-	-
Need for compensation work			
D&I water supply	No	No	Yes

Among these, the Cases 2 and 3 fulfill the required dependability of irrigation water supply, 80%, but the Case 1 is unsatisfactory. In order to satisfy the required dependability in the Case 1, it becomes necessary *either to develop an additional water source or to reduce the proposed* irrigable area by about 500 ha. For the additional water source, it will be necessary to construct storage facilities with a capacity of about 6 million cu.m. The construction cost of such facilities will be about M$ 20 million for a regulating pond in the Swamp area and M$ 70 million for a storage dam. Such development for additional water sources is expensive and is not recommended.

The amount of water deficit is smallest in the Case 3. However, the provision of compensation work is necessary for the existing D&I water supply facilities. In compensating D&I water for plantations in the State of Perak, an administrative arrangement will be necessary between the two States, Perak and Selangor. This will make the problem complicated, and the Case 3 is not be recommended.

In the Case 2, the deficit of water will occur twice in 10 years, which fulfill the proposed dependability of 80%. No administrative arrangement is required between the two States and no compensation work is necessary. The Case 2 has more advantages than the other two Cases.

The influence of delay of cropping from the proposed schedule was also examined for each Case. The water balance study was conducted on the assumption that the cropping is made 10 to 40 days behind. The results of study are summarized in the table below on the assumption that cropping 30 days behind schedule.

	Case 1	Case 2	Case 3
Frequency of water deficit	6/10	3/10	2/10
Main season paddy	3/10	2/10	1/10
Off-season paddy	3/10	1/10	1/10
Amount of water deficit (million cu.m)			
Biggest deficit	51	49	39
2nd biggest deficit	25	24	20
3rd biggest deficit	21	20	14

Even if the fixed irrigation schedule is two weeks behind, the increase in water deficit is negligible. If cropping is delayed over 30 days, however, the water deficit becomes significant in all Cases. It may be difficult to follow the fixed irrigation schedule strictly for a few years after the proposed water management is introduced in the project area. Some delay will occur in the actual cropping. In order to cope with such possible delay, it is desirable that the Bagan Terap pumphouse is retained to supplement supplies in the event of water shortage.

Taking all the above into account, the Case 2 is recommended as the most realistic alternative at present. Namely, all the irrigable area in eight compartments should be served by BRH, and the area of 1,200 ha commanded by the pumphouse at present will take water from the Main Canal under normal conditions, but will have supplement supplies from the pumphouse in case of water shortage.

5.4 Improvement Plan of Facilities

5.4.1 Bernam River Headworks

The following improvement works are necessary for BRH in order to surely divert the required amount of water for irrigation and other uses. Plan of improvement of BRH is shown in Fig. 48.

a. Increase in height of radial gates:

   In order to divert the design discharge of 30.6 cu.m/s, the flow capacity of the intake of BRH should be increased. This can be obtained by increasing the height of the radial gates by 15 cm.

b. Provision of electrically driven hoists to the intake:

   For the frequent and timely operation of gates, the present hoists should be replaced by electrically driven ones.

c. Replacement of screens:

   The existing screens should be replaced. For lifting and cleaning screens, supports for a chain block and an operation deck are necessary.

5.4.2 Main Canal

(1) Increase in flow capacity

The flow capacity of the Main Canal has to be increased by desilting and enlarging the canal section.

a. Design discharge

The maximum water requirement occurs when presaturation is practiced in ISA-3. The maximum water requirement is adopted as the design discharge of the Main Canal. The design discharge of various sections of the Main Canal is calculated as shown in Fig. 47. The design discharge at the head of the main conveyance system is 30.6 cu.m/s.

b. FSL of the Main Canal

FSL of the improved Main Canal has been determined so as not to be below the present FSL. FSL of the existing cross regulator should be 3.8 m (12.5 ft) to command the high lands of TASN 1 to 4. The designed water level at the Tengi Headworks should be 4.4 m (14.5 ft) to cope with the present crest elevation of the Tengi Spillway. The water level in the Main Canal should be controlled by three cross regulators, one additional regulator at TASL 10 (No.1) and two existing ones at PB a-a line (No.2), and at the end of the Main Canal (No.3). The water level along the Main Canal should be maintained at the following FSL.

Structure	Location	FSL
Cross regulator No.1	TASL 10	4.1 m (13.4 ft)
Cross regulator No.2	PB a-a	3.8 m (12.5 ft)
Cross regulator No.3	End of Main Canal	3.7 m (12.0 ft)
Secondary canal, c-c line	Head of the c-c line	3.4 m (11.0 ft)

c. Conditions of hydraulic calculation

Canal sections are determined based on back water calculations. For the calculation, the Manning's formula is applied. As for the roughness coefficient, a rather conservative value of 0.03 is adopted taking into account the wide-spread aquatic weeds in the canal and difficulties in proper maintenance.

d. Canal sections

Each canal section is trapezoidal in shape. The side slope of the canal were determined by referring to soil conditions of both banks, namely 1 to 2 for the left bank and 1 to 3 for the swamp side. Both side slopes downstream of the existing cross regulator are 1 to 2.

Canal bed elevation was decided based on the bed height of the existing structures. The bed height of cross regulators No. 2 and No. 3 is 0.91 m (3.0 ft). The canal bed between these structures has no inclination. The canal bed upstream of cross regulator No. 2 is parallel to the proposed FSL. The elevation of canal bed is set at 0.91 m (3.0 ft) at the cross regulator. It is gradually increased upstream. The water depth in the canal is about 2.9 m. As a result, the maximum excavation becomes about 1.0 m deep.

The freeboard of the canal is 60 cm in all the reaches. At the borders of compartments and branches of secondary canals, the canal section is changed. Seven different types of canal sections are proposed for a distance of about 35 km between the Tengi Headworks and the end of the Main Canal. The bottom width varies from 27 m to 5 m. Typical canal sections are shown in Fig. 49. Most of the proposed sections can be secured within the present canal sections by desilting and trimming both slopes of embankment.

Proposed longitudinal section of the Main Canal is illustrated in Fig. 50. The water level at the design discharge is also shown in the figure. This is the proposed FSL. It is noted that the proposed FSL is 10 to 17 cm higher than the present FSL as shown in Fig. 51.

e. Removal of existing timber bridges

Three timber bridges obstruct the flow in the Main Canal. These bridges should be removed. If the timber developers still need to cross the Main Canal, they should reconstruct bridges by their own expenses. Shape and number of piers, and the clearance of the bridges should fulfill the DID's requirements. It should be prohibited to use the water course of the Main Canal for transporting timber.

As for the DID's concrete bridge, any improvement work would not be required at present. However, the bridge should be properly maintained and aquatic weeds gathered in front of the bridge should be removed from the Canal.

(2) Installation of additional cross regulator

With the increase in flow capacity of the Main Canal, a considerable drawdown in water level is anticipated in the upper reaches of the Main Canal when the flow is less than the design discharge. In order to determine the changes in water levels under different conditions of discharge and to judge the necessity for cross regulators, the water level in the Main Canal is calculated in the following three cases of low discharge.

	Conditions	Max. Discharge (cu.m/s)
Case 1	Presaturation Irrigation in ISA No. 2	19.9
Case 2	Presaturation Irrigation in ISA No. 1	15.7
Case 3	Normal irrigation in all ISA	22.2

The results of calculation are summarized in Table 28 and Fig. 51. The water level at the Tengi Headworks for each case is compared with the present FSL as summarized below.

	Water Level (m)	Drawdown (m)
Case 1	4.08	0.18
Case 2	3.92	0.34
Case 3	4.17	0.09

The present FSL of a tertiary canal is set at its head at about 15 cm (0.5 ft) below the present FSL of the Main Canal. Thus if the water level in the Main Canal drops more than 15 cm below the proposed FSL, the design discharge cannot be diverted into tertiary canals. In order to supply water satisfactorily to each tertiary canal, the range of drawdown in water level of the Main Canal should be less than 15 cm. As seen in the table above, the drawdown would exceed 15 cm in the cases 1 and 2.

Consequently, it is necessary to install a cross regulator in the Main Canal. The location should be about half way on the Main Canal between the Tengi Headworks and the existing cross regulator. Taking into account the proposed irrigation schedule, the downstream section of TASL 10 is recommended as the most suitable location. The plan of the additional cross regulator is shown in Fig. 52.

(3) Improvement of existing cross regulator

The fixed weir of the existing cross regulator constricts the flow in the Main Canal. Concerning the flow capacity of the regulator, the following three cases were examined.

Case 1 : Estimation of the downstream water level, with the upstream water level kept at the present FSL, 3.7 m (12.0 ft), and the present design discharge of 8.8 cu.m/s (310 cusec).

Case 2 : Estimation of amount of discharge with the upstream water level kept at the revised FSL, 3.8 m (12.5 ft), and the downstream water level kept at 3.64 m (11.94 ft) to maintain the water level of the b-b line at FSL, 3.59 m (11.77 ft).

Case 3 : Estimation of the upstream water level with the revised design discharge, 12.4 cu.m/s (440 cusec) and the downstream water level kept at 3.64 m (11.94 ft) to maintain the water level of the b-b line at FSL, 3.59 m (11.77 ft).

The results of the calculations are shown below.

	Case 1	Case 2	Case 3
U/S water level	3.658 m (12.00 ft)	3.810 m (12.50 ft)	3.872 m (12.70 ft)
D/S water level	3.505 m (11.50 ft)	3.639 m (11.94 ft)	3.639 m (11.94 ft)
Difference in water level	0.153 m (0.50 ft)	0.171 m (0.56 ft)	0.233 m (0.76 ft)
Discharge	8.8 cu.m/s (310 cusec)	10.5 cu.m/s (370 cusec)	12.4 cu.m/s (440 cusec)

The case 1 study reveals that the hydraulic loss is 0.15 m (0.5 ft) with the present discharge. The downstream water level becomes 3.51 m (11.5 ft) and FSL of the b-b line, 3.59 m (11.77 ft), cannot be maintained. The case 2 study shows that the downstream water level can be kept at the required level, only when the discharge is less than 10.5 cu.m/s (370 cusec). The revised design discharge, 12.4 cu.m/s (440 cusec), cannot be passed. The case 3 study indicates that the upstream water level is required to be 3.87m (12.7 ft) in order to pass through the revised design discharge, 12.4 cu.m/s (440 cusec), without modifying the existing cross regulator.

From the above case studies, it is judged that the discharge capacity of the cross regulator is insufficient to pass the revised design discharge. If the regulator is not improved, the canal embankment should be raised 0.3 m (0.7 ft) compared with the present height for a reach of about 28 km. The crest elevation of spillways should also be raised. This would not be the most economic solution. It is, therefore, proposed that the existing fixed weir of cross regulator should be demolished and replaced by a movable weir. In order to maintain the upstream water level at FSL, it is recommended that a gate should be provided which will keep the upstream water level constant. The improvement plan for the existing cross regulator is shown in Fig. 53.

(4) Stopping leakage

There is a substantial amount of water leaking out from the Main Canal into drains. Without stopping such leakage, no improvement work will be effective. Consequently, the leakage must be stopped. It should be noted, however, that the leaking water is not totally wasted. It is used for domestic purposes by people living along the drains. Complete stopping of leaking water will cause much inconvenience to the people and bring some social problems.

As regards the use of the leaking water, a questionnaire survey was carried out by DID Kuala Selangor. The survey was done by questioning three family-heads selected from each drain concerned. Total number of families questioned was 81. It was found that the number of households along drains is 1,480 in total. Assuming an average of six persons per household, about 8,880 persons living along the drains concerned. If one person consumes 30 gallons of water daily, the total requirement is estimated at 266,400 gal/day or 0.49 cusec.

Water in the drains is used for many purposes. It is used for washing and bathing by all the people questioned. Besides, about 9% of the people use it for cooking and drinking, too. About 90% of the people would not use the water in the drains for domestic purposes if the piped water supply was adequate. At present, about 25% of the houses are equipped with piped water supply. But, the supply is not enough for all domestic requirements. It is sufficient only for drinking and cooking. The water in the drains is so important for daily domestic use that three quarters of the people oppose the idea of closing the leaks. Only 7% of the people who have wells near their houses agree to the idea. During dry spells, the people are supplied with water for drinking from lorry tankers operated by the State Waterworks Department or from stand pipes along the Tanjong Karang-Sungai Besar main road.

The existing water supply distribution network is shown in Fig. 54. Due to inadequate water pressure, water can be supplied only to the area near the main road. The State Waterworks Department has a plan to construct a new water treatment plant of 6 mgd at Parit 1 Sungai Burong. The State Waterworks Department will use the existing network to distribute water to its users. For areas which have no network at present, it will be installed upon the request of users. The plan is to be completed in two years.

Until piped water can be supplied to the area by the State Waterworks Department, water in the drains will be used for domestic purposes and it will be necessary to divert some amount of water form the Main Canal in order to keep the water in the drains clean. However, the present leaking water of about 7.9 cu.m/s (280 cusec) is too much compared with the requirement of 266,400 gal/day or 0.49 cusec. The following alternative remedies are proposed to cope with the problem:

a. Construction of wells:

   Each house to be provided with well. Assuming that 93% of houses do not have wells at present, the cost for digging wells is estimated at M$68,820 as follows:

   1,480 wells x 93 % x M$50/well = M$68,820

b. Provision of water tanks and pipeline:

   For each drain, an elevated tank with a pump to be placed close to the Main Canal and the tank to be connected to the existing pipe network. In total 26 tanks would be necessary. In order to properly connect these tanks with the network, about 50 km of new pipeline would be necessary. The construction costs for these facilities are estimated at about M$1.4 million.

c. Placement of 6-inch pipe to the Main Canal:

All existing leaks to be replaced by a 6-inch PVC pipe at each point of leakage. The pipes to be placed at about 0.3 m (1 ft) below the water surface in the Main Canal. The flow from each pipe is estimated at 0.04 cu.m/s (1.5 cusec). Such pipes would be placed at 26 places in total. Thus, a total of 1.1 cu.m/s (39 cusec) would be released from the Main Canal. This is considered to be quite acceptable leakage compared with the present leak of 7.9 cu.m/s (280 cusec). Assuming that M$150 per point are required, the total cost of installation is estimated at M$3,900.

It should be noted in consideration of the above alternatives that these would be temporary measures until the State Waterworks Department project is completed. In case of alternative-a, wells would not be necessary once the piped water is supplied. For the alternative-b, the facilities would be used only for a few years, until the above project is completed. This would be uneconomical and, furthermore, problems would arise when these facilities are dismantled. Alternative-c would be a low cost solution and would reduce the leakage substantially. It is concluded that alternative-c is the most practical solution and is recommended.

5.4.3 Extension of the Main Canal

With the reduction of released water at BRH from the present 6.2 cu.m/s to 1.5 cu.m/s, the Bagan Terap pumphouse will be operated only when water shortage occurs. In normal conditions, BRH will supply water to all the project area through the Main Canal. With this change in irrigation network, the area of 1,520 ha presently served by the Bagan Terap pumphouse will be commanded by the Main Canal.

(1) Proposed canal route

As for possible canal routes, there are two alternatives. Alternative-1 is to reconstruct the b-b line in Bagan Terap, and alternative-2 is to use the original alignment of the Main Canal presently used for drainage and which hereinafter we shall call "the trace" of the Main Canal. Both alternative routes start from the Main Canal near the offtake for the b-b line and end at the diversion point of the existing canal network in the Bagan Terap compartment (site A). The location of these alternative routes is shown in Fig. 55.

FSL at the offtake of the b-b line (site B) is 3.64 m (11.94 ft), and FSL at site A is 3.33 m (10.92 ft). The available head is therefore limited to 0.31 m (1.02 ft). The total length of proposed canal route is about 9.5 km. Thus, the hydraulic gradient would be only 1 to 31,000. The required flow area at the head of canal would be about 12 sq.m and 17 sq.m for a concrete lined canal and an earth canal, respectively. The present b-b line has a flow area of 6 sq.m at the head. If the b-b line is selected for the extension, the canal should be completely reconstructed. It would require acquisition of additional land for reconstruction. By contrast, the trace of the main canal has enough sectional area to cope with the requirement. Alternative-2 has a distinct advantage over alternative-1. Thus, the trace of the Main Canal is selected as the proposed canal route for extension of the Main Canal. It is named as the secondary canal, d-d line.

(2) Preliminary design of canal

a. Commanding area and design discharge

The command area of the extension canal is the sum of 1,200 ha served by the Bagan Terap pumphouse and 320 ha of Sungai Panjang area. As shown in Fig. 56, the required discharge is 3.55 cu.m/s at the head of the canal. This is adopted as the design discharge of the canal.

b. FSL

FSL of the Main Canal is 3.69 m (12.11 ft) at the proposed offtake site of the extension canal. Taking into account that the hydraulic head loss of 5 cm at the offtake, FSL of the extension canal is set at 3.64 m (11.94 ft) at the head. The canal section should be determined such that the water is not below 3.33 m (10.92 ft) at site A.

c. Canal section

The trace of the Main Canal has enough sectional area, but the height of both banks are not enough to provide freeboard of 60 cm. The present section should be trimmed in both sides and both banks raised. The typical canal section and the longitudinal section are shown in Fig. 56.

(3) Related structures

a. Offtake

In case of water shortage in the main conveyance system, the Bagan Terap pumphouse should be operated to supplement the water to the command area by the extension canal. The command area should be separated from the main conveyance system. Therefore, an offtake is necessary at the head of the canal.

b. Catch drain

At present, the trace of the Main Canal is used as a drainage canal. Runoff enters the trace from the area adjacent to the permanent crop area. The water level in the trace will be raised after the improvements. In order to drain runoff, a catch drain should be constructed along the extension canal. Another catch drain of about 600 m long is also required on the opposite side of the extension canal in order to drain off water from the paddy fields. These catch drains will be connected with the existing drainage culvert crossing the Main Canal near the proposed offtake.

5.4.4 Distribution network

(1) Offtakes

As pointed out in Section 4.3.4, it is difficult in practice to adjust diversion to the target amount at the offtake. It is, therefore, proposed that operation of gates should aim to maintain the water level at the head of a tertiary canal at FSL or NSL. For operation, only the turnout gate would be operated to adjust the diversion and the orifice gate would be opened fully.

After the screens were removed, a lot of rubbish and aquatic weeds in the Main Canal have obstructed the tertiary canals. These screens should be replaced. The location and shape of the improved screen should be suitable for cleaning rubbish and aquatic weeds. An operation deck should also be provided. The improvement plan of offtake is shown in Fig. 57.

(2) Check structure

In order to reduce the present constraints on operating and maintaining check structures, the following improvement plans are proposed.

a. Improvement of gate

It should not be necessary to measure discharge at a check structure. The gate should be operated only for adjusting the upstream water level. To fulfill this requirement, it is proposed to improve the existing gate from an overflow-type to an underflow-type as shown in Fig. 58. The improved gate is smaller in size and is not affected by rubbish deposited in a well chamber. The operation of the gate will become simple and easy.

b. Installation of blow-off

One of the difficulties in cleaning well chambers is that well chambers never dry up. Cleaning work under water is too hard for the gatekeeper to do frequently. It is proposed to install a blow-off in both the well chamber and the inlet as shown in Fig. 58. In order to stop water for the cleaning work, grooves for stop-logs should be provided in the upstream conduit.

(3) Slot

The installation of slots is needed to prevent the drawdown of water level in the conduit during the normal irrigation period. The water level in the conduits downstream of cross bund 2 is almost parallel to the top of conduits. Water can be evenly distributed to each farm lot. Installation of a slot would not be necessary. However, water levels in conduits upstream of cross bund 2 becomes low in the upstream reaches. At least, one or two slots will be necessary to maintain the water level.

(4) Offtake pipe

Offtake pipes are not installed uniformly in height. This makes the distribution of water to each farm lot uneven. About 8% of the offtake pipes should be relocated. The selection of offtake pipes to be relocated will be made with the help of hydraulic simulation analysis on the respective concrete conduit.

5.4.5 Drainage system

Even after completion of improvement/rehabilitation works, it will be necessary to maintain the water level in drains at a suitable level to prevent excessive seepage of water. The installation of drainage control at the end of each tertiary drain will be essential to lower the water level in the main drain and to protect the paddy fields from flood damage. An additional nine drainage control gates should be provided in the two compartments, Panchang Bedena and Bagan Terap. There are seven culverts at the crossings of the main drain along the c-c line with the existing roads. These prevent the smooth drainage in the above compartments. These culverts should be replaced by bridges. The location of these proposed improvement work is shown in Fig. 59.

5.4.6 Farm roads

With the expansion of mechanized farming in the project area, the demand for farm roads has rapidly increased. About a half of the farm lots in the project area have no direct access to the existing roads. This causes many problems in the use of machinery as well as in maintaining 'batas'. The additional farm roads should be placed so that all farm lots are accessible from the roads. The total length of additional farm roads is about 475 km as summarized below. The location of these additional farm roads is shown in Fig. 60.

Compartment	Length (km)
Sawah Sempadan	55.8
Sungai Burong	94.5
Sekinchan	47.5
Sungai Leman	41.5
Pasir Panjang	41.2
Sungai Nipah	52.8
Panchang Bedena	83.4
Bagan Terap	57.9
Total	**474.6**

In order to minimize the land for additional road construction, the width of road should be limited but wide enough to allow the passage of heavy equipment such as a harvester. The width of additional farm roads should be at least 3.0 m (10 ft) taking into account the width of harvester used in the project area. The typical cross section of farm road is shown in Fig. 61.

5.5 Proposed Water Management

5.5.1 Basic concepts of proposed water management

(1) Fixed irrigation schedule

The proposed cropping schedule for paddy in the project area has been prepared taking into account various hydro-meteorological and agronomic factors. These factors are the seasonal fluctuation of runoff of the Bernam river, distribution of rainfall, proposed farming practices, growing period of paddy, timing of harvest and out-breaks of insects. The irrigation schedule has been proposed to match the proposed cropping schedule. It has been found that water will be short if the cropping schedule is delayed over 30 days. It is, therefore, of utmost importance to keep the fixed irrigation schedule for proper water management of the Project.

(2) Importance of maintenance

Weeds grow fast. There is a lot of rubbish and debris in the system.

These prevent project facilities functioning well and cause many water-related problems. It cannot be emphasized enough that proper maintenance is imperative for project facilities. At present, DID are solely responsible for maintenance. However, DID cannot do all that is required with the limited number of staff. Farmers must be urged to participate in the maintenance work, especially in keeping tertiary canals free of weeds, rubbish and debris, in order to improve the reliability of their own water supply.

(3) Effective use of Bernam river water

The main water source of the Project is the runoff of the Bernam river. The intake at BRH is of the run-of-river type. This must be taken into account in executing water management of the Project. During normal season when enough water is available, the water management can be lenient. During water shortage, however, stricter water management is required.

(4) Measures to be taken during water shortage

Even after the proposed improvement work is completed and proper water management is achieved, water will still be short probably once or twice in 10 years. In times of water shortage, priority should be given to distributing water evenly to the whole project area.

(5) Monitoring for proper water management

The gradient of the Main Canal is so gentle that discharge in every section of the Main Canal is greatly influenced by changes in water level. Even if the discharge is precisely measured in a certain section of the Main Canal, it includes the amount of water derived from the change in storage volume in the Main Canal. This makes discharge measurement meaningless. On the other hand, since the intake at BRH is of the run-of-river type, as much water as possible can be taken according to the demands by the project area. Thus, it is not important for water management to know discharges at certain sites of the system. What is important is the regular monitoring of water levels at suitable sites throughout the system.

5.5.2 Operation of main conveyance system

(1) Bernam River Headworks

The radial gates on the barrage should be so operated that the upstream water level of BRH is maintained between 9.6 m (31.5 ft) and 10.1 m (33.0 ft). If the radial gates have to be opened to fulfill the above requirement, the middle gate should be opened first. The right gate second and the left gate last. If a radial gate is partially opened, the opening should be more than 15 cm in order to prevent vibration of the gate. The number of intake gates to be opened should be so determined that the upstream water level of each cross regulator and the water level in the c-c line can be kept at FSL. If intake gates have to be closed, the gates should be closed starting from the gate upstream. Partial opening of intake gates must be prohibited. The scour gate should normally be fully opened. When the upstream water level at each cross regulator and the water level in the c-c line cannot be maintained at FSL, even when all intake gates are opened, the scour gate should be closed to reduce the flow through the scour sluice to 1.5 cu.m/s.

The screens in front of intake gates should always be kept clean. If the screens are kept clean, there is a relationship between water levels upstream of BRH and 200 m downstream of the intake in the Feeder Canal as shown in Fig. 62. Water levels at the both sites should be measured twice a day at 9 a.m and 3 p.m. The result of these measurements should be plotted on the figure. If the plot lies above the line in the figure, it will indicate an accumulation of rubbish in front of the screens. The screens should be cleaned immediately.

(2) Main Canal

The water level in the Main Canal is regulated and stabilized by three cross regulators. The water level should be maintained at the following FSLs.

Structure	Location	FSL
Cross regulator No.1	TASL 10	4.1 m (13.4 ft)
Cross regulator No.2	PB a-a	3.8 m (12.5 ft)
Cross regulator No.3	End of Main Canal	3.7 m (12.0 ft)
Secondary canal, c-c line	Head of the c-c line	3.4 m (11.0 ft)

5.5.3 Operation of distribution network

(1) Presaturation

The flow capacity of tertiary canals as well as the water source of the Project could not meet the peak water demand for the direct seeding method, if planting is started simultaneously. It is, therefore, necessary to introduce rotational irrigation in tertiary canals during presaturation period.

Following the fixed irrigation schedule, presaturation should be started within 30 days in an area commanded by one tertiary canal. The area is divided by the existing cross bunds into three blocks with similar extent of area. Presaturation is practiced in rotation from the upstream block with about 10-day intervals. The flow capacity of the offtake pipe is insufficient for the water demand during presaturation. The use of syphons is imperative during presaturation period.

(2) Normal irrigation

After the presaturation period is over, the elevation of check gates and slots should be adjusted to the predetermined positions for the normal irrigation supply. The amount of water diverted into a tertiary canal should be regulated and controlled by an offtake gate, by adjusting the water level in the tertiary canal to NSL. These adjustments are to be made only once at the beginning of the normal irrigation period and water should be supplied continuously during the normal irrigation period.

Each tertiary canal has different characteristics. Proper elevation of check gates and slots as well as NSL should be determined and recorded for each canal through hydraulic simulation analysis or trial operations at the site.

5.5.4 Monitoring of the main conveyance system

(1) Organization for monitoring

It is proposed that a Main Conveyance System Operation and Maintenance Unit (MOMU) be established with a newly appointed Engineer as a head to secure improved water management. The major tasks of MOMU will be monitoring and regulating water level in the main conveyance system as well as operation and maintenance of related facilities of the system.

(2) Monitoring items

The most important element in water management of the main conveyance system will be to stabilize and maintain the water level in the Main Canal at FSLs. It is, therefore, essential to monitor water levels regularly at suitable points in the system. It is proposed that water levels be observed and recorded at the following seven sites.

1. Upstream water level of BRH
2. Water level at the head of the Feeder Canal (200 m downstream of BRH)
3. Upstream water level of Tengi Headworks
4. Upstream water level of cross regulator No.1
5. Upstream water level of cross regulator No.2
6. Upstream water level of cross regulator No.3
7. Water level of the head of the c-c line

(3) Monitoring and feedback method

Water levels at the seven sites should be observed twice a day, at 9 a.m. and 3 p.m., by the gatekeepers or the operators of MOMU. The observed data should be informed to both the main and branch offices. The head of MOMU (Engineer) should analyze the data in order to maintain the water level in the Main Canal at FSL. The data and results of analysis should be informed to the Engineer in charge of irrigation every week. However, when the water level in the Main Canal becomes below FSL or any problems arise in the main conveyance system, the staff of MOMU should promptly notify the situations and problems to the Engineer, MOMU, for taking necessary action. The Engineer, MOMU, should give instructions to his subordinates, the Chief Irrigation Inspector, and Senior Irrigation Inspectors on the method of controlling BRH, cross regulators, spillways, end control gates at the ends of the c-c line and CHOs.

(4) Recording

The technical assistant of MOMU should compile records on the water management of the main conveyance system under the Engineer. Proposed recording items are as listed below.

a. Water level at the seven sites listed above,
b. Operation of facilities on the main conveyance system,
c. Measures taken during water shortage, and
d. Maintenance of the main conveyance system.

(5) Communication

Telephones are available at the DID offices and at FDScs. However, telephones are sometimes interrupted and lines are often busy for other purposes. Close and consistent communication cannot be maintained by telephones. Furthermore, the operational cost is high. For proper water management of the project, good communication should always be maintained between offices. It is recommended that the project area be equipped with a radio system for the exclusive use in irrigation water management.

The proposed radio telecommunication system is illustrated in Fig. 63. The main station would be established in DID, Tanjong Karang, and connected with DID, Kuala Selangor. A branch station would be established in DID, Sungai Besar. In addition to the above, seven sub-stations are proposed at the following sites.

Name of Sub-station	Location	Facilities and area covered
1. BRH	BRH quarters	BRH Feeder Canal
2. Sawah Sempadan	FDSc, SS	Tengi Headworks Tengi Spillway Sawah Sempadan compartment
3. Sungai Burong	FDSc, SB	Sungai Burong compartment
4. Sekinchan	FDSc, S	Regulator No. 1 Sekinchan compartment Sungai Leman compartment
5. Pasir Panjang	DID station	Pasir Panjang compartment
6. Sungai Nipah	FDSc, SN	Sungai Nipah compartment
7. Sungai Besar	FDC, SB	Regulator No. 2 Regulator No. 3 Haji Dorani Spillway Secondary canal a-a line Secondary canal b-b line Secondary canal c-c line Secondary canal d-d line End control gates on the c-c Bagan Terap pumphouse Panchang Bedena compartment Bagan Terap compartment

5.5.5 Monitoring of the distribution network

(1) Monitoring items

In order to take necessary action to rectify water problems and to promote proper on-farm water management practices, it is important to monitor the day-to-day water situation in the distribution network. The following water level should be monitored and recorded for each tertiary canal.

1. Water level in the Main Canal in front of the offtake,
2. Water level at the head of tertiary canal,
3. Upstream and downstream water level of each check structure,
4. Water level at the end of tertiary canal, and
5. Water level in drain at the end control gate.

For the proper water management of the project, it is of the utmost importance to keep to the fixed irrigation schedule. Thus, farming activities which affect the water management should also be monitored in addition to the above to pinpoint water-related problems. Weekly monitoring on farming activities should be done for each lot by classifying the activities into the following six categories.

Symbol	Monitoring Items
A	Direct seeding completed
B	Presaturation started
C	Presaturation completed
D	Transplanting completed
E	Normal irrigation stopped
F	Harvesting completed

(2) Monitoring and feedback method

Water levels at the sites proposed as above should be observed twice a day, at 9 a.m. and 3 p.m., by the gatekeeper of each tertiary canal. When the water level in a tertiary canal is below FSL/NSL, measures should be taken at the site by the gatekeeper by means of cleaning the tertiary canal and/or controlling the offtake gate, check gates and slots. If the situation is beyond the capacity of the gatekeeper, the Irrigation Overseer in charge will have to be informed. The Irrigation Overseer should inspect the sites and analyze the cause of problems to report to the Irrigation Inspector. For remedial action, the Irrigation Inspector should issue directives to the relevant staff.

Weekly data on the farming activities recorded by gatekeepers should be transferred to the Irrigation Overseer. Then the Irrigation Overseer should check data and send them to the Irrigation Inspector, and Irrigaion Inspector should analyze the data. If no farming activities have started even though water had been supplied over the past two weeks, the Irrigation Inspector will have to bring this to the attention of AICPLC so that corrective measures can be taken. When all farming activities for one crop season are completed in one compartment, Irrigation Inspectors should prepare maps showing the delay of farming activities from the fixed schedule. The analysis of these maps are quite effective to pinpoint lots and areas with water-related problems, and to take necessary actions for solving them.

All data and information as well as instructions given should be properly recorded and neatly compiled. The Irrigation Inspector should have responsibility for compiling data and information and submitting them to the Senior Irrigation Inspector every month. To maintain proper coordination between compartments, the Engineer in charge of distribution system and field as well as Pilot Project will extend his roles over irrigation staff.

5.5.6 Measures to be taken during water shortage

The automatic gates which will keep upstream water levels constant will be provided at cross regulators No. 1 and No. 2. The upstream water level at these two cross regulators will be automatically kept at FSL. Operation of BRH should be made with an aim of maintaining the water level in the c-c line of Panchang Bedena at FSL of 3.4 m (11.0 ft). When the FSL in the c-c line cannot be maintained, even if as much water is diverted as possible from the intake at BRH, leakage along the Main Canal should be quickly sought out and stopped, if any. Over-tapping at CHOs should be prohibited. If it can be confirmed that there is no significant leakage and no over-tapping and if the diverted discharge at BRH is less than 25 cu.m/sec, it is a time of water shortage and the following measures need to be taken.

(1) Growing stage of paddy should be checked and if there is an area where no water is required, the water supply to such area should be stopped.

(2) The offtake gate at the head of the d-d line should be closed, and the pumps at Bagan Terap should be operated to supply water to the 1,200 ha in the Bagan Terap compartment and the 320 ha in the Sungai Panjang.

(3) For the remaining area, the water should be evenly distributed. In

order to achieve even distribution, the inspection to each tertiary canal should be made more frequently than in normal conditions, say at least three times a day, in order to confirm that no over-tapping is taken place.

(4) If the water is still insufficeint for more than two weeks, even after the above measures are taken, the following rotational irrigation should be applied in the Main Canal, according to the degree of water deficit.

(5) If the diverted discharge is less than 23 cu.m/sec and more than 19.0 cu.m/sec, the withdrawal of water to each tertiary canal should be limited at 75% of the requirement for normal irrigation. A quater of the offtakes in each compartment should be closed and the remaining offtakes should be opened for one week. Such operation should be made alternately and repeated throughout the whole area.

(6) If the diverted discharge is less than 19 cu.m/sec, the withdrawal of water to each tertiary canal should be limited at 50% of the requirement for normal irrigation. A half of the offtakes in each compartment should be opened and the remaining half should be closed for one week. Such operation should be made alternately and repeated throughout the whole area.

(7) Any area under presaturation should be excluded from the above rotational irrigation, and water should be supplied continuously.

5.6 Action Plan for Water Management

5.6.1 Improvement of operation and maintenance organization

There is no need to increase the Federal DID staff allocated to PBLS, while the operation and maintenance organization within the State DID will have to be improved. The irrigation staff lower than Irrigation Inspectors have already been increased to almost moderate extent; therefore; several points are recommended for the further improvement mainly in the senior staff.

(1) Grading-up of the existing Engineers

The Senior Engineer, Kuala Selangor, should be of superscale 'F' as against the present grade of superscale 'G'. With a view to strengthening the work force of Engineers in the PBLS area, a stratagem will have to be applied that the head in the PBLS area be of the same grade as in KADA. This would enable the appointment of additional force of Engineers to the organization of DID, Kuala Selangor. Concurrently, the roles and grades of the Engineers, Tanjong Karang and Sungai Besar, will have to be reviewed as shown below.

(2) Separtation of drainage matters and the responsible Engineers

There should be clear responsibilities between the irrigation and drainage matters. The chief of the drainage staff should be an Engineer (superscale 'G') who is stationed at the Sungai Besar DID office. It will be necessary to deplay five Engineers (timescale) to the respective drainage areas of from 15,000 to 18,000 ha. The total drainage areas amount to 82,000 ha. In the Sabak Bernam District, the said Engineer will directly supervise two subordinate Engineers. On the other hand, in the Kuala Selagor District, the drainage areas of Blocks I, II, and III will be administered by three Engineers (timescale) under one supervising Engineer (senior timescale) stationed at Kuala Selangor.

The composition of Engineers in charge of drainage areas of PBLS would consequently be as follows:

Engineer S.S. 'G' (Sg. Besar)	(Sabak Bernam District)	Engineer timescale (Sg. Besar)	Blocks I and II 17,000 ha
		Engineer timescale (Sg. Besar)	Block III and part of Coastal Belt 15,000 ha
	(Kuala Selangor District) Engineer Senior timescale (Kuala Selangor)	Engineer timescale (Tg. Karang)	Block I and part of Coastal Belt 15,000 ha
		Engineer timescale (K. Selangor)	Block II 17,000 ha
		Engineer timescale (K. Selangor)	Block III 18,000 ha
		<u>Total Drainage Area</u>	<u>82,000 ha</u>

(3) Mechanical Engineer for the Store and Workshop, Tanjong Karang

To take care of departmental maintenance works not only in irrigation areas but also in drainage areas, one Mechanical Engineer (timescale) should be stationed at the Tanjong Karang DID office where the Store and Workshop are located. This Mechanical Engineer is to keep a close relation to the irrigation staff as well as to the drainage staff through the respective heads. The service level of the equipped machinery should be kept as high as possible under his control. He would arrange repair and maintenance work of the machinery which are sent to the other DID workshops outside PBLS, such as in Ipoh.

(4) Appointment of an Engineer in charge of irrigation

An Engineer, assumed to be superscale 'G' in grade, should be appointed under the Senior Engineer. He will be responsible for all matters in the irrigation area covering eight compartments.

Administration of finance in operation and maintenance, management of all the irrigation staff, planning on operation procedures and maintenance work should be carried out by him. Effective water management would be ensured with this appointment. Senior Irrigation Inspectors and Irrigation Inspectors should be attached directly to the Chief Irrigation Inspector, not to the existing Engineers.

The Engineer should be stationed at DID, Tanjong Karang. The Chief Irrigation Inspector would work closely with him, coordinating and supervising the practical aspects of water management. With regard to the proposed day-to-day water management, the Engineer and the Chief Irrigation Inspector, together with the other Engineers (to be mentioned later), will act as a central unit to give directions to and get feedback from the staff in the respective compartments. Necessary actions will be taken after the review of the monitored data and information. The Engineer will instruct the irrigation staff in the respective compartments, on one hand, and forward necessary matters to the Senior Engineer, Kuala Selangor, on the other.

(5) Filling of the vacant Senior Irrigation Inspector

The Senior Irrigation Inspector, Tanjong Karang, has to conduct water management for four upstream irrigation compartments area-wide. The filling of the vacant seat of this Senior Irrigation Inspector is an urgent need. With this position filled, the Chief Irrigation Inspector would be able to look over practical aspects in the whole irrigation areas.

(6) *Creation of the Main Conveyance System Operation* and Maintenance Unit (MOMU)

A unit composed of three teams for BRH, cross regulators and spillways should be set up under the Engineer in charge of irrigation. The main tasks of MOMU will be monitoring and regulation of water level along the main conveyance system as well as operation and maintenance of the related structures and facilities. Analysis of the monitored data will be carried out by MOMU and the results are distributed to the irrigation staff to take necessary actions. In terms of withdrawal of water from the Main Canal, MOMU will provide basic data and information to both the Senior Irrigation and Chief Irrigation Inspectors to coordinate Irrigation Inspectors responsible for the individual irrigation compartments.

The head of MOMU is to be an Engineer (timescale in grade) who should be newly appointed under the Engineer in charge of irrigation. He has to be assisted by at least one personnel (Technical Assistant), stationed at the Tanjong Karang DID office. Analysis and conveyance of the monitored data will be the major tasks of them. The countermeasures will also be formulated.

The BRH team might remain the same as at present. The special-grade Irrigation Overseer will supervise the existing staff force at BRH quarters.

Operation and maintenance of the three cross regulators coupled with monitoring activities of water levels will require one gatekeeper each. A gatekeeper should be newly appointed to No.1 cross regulator. The a-a line gatekeeper, who carries out the present tasks for No. 2, should be attached to MOMU. (At the same time, the b-b line gatekeeper will also belong to MOMU.) The gatekeeper of No. 3 cross regulator should be switched from the operator of the Tengi Headworks. The quarters of these cross regulator gatekeepers might be the nearest FDSc, Sekinchan and FDC, Sungai Besar.

New appointment will not be required for a spillway operator. The existing two operators, for the Tengi and Haji Dorani Spillways, may continue the present tasks, stationed at the same FDSc, Sawah Sempadan, and FDC, Sungai Besar, respectively. These two spillway operators should be attached to MOMU. The operator of the Tengi Spillway will have an additional duty to operate the Tengi Headworks, since the present operator would be shifted to No.3 cross regulator.

(7) Staff increase in irrigation compartments

Distribution of responsibilities among the irrigation staff in the respective compartments seems well-defined, and the number of staff is almost enough. Irrigation Overseers and gatekeepers need not to be increased.

Division of Sungai Burong and Panchang Bedena into two Irrigation Inspector areas is recommended. The purpose is for attaining greater effectiveness in operation and maintenance, especially the proposed day-to-day water management, since these two compartments cover a wide area and contain more sub-blocks inside than usual. The area division would be: in Sungai Burong; TASB1 to TASB6 and TASB7 to TASB13, and in Panchang Bedena; a-a and b-b line command areas plus outside extension area, and c-c line command area. To each area divided, one Irrigation Inspector should be appointed. In view of one Irrigation Inspector manned at present, additional one should be newly appointed to each compartment.

The present staff force of eight Irrigation Inspectors, 23 Irrigation Overseers and 82 gatekeepers will be changed into 10 Irrigation Inspectors, 23 Irrigation Overseers and 82 irrigation gatekeepers located in the respective compartments.

Besides the above modifications, one Engineeer (assumed to be timescale in grade) should coordinate operation and maintenance in irrigation system among the compartments. This task closely relating to the trials in tertiary canals, the Engineer in charge of the Water Management Extension Pilot Project for TASB4 should take the responsibility.

(8) Water Management Extension Pilot Project team for TASB4

The existing staff force of one Irrigation Inspector, one Irrigation Overseer, one gatekeeper and two laborers under the Engineer in charge is moderate to undertake trial operations for water management. Modification of staff force will thus not be proposed, but the scope of work is to be revised. The team should be under the Engineer in charge of irrigation. Furthermore, the Engineer will have to play a greater role in the field; which is mentioned in the succeeding section 5.6.2.

(9) Summary of recommendations on the irrigation staff

With several recommendations, the following irrigation staff will be required additionally.

Engineer (in charge of irrigation)	1
Engineer (head of MOMU)	1
Senior Irrigation Inspector, Tanjong Karang	1
Irrigation Inspectors, Sungai Burong and Panchang Bedena	2
Technical assistant, MOMU	1
Gatekeeper, No.1 cross regulator	1

Of which, the Senior Irrigation Inspector, Tanjong Karang, is the filling of vacancy and others are all for new posts. The Engineer in charge of irrigation should be superscale 'G', and the Engineer, MOMU, timescale. The irrigation staff in the PBLS area will have three full-time Engineers in total. Figure 64 shows the existing organizational structure, and Fig. 65 the proposed one.

5.6.2 Water management extension

(1) Rationale

As an agency responsible for irrigation water supply, DID should ensure effective water management in the irrigation system; not only in the main conveyance system, but also in the distribution network. A sufficient volume of water should be allocated to tertiary canals through operating various control structures. Along each tertiary canal line, an appropriate quantity of water has to be supplied to each farm lot, to meet the field requirements. Water management activities of DID thus reach up to the field offtakes in tertiary canals.

The setting up of MOMU has been proposed for the main conveyance system. It will cover monitoring and regulation of water levels, operation and maintenance of the main conveyance system, as well as coordinative functions in withdrawal of water from the Main Canal. If this system is working properly, effective water management would be ensured up to the head of tertiary canals. Water allocation into the secondary canals will also be controlled in connection with the activities of MOMU.

Standard methods of water management in tertiary canals have not yet been established in the project area. At present, water discharge is adjusted at the head of tertiary canals, according to the experiences of the irrigation staff. Effective operation procedures of cross bund checks have never been developed. Improper setting of field offtakes has caused an uneven distribution of water along tertiary canals. Tertiary canals themselves contain various defects in structures. Such shortcomings should be clarified and practical operation procedures in tertiary canals be found out. At the same time, maintenance work to recover the capacities in the irrigation system should be identified in the light of the structural defects to be revealed. Afterwards, effective ways to extend established expertises will have to be looked for. Farmers will have to cooperate with DID achieving this.

(2) Responsibility of DID, roles of farmers, and other agencies

DID should ensure efficient and sufficient supply of water up to the outlet of field offtakes along the tertiary canal, at first hand. DID will also have to encourage farmers to obtain their cooperation in operation and maintenance, particularly in clearing works for canals and drains.

Water control activities at on-farm level rely on farmers, from field offtakes to field drains. Water application in each farm lot is incidental to the various stages of paddy cultivation, and water control forms part of farming practices to be conducted by the farmers.

Guidance and training to farmers on farming practices are provided through agricultural extension services of DOA. In this context, the extension staff of DOA should encourage farmers to undertake suitable activities such as:

a. Arrangement of agricultural input supply,
b. Timing and methods of land leveling,
c. *Timing of preparation works before water supply,*
d. Arrangement of labour work and farm machinery,
e. Frequency and volume of water application at the respective, stages of paddy cultivation, and
f. Maintenance of on-farm water control devices such as batas, field drains or ditches.

In addition, adherence to the planting schedule recommended by AICPLC and saving excessive water use in the field will also have to be promoted by DOA.

On Mini-estates, the management staff of Area FOs will undertake these responsibilities, instead of DOA. In line with the set-up farming schedule of the respective Mini-estates, the field supervisors should enforce the management policies (refer to Annex-E).

Measures to cope with rotational irrigation along tertiary lines, for presaturation or in times of drought, will not be so different. Farmers along one tertiary line will be grouped into three rotational blocks. The farmers within one rotational block should finish the presaturation concurrently. For this purpose,

a. The Paddy Planting Schedule Committee will determine the dates of water supply to each rotational block,
b. AICPLC will notify and enforce the planting schedule to be recommended in rotation,
c. DID supplies enough water according to the determined *rotational schedule, and*
d. DOA promotes the consistency with the planting schedule within rotational blocks.

(3) Establishment of effective water management practices

Trials should first be conducted for the establishment of water management practices in tertiary canals. Investigations through trial operations will help to identify the constraints in controlling water as well as structural defects in the irrigation system.

The Water Management Extension Pilot Project team was set up by DID to carry out the investigation and monitoring along TASB4 in Sungai Burong. This team will have to be employed in this attempt with the present staff force. It is suggested that the scope of work of the team should be modified as follows:

<u>Objectives</u>
Establishment of effective water management practices to ensure a sufficient and equitable supply of water along the tertiary canal through trial operations on TASB4

<u>Targets of investigation</u>
a. Clarification of constraints to water management in the

tertiary canal;

b. Clarification of structural defects in the irrigation system, in terms of operation and maintenance;
c. Identification of urgent improvement and repair works required on structures and facilities;
d. Identification of proper operation at procedures and maintenance work in the irrigation system, either for presaturation or during normal irrigation; and
e. Finding out an effective means of extension of the improved water management practices.

To attain these targets, monitoring of the farming activities, water level, and water supply conditions is of the utmost importance. Therein, trial operations should be conducted. Activities to be recommended to the Pilot Project team are:

a. Trials on the proposed day-to-day water management;
b. Trial operation of rotational irrigation for presaturation;
c. Trial operation during normal irrigation period;
d. Trial operation using slots and the improved check gates;
e. Trial operation to control water level in drains; and
f. Attempts to promote farmers' involvement in cleaning the tertiary canals.

After these are carried out, the facts might be obtained, such as:

a. Unsuitability of check gates for structures;
b. Necessity for provision of slots at suitable locations;
c. Improper setting of offtake pipes;
d. Unsuitable and not functioning control gates of drains;
e. Operational procedures for structures for rotational irrigation;
f. Operational procedures for structures during normal irrigation; and
g. Necessity and difficulties of clearing works in tertiary canals.

Investigation results by the team should be forwarded to and looked into by the Engineer in charge, to be applied throghout the whole project area.

(4) Extending the water management practices established

Of the investigation results of the Pilot Project team on TASB4, those relating to operation and maintenance of irrigation facilities should be conveyed to other Irrigation Inspectors and Irrigation Overseers in the area, after review by the Engineers. As the various tertiary canals have different characteristics, simultaneous application of the findings would not be practical; however, some indications may be obtained from the trial results. The Engineer in charge of the Pilot Project should coordinate these field staff in an attempt of result permeation. He will be responsible for coordination as well, besides the trials in the Pilot Project.

Irrigation Inspectors and Irrigation Overseers assigned in compartments will have to conduct the trial operations, respectively. Before the trial operations, each tertiary canal should be surveyed, from which the necessary data will be obtained for the hydraulic simulation analysis to determine precise heights of check gates, location of slots, etc. FSL and NSL should be marked in the tertiary canal, afterwards. Assistance of the Federal DID staff in the PBLS area will have to be extended in these work. Standard operation procedures and required maintenance work for the irrigation system would be clarified in the course of these experiences.

When structural defects are revealed in the irrigation system, the Engineer in charge of irrigation should forward the facts to the Senior Engineer, Kuala Selangor, for the necessary action. Almost all such defects should be corrected with the direct commitments of the Federal DID personnel stationed at PBLS complexes, Kuala Selangor and Sungai Besar.

(5) Farmers' involvement in maintenance works

It has been observed that maintenance works, especially clearing work, must be carried out frequently to retain the design capacities of canals and drains. Clearing in drains has been undertaken by contractors with funds from DID. The DID irrigation staff however cannot cope with the work load of keeping tertiary canals clear of weeds and rubbish. A tertiary canal is too long for one gatekeeper to carry out the clearing work by himself. In addition, due to structural defects, the water inside the canal cannot be drained out completely. This makes effective clearing work difficult even if undertaken by the irrigation staff.

A number of farmers along tertiary canals will have to participate in clearing of tertiary canals. Consequently, DID should encourage farmers' involvement. Encouragement should be made in a group approach, utilizing the Ketua Blok system and the group farming under DOA (refer to Annex E).

Nevertheless, the ultimate aim in promoting farmers' involvement will be autonomous on-farm water management in groups. Even partially, the consciousness of participation in maintenance works might facilitate water control activities among the farmers. Ultimately, when farmers carry out water management by themselves, they could be delegated with part of operation and maintenance of the irrigation system and planning powers including the determination of water supply schedule. However, for the time being, their involvement should be promoted only in clearing tertiary canals, by DID.

5.6.3 Training programme

It is imperative to strengthen capabilities of the irrigation staff with the provision of suitable training. Staff training will comprise that in the existing courses and that to be newly formulated exclusively for the staff in the area. At the same time, there is a need to train the DOA extension staff and the farmers' leaders in water management. Towards the DOA extension staff, DID's existing training facilities should be utilized. On the other hand, training for farmers will have to be conducted in the project area.

(1) *Training at the National Water Management Training Centre*

The existing training courses at NWMTC, Kota Bharu, will have to be utilized to provide basic concepts of water management and an understanding of paddy cultivation. The personnel to be sent there should be Irrigation Inspectors and Irrigation Overseers from DID, and Area AAOs and extension Agriculture Technicians from DOA in the project area.

(2) Training in the project area

Specific concepts of water management should be taught to the irrigation staff in respect of problems and characteristics peculiar to the Tanjong Karang Irrigation Scheme. At the same time, the revised operation procedures and maintenance work stipulated in Operation and Maintenance Manual will need to be permeated among them immediately.

The Tanjong Karang DID office and FDC, Sungai Besar, would be used as training facilities. Both the Chief and Senior Irrigation Inspectors might provide lectures on their respective facilities for Irrigation Inspectors and Irrigation Overseers. The training programme should be formulated in the Follow-up Programme of the Project, to which assistance of foreign experts will be extended. Lectures or briefing by these experts would also be envisaged. Translation of the Manual into Bahasa Malaysia will be required, as well as the immediate distribution to the irrigation staff down to Irrigation Overseers.

When the Engineer in charge of irrigation is appointed, he should review the contents of the training programme. Majority of training would be provided in-service for the daily operation and maintenance of the irrigation system, afterwards. Compilation and analysis of the monitored data in day-to-day water management and for the main conveyance system should form part of this kind of in-service training.

Training for farmers should be conducted by the members of AICPLC, who are mostly DID irrigation staff and DOA extension staff. The trainee will be selected among the farmers' leaders such as the Ketua Bloks and the members of farmers' committees for the group farming (see Annex E). Training contents consist of matters necessary for on-farm water management, and FDC and FDScs will be used as training facilities.

6. IMPLEMENTATION SCHEDULE OF THE PROJECT

The Study revealed many water-related problems contained in the project area. Alternative plans for the solution and improvement plans for the project facilities are proposed. In addition, the need of institutional arrangement is also pointed out. Utmost importance will be placed on the implementation of these plans and arrangement for realizing proper water management. The implementation schedule of water management is shown below and a flow chart showing the schedule is illustrated in Table 29.

6.1 Improvement of Facilities

Based on the Study, the following improvement of project facilities is recommended.

(1) Bernam River Headworks

a. Increase in height of the radial gates
b. Provision of electrically driven hoists to the intake
c. Replacement of screens, and provision of a support for chain block and a operation deck in front of screens

(2) Main Canal

a. Enlargement of canal sections including the removal of three timber bridges
b. Construction of an additional cross regulator
c. Improvement of existing cross regulator
d. Stopping leakage water

(3) Secondary canal

a. Construction of the d-d line
b. Banking of the c-c line

(4) Tertiary canals

a. Construction of concrete conduits in Sawa Sempadan, Sungai Nipah and Panchang Bedena extension area
b. Provision of screen of offtake structure
c. Improvement of check gates and slots
d. Change in location of offtake pipes

(5) Drainage facilities

a. Construction of drainage controls
b. Construction of bridges

(6) Construction of farm roads

(7) Provision of a radio telecommunication network

Except for construction of the farm roads, all other work proposed should be carried out as soon as possible. Taking into account the current tight budgetary conditions of the Government, it is recommended that the work be completed within three years: between 1987 and 1989 as shown in Table 29. If the budget allocated is not enough to follow the proposed schedule, the work should be commenced following the priority mentioned in Table 30.

The total length of additional farm roads required is estimated at 475 km. It will be unnecessary to construct all the additional farm roads in a short period. The construction should be made according to priorities and the available budget allocated to DID. It is planned to construct 15% of proposed farm roads annually.

6.2 Procurement of Equipment for O&M

For undertaking proper maintenance of project facilities, it is necessary to procure the following equipment for exclusive use in the irrigation area. In addition to the above, equipment for operation and monitoring is also needed.

Equipment	Requirement
1. Backhoe loader	2 nos.
2. Hydraulic excavator	2 nos.
3. Dredger	1 no.
4. Aquatic weed cutter	2 nos.
5. Radio system	10 sets

This equipment should be procured by the end of 1988, before proposed improvement work of the main conveyance system will be completed.

6.3 Institutional Arrangements

For the purpose of attaining proper water management, the organization of DID for operation and maintenance should be improved.

(1) Establishment of MOMU

MOMU plays an important role in the improved water management. MOMU should be created by the end of 1988 when the construction work in the main conveyance system should be completed. Responsibilities of MOMU may be summarized as follows:

a. monitoring of water levels in the main conveyance system
b. regulating water levels in the main conveyance system
c. operation and maintenance of BRH, cross regulators and spillways
d. compilation and analysis of the monitored data
e. coordination of water withdrawals from the Main Canal

(2) Recruitment of personnel

The appointment of the Engineers (Irrigation and MOMU), filling of the post of Senior Irrigation Inspecter, Tanjong Karang, and the appointment of two additional Irrigation Inspectors are proposed. The Engineers should be appointed in 1988, together with two Irrigation Inspectors. The post of Senior Irrigation Inspector, Tanjong Karang, should be filled as soon as possible as a matter of urgency. Technical Assistant, MOMU, and gatekeeper, No.1 cross regulator, will be on the staff of MOMU, thus being appointed within 1988.

6.4 Establishment of Monitoring System

(1) Monitoring of the main conveyance system

In order to stabilize and maintain the water level in the Main Canal at FSLs, the introduction of an effective monitoring and feedback system is necessary. Implementation of monitoring of the main conveyance system includes the following.

a. Establishment of staff gauges at the seven sites proposed
b. Preparation of forms for record keeping and reporting
c. Installation of the radio system
d. Training of staff for monitoring and recording

The proposed monitoring system for the main conveyance system should be established by the end of 1988, prior to completion of improvements to the Main Canal.

(2) Monitoring of the distribution network

In order to facilitate prompt action to rectify water problems and to promote proper on-farm water management practices, it is important to monitor the day-to-day water situation in tertiary canals. In addition, farming activities affecting water management should also be monitored in order to pinpoint areas with water-related problems. Preparatory work for the monitoring system in the distribution network includes the following.

a. Establishment of staff gauges
b. Preparation of forms and maps for monitoring and record keeping

The proposed monitoring system for the distribution network should be established by the end of 1988, when MOMU will be established and the Engineer in charge of irrigation will be manned.

6.5 Water Management Pilot Project

In order to establish an effective water management in tertiary canal, the following activities should be performed on TASB4 by the Pilot Project team.

a. Trials on the proposed day-to-day water management
b. Trial operation of rotational irrigation
c. Trial operation during normal irrigation
d. Trial operation using slots and improved checks
e. Trial operation to control the water level in drain properly
f. Attempts to promote farmers' involvement in clearing tertiary canal

Through these, the present constraints to water management on the tertiary canal should be clarified and proper operation and maintenance procedures should be identified. The targets of the Pilot Project should be attained within three years from 1987, to spread the results over the whole project area.

6.6 Extension of Water Management

Out of the investigation results by the Pilot Project, those relating to operation and maintenance should be informed to other Irrigation Inspectors and Irrigation Overseers. As the different tertiary canals have different characteristics, simultaneous application of the findings will not be practical. The Engineer in charge of the Pilot Project would coordinate the irrigation staff in application of the results. Irrigation Inspectors and Irrigation Overseers should conduct the following with the assistance from the Federal DID staff.

a. survey on the respective tertiary canals
b. hydraulic simulation analysis
c. trial operation
d. marking FSL and NSL in tertiary canals

Through hydraulic simulation analysis and trial operations on tertiary canals, structural defects of the present tertiary canals should be clarified and necessary actions should be taken. The precise height of check gates and suitable location and height of slots should be predetermined for each tertiary canal. It is proposed that such extension should be completed by the end of 1990.

6.7 Training Programme

Training to strengthen the capabilities of DID irrigation and DOA extension staff should be conducted either at NWMTC, Kota Bharu, or in the project area. Concepts of water management and the matters stipulated in the Operation and Maintenance Manual should be disseminated to Irrigation Inspectors and Irrigation Overseers.

(1) Training in the project area

A preliminary training programme on O&M Manual, for the first three years' duration from 1987, should be formulated and immediately implemented in the project area. The revised O&M Manual should be translated into Bahasa Malaysia and distributed by the end of 1987. After the preliminary period, in-service training will have to be followed for daily operation and maintenance in irrigation system, in the light of expertises accumulated in the experiences of day-to-day water management. The training in the project area should include the following.

a. specific concepts of water management in the project area
b. characteristics and problems of the irrigation system
c. revised operation and maintenance procedures
d. procedures for monitoring of distribution network
e. on-farm water management to farmers' leaders (by AICPLC members)

(2) Training at NWMTC

In order to provide general information on water management and understandings in paddy cultivation, the NWMTC training should be continued for Irrigation Inspectors and Irrigation Oversees. All the Irrigation Inspectors and Irrigation Overseers in the project area should finish the participation to the courses once by 1991. From DOA, most of Area Assistant Agriculture Officers and extension Agriculture Technicians will be sent there by the same year.

6.8 Follow-up Programme

Technical advice and assistance from foreign experts may be necessary for several years until the proposed water management is in full operation. The technical advice and assistance will be concentrated on the following aspects on both the main conveyance system and distribution network.

a. implementation of the proposed improvement work
b. establishment of proper monitoring system
c. implementation of water management

Taking into accounts an institutional setup and the envisaged requirements, three experts may be needed. One irrigation expert will station at MOMU being in charge of the main conveyance system and another irrigation expert at the Pilot Project on TASB4 being in charge of the distribution network. One water management expert will be as a team leader to generalize the work conducted by the irrigation experts. Two irrigation experts will work continuously for three years from 1987. Assignment period of the water management expert might be short. He will visit the site once or twice a year when the necessity arises.

7. COSTS AND BENEFITS

7.1 Project Costs

Costs for the proposed improvement work are estimated based on the prevailing construction costs in the project area in 1986. The total investment costs amount to M$32.5 million, which are composed of 30.5M$ million for the improvement of facilities and M$2 million for the procurement of O&M equipment. Breakdown of the project costs is shown in Table 30.

Annual O&M costs of the Project excluding salaries for the DID staff are estimated based on the O&M budget of PBLS in 1987. Costs to be spent for maintaining GRP is excluded from the budget, and O&M costs of the additional equipment is added to the budget. Total amount of O&M costs is estimated at M$ 2.5 million as shown in Table 31. The total amount includes O&M costs of the Bagan Terap pumphouse.

7.2 Project Benefits

7.2.1 Increase in paddy production

Direct benefits derived from the implementation of the Project will be the increase in unit yield of paddy and the increase in cropping intensity. The present cropping intensity 1.77 will be increased to 2.0 with consistent double cropping of paddy under the fixed irrigation schedule. The present yields of paddy, 2.89 ton/ha for the first season crop and 3.35 ton/ha for the second season crop will increase to the original target yields of PBLS, 4.4 ton/ha for the main season crop and 4.7 ton/ha for the off-season crop. The record of the highest yields in the past show the high potential of paddy production in the project area. It ranges from 4.2 to 5.7 ton/ha during the past five years from 1981 to 1985 as shown in Table 9. With expansion of improved farming practices coupled with the improvement of irrigation water supply, it is anticipated that most of the farmers will attain the original target yield of PBLS. Annual production of paddy in the project area is estimated at about 121,500 tons in 1990, the target year of PBLS, and about 166,700 tons in

1995, the target year of the Project, as shown below.

	Off-season (First Season)	Main Season (Second Season)	Annual
Present (Average during the period from 1981 to 1985)			
Cropped area (ha)	15,460	16,400	31,860
Unit yield (ton/ha)	2.89	3.35	
Production (ton)	44,680	54,950	99,630
Cropping intensity	0.86	0.91	1.77
1990 (Target year of PBLS)			
Cropped area (ha)	16,000	16,400	32,400
Unit yield (ton/ha)	3.70	3.80	
Production (ton)	59,200	62,320	121,520
Cropping intensity	0.89	0.91	1.80
1995 (Target year of the Project)			
Cropped area (ha)	18,320	18,320	36,640
Unit yield (ton/ha)	4.70	4.40	
Production (ton)	86,100	80,600	166,700
Cropping intensity	1.00	1.00	2.00

7.2.2 Improvement of productivity for paddy cultivation

The increase in paddy yield will improve returns from paddy cultivation in the project area. Crop budgets for paddy cultivation under the with-project condition were analyzed as shown in Tables 32 and 33, and as summarized below.

	Present*			With Project**		
	First Season	Second Season	Average	Main Season	Off-season	Average
Production cost (M$/ha)	1,225	1,283	1,254	1,387	1,389	1,388
Gross income (M$/ha)	1,554	1,907	1,731	2,416	2,581	2,499
Net return (M$/ha)	329	624	477	1,029	1,192	1,111
Production cost of rice (M$/ton)	823	700	762	585	547	566

Remarks: *= Average during the past 5 years (1981-1985), **= 1986 constant price

Under the with-project condition, the net return is expected to be doubled in comparison with the present condition. The unit production cost of milled rice would then be lower than the price of imported rice which was estimated at about M$608/ton in 1985.

7.2.3 Improvement in farmers' economy

The increase in net return will improve the farmers' economy and make paddy cultivation more attractive for farmers. In order to assess the benefits of the Project from the farmers' viewpoint, a farm budget analysis was made for a typical farmers holding farm land of 1.2 ha. The result of analysis is shown in Table 34, and summarized below.

(Unit: M$)

	Present		With Project/2	
	7 Compart-ments /1	Sekinchan	7 Compart-ments/1	Sekinchan
1. Gross income	4,600	8,637	7,633	10,522
a. Farm income	3,755	5,940	6,788	7,825
b. Off-farm income	845	2,697	845	2,697
2. Gross outgo				
a. Production cost	1,589	2,192	2,048	2,385
b. Land rent	1,007	1,975	1,007	1,975
c. Land and water charge	17	17	17	17
3. Living expenses and net reserve				
a. Owner operator/3	2,994	6,428	5,532	8,120
b. Tenant operator/4	2,004	4,470	4,542	6,162

Remarks; /1=Excluding Sekinchan /2=1986 constant prices
/3=(A)-(B.1)-(B.3) /4=(A)-(B.1)-(B.2)

Except in Sekinchan, the gross income of farmers will increase from M$4,600 to M$7,633 and will be over the median gross household income, M$7,150 in 1984, in rural areas of Peninsular Malaysia. The annual amount of living expenses and net reserves will also increase from M$2,994 to M$ 5,532 for owner operators and from M$2,004 to M$4,542 for tenant operators. In Sekinchan, it will increas from the M$6,428 to M$8,120 for owner operators and from M$4,470 to M$6,162 for tenant operators.

TABLES

Table 1 RESULTS OF WATER QUALITY ANALYSES

Unit: mg/lit

Sample Point	Main Canal		Drainage Canal			Swamp
	Tengi Head-works	End of Main Canal	Pan-chang Bedena	Sungai Busar	Sungai Nipah	
Electric Conductivity, (μs/cm)	35	37	205	145	80	180
Total Solids at 105°C	256	76	327	249	120	390
Suspended Solids	165	28	73	50	27	49
pH, (pH Unit)	6.3	6.2	6.1	5.9	5.8	3.8
Alkalinity (as $CaCO_3$)	11	9	39	20	19	0
Calcium	1.0	1.0	3.9	2.9	1.4	2.6
Chloride	3.5	0.5	35.5	23.5	12.5	27.0
Potassium	2.0	1.7	6.0	4.0	3.4	3.6
Magnesium	0.5	0.5	8.7	5.5	1.7	2.5
Sulphate	0.9	2.8	7.1	15	2.8	3.0
COD	21	27	121	5.9	70	359
Nitrate	1.3	0.80	0.64	0.45	0.53	0.57
Ammonia	0.11	0.05	0.71	0.43	0.78	0.78
Phosphate	0.04	0.03	0.11	0.05	0.04	0.42
Iron	7.9	1.7	5.7	7.7	4.9	0.5

Remarks: Sampling date = 18, July

Tested by Ampang Research Office of DID

Table 2 ELECTRIC CONDUCTIVITY AT BAGAN TERAP

Date		High Tide Time WL (m)	High Tide Time EC Value (μs/cm)	Highest EC Value (μs/cm)	Downstream WL of BRH (m)
Sept.	1	0.91	1,900	-	8.10
	2	1.43	2,200	-	7.60
	3	1.68	2,200	-	7.48
	4	1.89	2,200	-	7.10
	5	1.89	2,400	-	7.23
	6	2.20	2,800	3,250	7.08
	7	2.13	3,200	3,600	7.08
	8	2.10	3,450	4,000	7.08
	9	2.00	3,400	3,800	7.08
	10	1.74	3,250	3,600	7.05
	11	1.50	3,000	3,250	7.75
	12	1.14	3,000	3,100	7.25
	13	0.55	2,750	-	7.15
	14	0.85	2,600	-	7.35
	15	1.00	2,400	-	8.25
	16	1.30	2,400	-	9.15
	17	2.00	2,600	2,700	8.20
	18	2.11	2,200	2,600	7.60
	19	2.15	2,400	2,600	7.50

Remarks: WL = Water Level

Table 3 RESULT OF SEDIMENTATION ANALYSES

Location of Sampling	Date of Sampling	Total Solid at 105°C (mg/lit)	Suspended Solid (mg/lit)
1. D/S of Bernam Headworks	21/7/86	192	123
2. JKR bridge on Feeder canal	21/7/86	255	181
3. 10 km point of Feeder canal	21/7/86	233	193
4. Bagan Terap Pumphouse			
1) Bernam river at low tide	22/7/86	1,197	1,106
2) Bernam river at high tide			
0.3 m point	22/7/86	3,753	3,661
5 m point	22/7/86	4,500	4,152
10 m point	22/7/86	5,011	4,983
3) Outlet of pumphouse	22/7/86	4,551	4,407

Remarks: D/S = Downstream

Table 4 PRESENT LAND USE

Unit: ha

Irrigation Compartment	Paddy	Vegetables	Tree Crops	Fallow	Others/1	Gross Area
Sawa Sempadan	2,308	2	-	-	85	2,395
Sungai Burong	2,841	281	298	159	37	3,616
Sekinchan	1,483	295	46	-	33	1,857
Sungai Leman	1,596	169	85	256	27	2,133
Pasir Panjang	1,471	13	31	63	38	1,616
Sungai Nipah	1,938	-	-	2	79	2,019
Panchang Bedena	3,260	-	-	-	91	3,351
Bagan Terap	2,613	-	-	37	220	2,870
Total	17,510	760	460	517	610	19,857

Remarks: /1 = Including housing areas, public spaces, etc.

Source : PBLS, DID and DOA.

Table 5 MAIN FEATURES OF END CONTROL GATE

No.	Compartment	Name of Drain	Dimensions	Tidal Gate Concerned	Remarks
1.	Sawah Sempadan	PSS1	4'-00" ϕ	Sg.Johol,Point F	
2.	- do -	PSS3	5'-00" ϕ	- do -	
3.	- do -	PSS4	4'-00" ϕTwin	- do -	
4.	- do -	PSS6	4'-6"ϕ	- do -	
5.	- do -	PSS8	4'-00"x3'-00" Triple	Sg.Dungun	
6.	Sg.Burong	PSB1	4'-0"x4'-0"	Sg.Tengkorak	
7.	- do -	PSB5	- do -	- do -	
8.	- do -	PSB9	- do -	PT.3 Sg.Burong	
9.	- do -	PSB13	- do -	PT.4 Sg.Burong	
10.	Sekinchan	PS3	- do -	Sg.Labu	
11.	- do -	PS7	5'-0"ϕ	PT.6 Sekinchan	
12.	Sg.Leman	PSL3	4'-0"x4'-0"	Sg.Hj.Sirat	
13.	- do -	PSL8	- do -	- do -	
14.	- do -	PSL12	- do -	- do -	
15.	Pasir Panjang	PPP3	- do -	Sg.Pasir Panjang	
16.	- do -	PPP7	- do -	Sg.Abu Hashim	
17.	- do -	PPP9	2'-6" ϕ	- do -	
18.	- do -	PPP11	5'-0" ϕTwin	PT.12 Pasir Panjang	
19.	Sg.Nipah	PSN1	4'-0" ϕ	Sg.Nibong	
20.	- do -	PSN3	4'-0"x4"-0	- do -	
21.	- do -	PSN7	- do -	Sg.Nipah	
22.	- do -	PSN16	- do -	- do -	
23.	Panchang Bedena	PT.1 CABANG TIMOR	3'-0"ϕTwin	Sg.Hj Dorani	
24.	- do -	- do -	3'-0"ϕ	- do -	
25.	- do -	- do -	3'-0"ϕTwin	- do -	
26.	- do -	PT.1 BARAT	4'-0"ϕTriple	Sg.Besar	
27.	- do -	- do -	5'-0"ϕTwin	Sg.Besar,Sg.Burong	
28.	- do -	PPB17	2'-4"x2'-4"	Batu 39	Cannot release water
29.	- do -	PPB20, 21	4'-4"x4'-4"	Sabak Town	- do -
30.	- do -	PPB25	5'-6"x5'-6" Twin	Sg.Jawa Peringkat III	Drainage canal not constructed yet
31.	Bagan Terap	PT.13 TIMOR	no facility	T. Bendang	

Table 6 PRESENT CONDITION OF OFFTAKE

Compartment	Gate Removed	Gate Damaged	Steering Wheel Removed	Functioning	Total
Sawah Sempadan	-	-	-	12	CHO 2 AW 10
Sungai Burong	-	-	2	13	CHO13
Sekinchan	1	4	3	3	CHO 8
Sungai Leman	-	-	6	11	CHO11
Pasir Panjang	-	-	12	12	CHO12
Sungai Nipah	-	-	14	18	CHO18
Panchang Bedena	-	-	-	36	CHO36
Bagan Terap	-	-	-	30	CHO29 AW 1
Total	1	4	37	135	140

Remarks: CHO = Constant Head Orifice Offtake

AW = Adjustable Weir Offtake

Table 7 ANNUAL MAINTENANCE COSTS

Unit: M$1,000

Item	1984	1985	1986	Average Amount (%)
Purchasing Costs				
- Fuels and materials	396	372	453	407 (18.0)
- Equipments and parts	14	47	24	28 (1.2)
Maintenance Costs				
- Tengi river	16	14	20	17 (0.8)
- Irrigation and drainage canals	1,061	1,107	1,220	1,129 (50.4)
- Structures	54	54	54	54 (2.4)
- Replacement of GRP	440	428	315	394 (17.6)
- Farm roads	193	209	201	201 (9.0)
- Offices	12	13	15	13 (0.6)
Total	2,186	2,244	2,302	2,243 (100.0)
(M$/ha)	(120)	(123)	(126)	(123)

Remarks: Figures above not include salaries for DID staff.

Table 8 EXTENSION OF DIRECT SEEDING AREA

Unit: %

Year & Crop Season		Irrigation Compartment								Weighted Average
		SS	SB	SK	SL	PP	SN	PB	BT	
1979	I	-	-	68	**	-	-	**	**	10
	II	-	-	88	-	-	-	-	-	7
1980	I	-	-	90	-	-	-	-	-	9
	II	-	-	100	-	-	-	-	-	8
1981	I	-	-	100	**	**	**	-	-	8
	II	-	**	100	-	-	-	-	-	8
1982	I	-	-	100	5	-	13	-	-	10
	II	19	-	100	29	-	50	-	-	19
1983	I	**	17	100	60	85	80	**	**	65
	II	80	NA	100	NA	NA	NA	-	-	NA
1984	I	85	37	NA	NA	NA	NA	-	-	NA
	II	81	22	76	34	89	84	-	-	43
1985	I	81	49	74	36	87	55	-	-	37
	II	91	**	77	6	52	16	-	-	33
1986	I	90	71	96	21	17	1	-	-	35

Source: District DOA

Remarks: ** = missing crop season by delay of cropping in the preceding crop seasons

NA = data not available

- = transplanting only

Irrigation compartment; SS = Sawa Sempadan, SB = Sungai Burong, SK = Sekinchan, SL = Sungai Leman, PP = Pasir Panjang, SN = Sungai Nipah, PB = Panchang Bedena, BT = Bagan Terap

Table 9 UNIT YIELD OF PADDY

Unit: ton/ha

	1981	1982	1983	1984	1985	Weighted Average
First Crop Season						
Sawa Sempadang	2.81	3.74	*	2.33	2.24	2.78
Sungai Burong	2.45	3.12	1.92	3.03	2.40	2.62
Sekinchan	3.51	3.82	4.25	3.89	3.52	3.88
Sungai Leman	*	3.66	2.01	2.22	1.94	2.47
Pasir Panjang	*	3.36	1.98	2.05	2.17	2.39
Sungai Nipah	*	3.60	1.65	2.98	2.51	2.69
Panchang Bedena	2.84	3.90	*	3.32	1.88	3.09
Bagan Terap	2.57	4.22	*	3.25	2.51	3.34
Weighted Average	2.77	3.68	2.27	2.93	2.35	2.89
Second Crop Season						
Sawa Sempadang	3.53	2.92	2.21	2.28	3.19	2.83
Sungai Burong	*	3.19	2.81	2.67	*	2.90
Sekinchan	3.87	3.84	4.20	3.33	5.15	4.10
Sungai Leman	4.61	1.58	2.32	1.78	3.05	2.66
Pasir Panjang	5.71	2.92	2.10	1.97	2.89	3.11
Sungai Nipah	4.77	3.28	1.83	2.88	3.84	3.31
Panchang Bedena	3.88	3.88	3.78	3.48	4.01	3.80
Bagan Terap	4.38	3.33	3.40	3.79	3.91	3.77
Weighted Average	4.29	3.17	2.91	2.87	3.73	3.35
Annual Unit Yield (Weighted Average)						
Sawa Sempadang	3.17	3.33	2.21	2.31	2.72	2.81
Sungai Burong	2.45	3.16	2.36	2.85	2.40	2.73
Sekinchan	3.68	3.83	4.22	3.61	4.35	3.99
Sungai Leman	4.61	2.62	2.17	2.00	2.50	2.57
Pasir Panjang	5.71	3.15	2.04	2.01	2.53	2.75
Sungai Nipah	4.77	3.44	1.74	2.93	3.19	3.01
Panchang Bedena	3.35	3.89	3.78	3.40	2.99	3.50
Bagan Terap	3.48	3.79	3.40	3.52	3.22	3.58
Weighted Average	3.58	3.43	2.69	2.91	2.99	3.13

Remark: *; Not planted

Unit yield indicates the gross yield (wet paddy including foreign elements such as rachies branch, leaf, weeds, etc.).

Source: PBLS Office

Table 10 CROP BUDGET FOR FIRST SEASON PADDY

Unit: M$/ha

Item	1981	1982	1983	1984	1985
A. Production Cost					
1) Seed	17	20	30	32	30
2) Fertilizer	253	238	258	248	246
3) Weedicide	42	52	32	47	56
4) Insecticide	30	42	45	50	42
5) Hired labour and farm machinery					
- Land preparation	154	159	139	154	151
- Planting	186	186	193	181	189
- Harvesting	246	320	188	263	214
- Transportation	48	64	39	51	41
6) Family labour	300	198	186	216	216
7) Land and water charges	7	7	7	7	7
Financial cost in total	1,283	1,286	1,117	1,249	1,192
8) Land rent	434	496	563	563	580
Total paid cost					
- Owner operator 1) + 3) + 4) + 5) + 7)	730	850	673	785	730
- Tenant operator 1) + 3) + 4) + 5) + 7) + 8)	1,157	1,339	1,229	1,341	1,303
B. Gross Income	1,539	2,094	1,261	1,570	1,306
1) Yield (ton)	(2.77)	(3.68)	(2.27)	(2.93)	(2.35)
2) % of deduction (%)/1	(16)	(14)	(16)	(19)	(16)
3) Price (M$/100 kg)	(66.15)	(66.15)	(66.15)	(66.15)	(66.15)
C. Net Return					
1) Financial net return	256	808	144	321	114
2) Owner operator	809	1,244	588	785	576
3) Tenant operator	382	755	32	229	3
D. Production Cost of Rice					
1) Production of rice/2 (ton)	1.51	2.06	1.24	1.54	1.28
2) Production cost/3 (M$/ton)	850	624	901	811	931

Remarks: /1 = Adjustment to clean dry paddy weight.
/2 = Yield of paddy x (100% - % of deduction) x Milling recovery rate (65%).
/3 = Financial cost/Production of rice.

Source: Project Completion Report, PBLS, 1985.

Table 11 CROP BUDGET FOR SECOND SEASON PADDY

Unit: M$/ha

Item	1980	1981	1982	1983	1984
A. Production Cost					
1) Seed	20	20	25	32	30
2) Fertilizer	250	246	253	238	246
3) Weedicide	42	45	47	40	50
4) Insecticide	45	32	62	57	47
5) Hired labour and farm machinery					
- Land preparation	139	151	161	149	148
- Planting	188	191	193	186	191
- Harvesting	335	382	250	253	225
- Transportation	67	74	55	52	50
6) Family labour	268	218	193	216	216
7) Land and water charges	7	7	7	7	7
Financial cost in total	1,361	1,366	1,246	1,230	1,210
8) Land rent	340	414	590	588	560
Total paid cost					
- Owner operator 1) + 3) + 4) + 5) + 7)	843	902	800	776	748
- Tenant operator 1) + 3) + 4) + 5) + 7) + 8)	1,176	1,309	1,383	1,357	1,301
B. Gross Income	2,170	2,469	1,720	1,598	1,576
1) Yield (ton)	(3.86)	(4.29)	(3.17)	(2.91)	(2.87)
2) % of deduction (%)/1	(15)	(13)	(18)	(17)	(17)
3) Price (M$/100 kg)	(66.15)	(66.15)	(66.15)	(66.15)	(66.15)
C. Net Return					
1) Financial net return	809	1,103	474	368	366
2) Owner operator	1,327	1,567	920	822	828
3) Tenant operator	994	1,160	337	241	275
D. Production Cost of Rice					
1) Production of rice/2 (ton)	2.13	2.43	1.69	1.57	1.55
2) Production cost/3 (M$/ton)	639	562	737	783	781

Remarks: /1 = Adjustment to clean dry paddy weight
/2 = Yield of paddy x (100% - % of deduction) x Milling recovery rate (65%)
/3 = Financial cost/Production of rice

Source: Project Completion Report, PBLS, 1985

Table 12 STATE DOA EXTENSION STAFF

District	Service Area	Extension Block	Location of Office
1. Kuala Selangor			
District AO			DO, Kuala Selangor
AAO (Devl't)			
2 ATs (Devl't)			
	(1) Kuala Selangor North		
	Area AAO		FDSc, S.Sempadan
	2 ATs (Devl't)		
		Sawah Sempadan I-III	
		3 ATs (rice)	- do -
		Sawah Sempadan IV	
		1 AT (tree-crop)	- do -
		Sg. Burong I-IV	
		4 ATs (rice)	FDSc, Sg.Burong
	(2) Kuala Selangor South		
	- Omitted, due to all for tree-crops		
2. Sabak Bernam			
District AO			Next to DO,
AAO (Devl't)			Sabak Bernam
Senior AT (Devl't), AT (Devl't)			
	(3) Sabak Bernam South		
	Area AAO		FDSc, Sekinchan
	AT (Devl't)		
		Sekinchan I, II	
		2 ATs (rice)	FDSc, Sekinchan
		Sg. Leman I, II	
		2 ATs (rice)	- do -
		Pasir Panjang I, II	
		2 Ats (rice)	Agriculture Station
		1 AT (Devl't)	P.Panjang
		Sg. Nipah I-III	FDSc, Simpang Lima
		3 ATs (rice)	Sg.Nipah
	(4) Sabak Bernam Central		
	Area AAO		FDC, Sg.Besar
		Panchang Bedena I-IV	
		4 ATs (rice)	- do -
		Bagan Terap I-IV	- do -
	(5) Sabak Bernam North		
	- Omitted, due to all for tree-crops		

Remarks: AO: Agriculture Officer AAO: Assistant Agriculture Officer
AT: Agriculture Technician DO: District Office

Table 13 STATE DID IRRIGATION STAFF

Name of Irrigation Compartment	Area (ha)	Length of Tertiary Canals (km)	I.I.	I.O.	GK(I)	GK(D)
1. Sawah Sempadan	2,395	64.4	1	3	6	1
2. Sg. Burong	3,616	95.5	1	4	14	2
3. Sekinchan	1,857	49.9	1*	2	8	1
4. Sg. Leman	2,133	59.1	1	2	12	-
Sub-Total (C.I.I in charge)	10,001	268.9	4	11	40	4
5. Pasir Panjang	1,616	42.2	1	2	6	1
6. Sg. Nipah	2,019	53.3	1	3	7	1
7. Panchang Bedena	3,351	88.8	1	4	14	3
8. Bagan Terap	2,870	74.9	1	3	15	-
Sub-Total (S.I.I in charge)	9,856	259.2	4	12	42	5
Total	19,857	528.1	8	23	82	9

Remark: (1): Besides the above, the following are also irrigation O/M staff:

a) Water Management Extension Pilot Project team along TASB 4: 1 I.I., 1 I.O., 1 Gatekeeper (included in the figure above), 2 Labourers.

b) Bernam Headworks: 1 Special-grade I.O., 2 Gatekeepers, 1 Operator, 1 Greaser, 2 Drivers, 3 Labourers.

c) Tengi Spillway and Headworks: 2 Operators, Sawah Sempadam.

d) Bagan Terap Pump house: 2 Operators, 2 Greasers.

e) Secondary Canals, Panchang Bedena: 2 Gatekeepers. (a-a line: 1, b-b line: 1, c-c line: None)

(2): *: Senior I.O. (Acting II)

(3): Abbreviation:

C.I.I.: Chief Irrigation Inspector
S.I.I.: Senior Irrigation Inspector
I.I. : Irrigation Inspector
I.O. : Irrigation Overseer
GK(I) : Irrigation Gatekeeper
GK(D) : Drainage Gatekeeper

Table 14 RELATION BETWEEN RAINFALL AND GROUNDWATER LEVEL IN SWAMP DURING RAINY SEASON

Date	Rainfall (mm)	Increase in GW Level (mm)	Ratio
4. 9.86	39	105	2.69
10. 9.86	45	160	3.56
26. 9.86	22	60	2.73
2.10.86	31	92	2.97
8.12.86	82	258	3.15
Average			3.00

Remarks: GW = Groundwater

Table 15 DRAWDOWN RATE OF GROUNDWATER LEVEL IN SWAMP

Site of Observation	Distance from MC	Sept., 1986 (17th-24th)	Oct., 1986 (8th-15th)
	m	mm/d	mm/d
1	100	8.6	10.0
2	250	12.9	10.0
3	500	11.4	11.4
4	1,000	11.2	10.1
Average		11.0	10.4

Remarks: MC = Main Canal

Table 16 FARM MACHINERY REQUIREMENT UNDER PRESENT CONDITION

		Jan.			Feb.			Mar.			Apr.			May			June			July			Aug.			Sept.			Oct.			Nov.			Dec.			Peak Farm Machinery Requirement (No.)	Existing Farm Machinery (No.)
Cropping Schedule														1st Season (Off-season) 17,510 ha																	2nd Season (Main-season) 17,510 ha								
Working Schedule	Slashing																																						
	1st Rotavating																																						
	2nd Rotavating																																						
	Harvesting																																						
Workable Day/1 (%)		89			88			87			80			86			89			86			89			85			80			77			79				
Work Load/2	Slashing (ha/day)	328	328	328	332	332	332													339	339	339	328	328	328														
	1st Rotavating (ha/day)			328	332	332	332	335	335													339	328	328	328	343	343												
	2nd Rotavating					332	332	335	335	335	365	365												328	328	343	343	343	365	365									
	Harvesting (ton/day)	1099	1099	1099	1112														948	981	981	981	948	948												1238	1238		
Required Farm Machinery/3	Slasher (No.)	51	51	51	52	52	52													53	53	53	51	51	51													53	52
	Rotavator (No.)			68	69	138	138	140	140	70	76	76										71	68	137	137	143	143	71	76	76								143	113
	Harvester (No.)	60	60	60	60														52	53	53	53	52	52												67	67	67	65
	Tractor/4	51	51	119	121	190	190	140	140	70	76	76								53	53	124	119	188	188	143	143	71	76	76								190	113

/1 The workable day for mechanized farming was estimated on the basis of the rainfall data (1975-1984) at Sungai Nipah and the following criterion.

Rainfall (mm/day)	Workability (%)
< 9.9	100
> 10.0	0

/4 Slasher + Rotavator

/2 The work load (WL) was calculated as follows:
WL = AP/WP/WD
Where, *WP: Working Period (60 days)* *WD: Workable Day (%)*
AP: Area or Production
Production: 1st season 2.89* t/ha x 17,510 ha = 50,600 tons
2nd season 3.35* t/ha x 17,510 ha = 58,700 tons
* Average during the past 5 years (1981-1985)

/3 The *required farm machinery (FM)* was calculated as follows:
FM = WL/CA/OE
Where, CA: Working capacity on a weighted average in the project area
Slashing: 8 ha/day Rotavating: 6 ha/day
Harvesting: 23 tons/day
OE: Operation efficiency taking into account the losses for repair, movement from lot to other place, etc. (80%)

Table 17 RESULTS OF MEASUREMENT OF LEAKAGE

No.	Name of Drainage Canal or Structure	Water Level of Main Canal (m)	Leakage (cu.m/s)	Leakage (cu.sec)	Remarks
1.	PSS-2 (TA 4)	4.35	0.515	(18.19)	
2.	PSS-6 (TA 3)	4.35	0.097	(3.43)	
3.	PSS-9	4.63	0.152	(5.37)	Pipe
4.	PSS-10(TA 2)	4.35	0.470	(16.60)	
5.	Tengi Headworks	4.10	0.809	(28.57)	
6.	Spillway	4.10	1.169	(41.28)	
7.	PSB-1 (PARIT 1)	4.20	0.636	(22.46)	
8.	PSB-3 (TA 1)	4.55	0.173	(6.13)	
9.	PSB-5 (PARIT 2)	4.50	0.716	(25.36)	
10.	PSB-7 (TA 2)	4.40	0.607	(21.50)	
11.	PSB-9 (PARIT 3)	4.45	0.272	(9.64)	
12.	PSB-10	4.43	0.046	(1.63)	Pipe
13.	PSB-11(TA 3)	4.43	0.090	(3.19)	
14.	PSB-12	4.43	0.012	(0.43)	
15.	PS-1 (TA 4)	4.39	0.167	(5.92)	
16.	PS-2	4.35	0.005	(0.18)	
17.	PS-3 (PARIT 5)	4.35	0.376	(13.28)	
18.	PS-4	4.30	0.005	(0.18)	
19.	PS-5 (TA 5)	4.30	0.408	(14.41)	
20.	PS-6	4.25	0.010	(0.35)	
21.	PSL-1 (TA 6)	4.25	0.042	(1.48)	
22.	PSL-3 (PARIT 7)	4.20	0.174	(6.14)	
23.	PSL-4	4.18	0.138	(4.87)	Pipe
24.	PSL-5 (TA 7)	4.18	0.056	(1.98)	
25.	PSL-9	4.17	0.074	(2.61)	Pipe
26.	PSL-10(TA 8)	4.14	0.143	(5.05)	
27.	PSL-11	4.13	0.105	(3.71)	Pipe
28.	PSL-13	4.10	0.015	(0.53)	Pipe
29.	PPP-3 (PARIT 10)	4.05	0.079	(2.79)	
30.	PPP-4	4.03	0.010	(0.35)	
31.	PPP-12	4.05	0.031	(1.09)	
32.	Spillway	3.63	0.041	(1.45)	
33.	PSN-19 (PARIT 17)	3.63	0.284	(10.03)	
		TOTAL	7.927	(280.18)	

Remark: 280.18 cu.sec/1,000 cu.sec x 100 = 28.0%

Measurement in July 1986

Table 18 PRESENT CONDITION OF CHECK GATE

Compartment	Total Nos.	Removed	Damaged	Functioning
Sungai Burong				
C/B 4	12	10	0	2
C/B 3	13	8	0	5
C/B 2	14	7	0	7
C/B 1	15	4	0	11
Sub-total	54	29	0	25
Sekinchan				
C/B 3	7	2	3	2
C/B 2	8	4	2	2
C/B 1	8	5	2	1
Sub-total	23	11	7	5
Sungai Leman				
C/B 3	9	7	0	2
C/B 2	11	3	0	8
C/B 1	12	1	0	11
Sub-total	32	11	0	21
Pasir Panjang				
C/B 2	12	0	0	12
C/B 1	12	0	0	12
Sub-total	24	0	0	24
Panchang Bedena				
C/B 2	15	0	0	15
C/B 1	30	0	0	30
Sub-total	45	0	0	45
Began Terap				
C/B 1	21	0	0	21
Sub-total	21	0	0	21
Total	199	51	7	141

Table 19 SURVEY OF CHECK GATE

Difference Height (cm)	(inch)	SB	S	SL	PP	PB	BT	Total
		Number of Gate in Compartment						
0	(0)	4		1	15	20		40
0 - 5	(0 - 2)	4		4	4	3	10	25
5 - 10	(2 - 4)	8		4	3	2	4	21
10 - 15	(4 - 6)	7	1	2	1	7	3	21
15 - 20	(6 - 8)	1	1	1		8	2	13
20 - 25	(8 - 10)	1		5	1	2	2	11
25 - 30	(10 - 12)			3		2		5
30 - 35	(12 - 14)					1		1
35 - 41	(14 - 16)			1				1
41 - 46	(16 - 18)		1					1
51 - 56	(20 - 22)		1					1
61 - 66	(24 - 26)		1					1
	Total	25	5	21	24	45	21	141

Remarks: SB = Sungai Burong, S = Sekinchan, SL = Sungai Leman,
PP = Pasir Panjang, PB = Panchang Bedena, BT = Bagan Terap

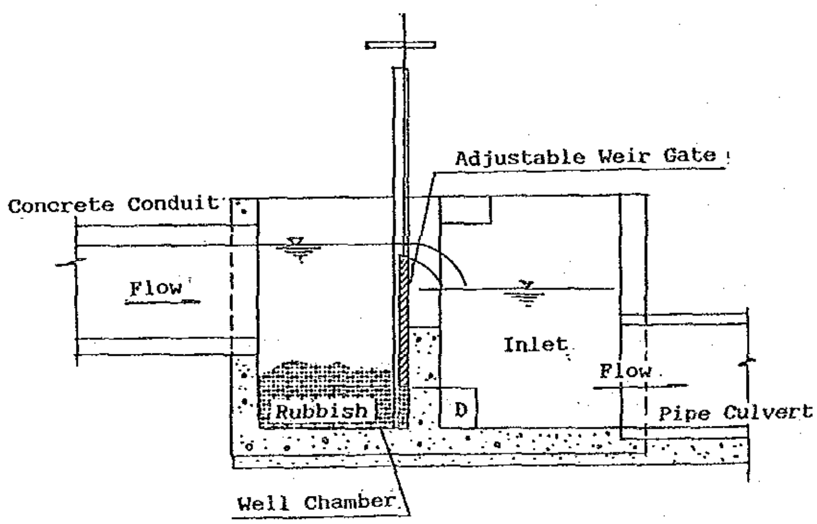

Table 20 RESULT OF DISCHARGE MEASUREMENT IN MAIN CONVEYANCE SYSTEM

Unit: cu.m/s

Date (1986)		Sungai Dusun	Upstream of Tengi Headworks
Feb.	5	16.91	26.03
	12	15.64	14.14
	19	19.32	14.16
	26	20.37	24.09
Mar.	5	14.59	12.22
	12	19.25	25.52
	19	3.94	-
	26	19.44	30.51
Apr.	2	28.06	32.19
	9	-	32.96
	16	22.86	48.03
May	7	14.25	25.76
	14	10.28	16.44
	21	15.54	15.69
June	18	22.43	-
	25	17.40	-
July	9	21.03	20.70
	16	16.53	15.00
	23	10.21	5.80
	30	22.18	17.32
Aug.	6	10.18	5.40
	13	12.07	8.12
	20	9.71	5.12
	27	7.94	6.25
Sept.	3	-	10.26
	10	22.12	14.20
	23	15.92	15.90
	24	21.93	21.13
	25	21.07	25.29

Table 21 ESTIMATE OF UPSTREAM DISCHARGE OF TENGI HEADWORKS

Date (1986)	Time (hr)	Q1 (cu.m/s)	WL (m)	ΔWL (m)	q (cu.m/s)	Q1 + q (cu.m/s)	Qo (cu.m/s)
May 7	6.0		4.51	-	-	-	
	9.0		4.50	+0.01	+1.20	15.45	
	12.0	14.25	4.45	+0.05	+6.02	20.27	25.76
	15.0		4.42	+0.03	+3.61	17.86	
	18.0		4.40	+0.02	+2.41	16.66	
July 23	9.0		4.05	-	-	-	
	12.0	10.21	4.08	-0.03	-3.61	6.60	5.80
	15.0		4.06	+0.02	+2.41	12.62	
	18.0		4.03	+0.03	+3.61	13.82	
July 30	6.0		4.50	-	-	-	
	9.0		4.56	-0.06	-7.22	14.96	
	12.0	22.18	4.60	-0.04	-4.81	17.37	17.32
	15.0		4.60	-	-	22.18	
	18.0		4.59	+0.01	+1.20	23.38	
	21.0		4.58	+0.01	+1.20	23.38	
	24.0		4.58	-	-	22.18	
Aug. 13	6.0		3.84	-	-	-	
	9.0		3.85	-0.01	-1.20	10.87	
	12.0	12.07	3.87	-0.02	-2.41	9.66	8.12
Sept.10	0.0		3.94	-	-	-	
	3.0		3.96	-0.02	-2.41	19.71	
	6.0		3.96	-	-	22.12	
	9.0		4.00	-0.04	-4.81	17.31	
	12.0	22.12	4.04	-0.04	-4.81	17.31	14.20
	15.0		4.10	-0.06	-7.22	14.90	
	18.0		4.10	-	-	22.12	
	21.0		4.11	-0.01	-1.20	20.92	
	24.0		4.15	-0.04	-4.81	17.31	

Remarks:
Q1 ; diverted discharge from BRH
WL ; water level at the Tengi Headworks
ΔWL ; difference in water level at the Tengi Headworks
q ; change in discharge in the Feeder Canal and the Tengi river
Q1 + q ; estimated discharge upstream of the Tengi Headworks
Qo ; Observed discharge upstream of the Tengi Headworks

Table 22 FUTURE LAND USE

Unit: ha

Compartment	Irrigated Area		Non-irrigated Area		Total
	Paddy	Vegetables	Tree Crops	Others/1	
Sawah Sempadan	2,310	-	-	85	2,395
Sungai Burong	2,890	391	298	37	3,616
Sekinchan	1,640	184	-	33	1,857
Sungai Leman	1,680	85	341/2	27	2,133
Pasir Panjang	1,470	-	108/2	38	1,616
Sungai Nipah	1,940	-	-	79	2,019
Panchang Bedena	3,260	-	-	91	3,351
Bagan Terap	2,650	-	-	220	2,870
Extension Area	480	-	-	63	543
Total	18,320	660	747	673	20,400

Remarks: /1 = Reserves and home yards

/2 = Newly converted area from paddy area to tree crop area

Table 23 PROPOSED FARMING PRACTICES FOR DRY DIRECT SEEDING

	Work Item	Commencement Date	Farm Inputs and Machinery
1)	Recommended varieties		MR 52, MR 71, MR 77, MR 84, etc.
2)	Growth period		135 days
3)	Land preparation		
	- Slashing	-30	Slasher
	- Burning	-25	
	- 1st Rotavating	-20	Rotavator
	- 2nd Rotavating	-5	Rotavator
	- Repairing of bund	-3	
4)	Seeding		
	- Manual seeding/ Mechnical seeding	0	Rotavator/Seed drill, Seed : 80 kg/ha
	- Inserting	+18	
5)	Fertilizing		
	- 1st top dressing	+20	Mixture (17.5:15.5:10): 100 kg/ha
	- 2nd top dressing	+35	Mixture (17.5:15.5:10): 100 kg/ha
	- 3rd top dressing	+55	Urea (46%) : 50 kg/ha
	- 4th top dressing	+75	Urea (46%) : 50 kg/ha
6)	Spraying of insecticides	+20	Furadan : 20 kg/ha
7)	Spraying of weedicides		
	- 1st spraying	-22	Paraquat : 4 lit/ha
	- 2nd spraying	-7	Paraquat : 4 lit/ha
	- 3rd spraying	+20	2,4-D BE : 2.5 kg/ha
8)	Irrigating		
	- Presaturation	+5	20 days after seeding
	- Normal irrigation	+25	85 days
	- Drainage	+110	
9)	Harvesting	+135	Harvester
10)	Rat control		Area-wise operation

Table 24 PROPOSED FARMING PRACTICES FOR WET DIRECT SEEDING

	Work Item	Commencement Date	Farm Inputs and Machinery
1)	Recommended varieties		MR 52, MR 71, MR 77 MR 84, etc.
2)	Growth period		130 days
3)	Land preparation		
	- Slashing	-30	Slasher
	- Burning	-25	
	- Rotavating	-20	Rotavator
	- Repairing of bund	-15	
	- Puddling	-5	Rotavator, 2 times
4)	Seeding		
	- Soaking of seed	-3	Seed : 80 kg/ha
	- Manual seeding	0	
	- Inserting	+18	
5)	Fertilizing		
	- 1st top dressing	+20	Mixture (17.5:15.5:10): 100 kg/ha
	- 2nd top dressing	+35	Mixture (17.5:15.5:10): 100 kg/ha
	- 3rd top dressing	+55	Urea (46%) : 50 kg/ha
	- 4th top dressing	+75	Urea (46%) : 60 kg/ha
6)	Spraying of insecticides	+20	Furadan : 20 kg/ha
7)	Spraying of weedicides		
	- 1st spraying	-22	Paraquat : 4 lit/ha
	- 2nd spraying	+20	2,4-D BE : 2.5 kg/ha
8)	Irrigating		
	- Presaturation	-20	
	- Normal irrigation	+20	85 days
	- Drainage	+105	
9)	Harvesting	+130	Harvester
10)	Rat control		Area-wise operation

Table 25 FARM INPUTS AND LABOUR REQUIREMENTS

Item		Dry Direct Seeding	Wet Direct Seeding
Farm Inputs Requirements			
1) Seed	(kg/ha)	80	80
2) Fertilizer			
- Urea (46%)	(kg/ha)	100	100
- Mixture (17.5:15.5:10)	(kg/ha)	200	200
3) Insecticide			
- Furadan	(kg/ha)	20	20
4) Weedicide			
- Paraquat	(lit/ha)	8	4
- 2, 4-D BE	(kg/ha)	2.5	2.5
5) Rodenticide	(kg/ha)	1	1
Labour Requirement	(man-day/ha)	34	34
1) Burning		1	1
2) Repairing of bund		3	3
3) Soaking of seed		-	1
4) Seeding		3	3
5) Inserting		3	3
6) Fertilizing		8	8
7) Spraying of insecticide		2	2
8) Spraying of weedicide		6	4
9) Irrigating		4	6
10) Others/1		4	4

Remarks: /1 = Including bagging of paddy after harvest and rat control.

Table 26 PROPOSED IRRIGATION SCHEDULE AREA

Unit: ha

Irrigation Schedule	Compartment	Paddy	Vegetable	Total
Area 1	Sungai Burong	2,890	350	3,240
	Sekinchan	1,640	170	1,810
	Sungai Leman	1,680	140	1,820
	Sub-total	6,210	660	6,870
Area 2	Sawah Sempadan	2,310	-	2,310
	Pasir Panjang	1,470	-	1,470
	Sungai Nipah	1,940	-	1,940
	Panchang Bedena (a-a)	950	-	950
	Extension area	160	-	160
	Sub-total	6,830	-	6,830
Area 3	Panchang Bedena (b-b and c-c)	2,310	-	2,310
	Bagan Terap			
	Gravity (main canal)	1,450	-	1,450
	Pumping	1,200	-	1,200
	Sungai Panjang (Extension area)	320	-	320
	Sub-total	5,280	-	5,280
	Total	18,320	660	18,980

Table 27 DOMESTIC AND INDUSTRIAL WATER DEMAND

Unit: cu.m/day

Location/scheme	Present	Future	Increment
Upstream of BRH			
Alah Batu scheme	11,400	11,620	220
Slim village scheme	-	260	260
New Sabak Bernam scheme	27,300	36,400	9,100
Sub-total	38,700	48,280	9,580
Downstream of BRH			
Sabak Bernam scheme	5,460	9,100	3,640
Estate in Perak			
United Plantation	2,760	2,760	-
Harrisons Plantation	1,000	1,000	-
Sungai Burong (Water Works)	-	27,300	27,300
Sub-total	9,220	40,160	30,940
Total	47,920	88,440	40,520

Table 28 RESULT OF BACK WATER CALCULATION FOR MAIN CANAL

Location	Distance	Base Width	Base EL	Present FSL	Design Discharge			Case 1 ISA2 Presaturation						Case 2 ISA1 Presaturation						Case 3 Normal Irrigation					
					with Regulator			without Regulator			with Regulator			without Regulator			with Regulator			without Regulator			with Regulator		
					Q	WL	Draw -down	Q	WL	Draw -down	Q	WL	Draw -down	Q	WL	Draw -down	Q	WL	Draw -down	Q	WL	Draw -down	Q	WL	Draw -down
(CH)	(m)	(m)	(m)	(m)	(m^3/s)	(m)	(m)	(m^3/s)	(m)	(m)	(m^3/s)	(m)	(m)	(m^3/s)	(m)	(m)	(m^3/s)	(m)	(m)	(m^3/s)	(m)	(m)	(m^3/s)	(m)	(m)
34,577	Reg.No.3		0.914			3.663															3.663			3.663	
	3,077	5			3.58			-			-			-			-			2.01			2.01		
31,500			0.914	3.587		3.684	+0.097														3.670	+0.083		3.670	+0.083
	900	14			8.79			-			-			-			-			4.93			4.93		
30,600			0.914			3.692															3.673			3.673	
	2,170	14			12.34			-			-			-			-			6.93			6.93		
28,430	Reg.No.2		0.914			3.730 3.800			3.800			3.800			3.800			3.800			3.685 3.800			3.685 3.800	
	230	17			12.34			-			-			-			-			6.93			6.93		
28,200			0.914			3.802			3.800			3.800			3.800			3.800			3.801			3.801	
	150	17			13.80			2.59			2.59			-			-			8.39			8.37		
28,050			0.917	3.658		3.804	+0.146		3.800	+0.146		3.800	+0.146		3.800			3.800			3.802	+0.144		3.802	+0.144
	7,650	17			16.35			7.13			7.13			-			-			10.94			10.94		
20,400			1.080	3.816		3.942	+0.126		3.828	+0.012		3.828	+0.012		3.800			3.800			3.867	+0.051		3.867	+0.051
	5,100	20			18.28			10.57			10.57			-			-			12.87			12.87		
15,300	Reg.No.1		1.188	3.929		4.032 4.100	+0.103 +0.171		3.864	-0.065		3.864 4.100	-0.065 +0.171		3.800	-0.129		3.800 4.100	+0.171		3.917	-0.012		3.917 4.100	-0.012 +0.171
	4,050	22			20.66			12.95			12.95			4.10			4.10			15.25			15.25		
11,250			1.275	4.023		4.173	+0.150		3.904	-0.119		4.129	+0.106		3.804	-0.219		4.103	+0.080		3.968	-0.055		4.140	+0.117
	3,300	24			23.02			15.31			15.31			8.14			8.14			17.61			17.61		
7,950			1.345	4.097		4.237	+0.140		3.945	-0.152		4.160	+0.063		3.817	-0.280		4.112	+0.015		4.017	-0.080		4.180	+0.083
	7,950	27			27.59			19.88			19.88			15.68			15.68			22.18			22.18		
0	Tengi HW		1.514	4.267		4.416	+0.149		4.084	-0.183		4.267	±0.000		3.923	-0.344		4.185	-0.087		4.173	-0.094		4.308	+0.041

Table 29 IMPLEMENTATION SCHEDULE OF THE PROJECT

Item	1987	1988	1989	1990
1. Improvement Work for Facilities				
(1) Bernam River Headworks	———			
(2) Main Canal				
a. Enlargement of canal sections	———	———		
b. Const. of new cross regulator	———	———		
c. Impr. of existing cross regulator	———	———		
(3) Secondary canal				
a. Construction of the d-d line		———		
b. Banking of the c-c line	———			
(4) Tertiary canals				
a. Construction of concrete conduits	———	———	———	
b. Improvement of structures	———	———	———	———
(5) Drainage facilities		———	———	
(6) Construction of farm roads	———	———	———	——— by 1993
2. Procurement of Equipment for O&M		———		
3. Institutional Arrangement				
(1) Establishment of MOMU		———		
(2) Recruitment of personnel				
a. Engineer		———		
b. S.I.I. Tanjong Karang	———			
c. Others		———		
4. Establishment of Monitoring System		———		
5. Water Management Pilot Project	———	———	———	
6. Extension of Water Management		———	———	———
7. Training Programme				
(1) Preparation of O&M Manual in Bahasa	———			
(2) Training for I.Is and I.Os at NWMTC	———	———	———	——— by 1991
(3) Training on revised O&M at site	———	———	———	
8. Follow-up Programme	———	———	———	———

Table 30 INVESTMENT AND PROCUREMENT COST OF THE PROJECT

Item	Priority*	Cost (M$1,000)
1. Investment Cost		
(1) Bernam River Headworks		
a. Increase in height of radial gates	A	4
b. Provision of electrically driven hoists	B	53
c. Improvement of screens	A	3
(2) Main Canal		
a. Enlargement of canal sections	A	600
b. Construction of new cross regulator	A	800
c. Improvement of existing cross regulator	A	300
(3) Secondary canal		
a. Construction of the d-d line	B	150
b. Banking of the c-c line	A	50
(4) Tertiary canals		
a. Construction of concrete conduits in SS, SN and Panchang Bedena extension area	B	17,800
b. Provision of screen of offtake structure	B	300
c. Improvement of check gates and slots	A	400
d. Change in location of offtake pipes	B	100
(5) Drainage facilities		
a. Construction of drainage controls	A	200
b. Construction of bridges	B	200
(6) Construction of farm roads including aquisition	C	9,500
Total Cost for Improvement Work		30,460
2. Procurement Cost		
(1) Backhoe loader (2 nos.)	B	350
(2) Hydraulic excavator (2 nos.)	B	400
(3) Dredger (1 no.)	B/C	450
(4) Aquatic weed cutter (2 nos.)	B	300
(5) Radio communication system (10 sets)	A	300
Total Cost for Procurement		1,800
Grand Total		32,260

Remarks: Priority* A; very urgent
B; urgent
C; According to the budget allocated

Table 31 OPERATION AND MAINTENANCE COST

Item	Amount (M$1,000)
Canal	57
Drain (Clearing)	699
Drain (Desiting)	332
Farm roads	419
Main canal	146
Secondary canal	48
Structures	33
Bridges	148
Pumphouse	276
Headworks	20
Machinary	294
Quarters	4
Others	24
Total	2,500

Table 32 CROP BUDGET FOR DRY DIRECT SEEDING

Item		M$/ha
A. Production Cost		1,389
1) Seed	80 kg x M$1.00/kg	80
2) Fertilizer		
- Urea	100 kg x M$0.48/kg	48
- Mixture	200 kg x M$0.76/kg	152
3) Weedicide		
- Paraquat	8 lit x M$7.88/lit	63
- 2, 4-D BE	2.5 kg x M$6.40/kg	16
4) Insecticide		
- Furadan	20 kg x M$3.13/kg	63
5) Rodenticide	1 kg x M$30.00/kg	30
6) Farm machinery		
- Slashing		42
- 1st rotavating		67
- 2nd rotavating		42
- Rotavating after seeding		42
- Harvesting	59 guni x M$6.00/guni	354
- Transportation	59 guni x M$1.30/guni	77
7) Labour	34 man-days x M$9.00	306
8) Others/1		7
B. Gross Income		2,581
- Yield of paddy	4.7 tons	
- % of deduction/2	17%	
- Price	M$66.15/100 kg	
C. Net return (B-A)		1,192
D. Production Cost of Rice		
- Production of rice/3 (ton)		2.54
- Production cost/4 (M$/ton)		547

Remarks: /1 = Land and water charges

/2 = Adjustment to clean dry paddy weight

/3 = Yield of paddy x (100% - % of deduction) x Milling recovery rate (65%)

/4 = Production cost of paddy / Production of rice

Table 33 CROP BUDGET FOR WET DIRECT SEEDING

Item		M$/ha
A. Production Cost		1,387
1) Seed	80 kg x M$1.00/kg	80
2) Fertilizer		
- Urea	100 kg x M$0.48/kg	48
- Mixture	200 kg x M$0.76/kg	152
3) Weedicide		
- Paraquat	4 lit x M$7.88/lit	32
- 2, 4-D BE	2.5 kg x M$6.40/kg	16
4) Insecticide		
- Furadan	20 kg x M$3.13/kg	63
5) Rodenticide	1 kg x M$30.00/kg	30
6) Farm machinery		
- Slashing		42
- Rotavating		67
- 1st pudding		75
- 2nd pudding		58
- Harvesting	55 guni x M$6.00/guni	300
- Transportation	55 guni x M$1.30/guni	72
7) Labour	35 man-days x M$9.00	315
8) Others/1		7
B. Gross Income		2,416
- Yield of paddy	4.4 tons	
- % of deduction/2	17%	
- Price	M$66.15/100 kg	
C. Net return (B-A)		1,029
D. Production Cost of Rice		
- Production of rice/3 (ton)		2.37
- Production cost/4 (M$/ton)		585

Remarks: /1 = Land and water charges

/2 = Adjustment to clean dry paddy weight

/3 = Yield of paddy x (100% - % of deduction) x Milling recovery rate (65%)

/4 = Production cost of paddy / Production of rice

Table 34 TYPICAL FARM BUDGET UNDER WITH-PROJECT CONDITION (1986 CONSTANT PRICES)

Farm Size: 1.2 ha

Unit: M$

Item	Present Condition		With Project Condition	
	7 Compart-ments/1	Sekinchan	7 Compart-ments/1	Sekinchan
A. Gross Income	4,600	8,637	7,633	10,522
1) Farm income	3,755	5,940	6,788	7,825
- Main season paddy	1,538	2,078	2,899	2,899
- Off-season paddy	1,425	2,033	3,097	3,097
- Other crops	135	736	135	736
- Other agricultural activities	657	1,093	657	1,093
2) Off-farm income	845	2,697	845	2,697
B. Gross Outgo				
1) Production cost/2	1,589	2,192	2,084	2,385
- Fertilizer	-	147	-	-
- Seed	59	96	192	192
- Weedicide	88	147	152	152
- Insecticide	76	167	151	151
- Hired labour and machinery				
ploughing	263	501	522	522
planting	424	-	-	-
Harvesting	501	607	821	821
Transportation	111	159	179	179
- Cost for other crops/3	67	368	67	368
2) Land rent/4	1,007	1,975	1,007	1,975
3) Land and water charges	17	17	17	17
C. Living Expenses and Net Reserve				
- Owner operator (A)-(B.1)-(B.3)	2,994	6,428	5,532	8,120
- Tenant operator (A)-(B.1)-(B.2)	2,004	4,470	4,542	6,162

Remarks: /1 = Excluding Sekinchan.
/2 = Excluding costs of family labour and subsidized fertilizer.
/3 = 50% of income from other crops.
/4 = Including land and water charges.

Source: (1) Incomes of other crops, agricultural activities and off-farm.
- Laporan Kajian 1984, PBLS.
(2) Farm income and production cost for paddy.
- PBLS Monitoring Survey, PBLS Office.

FIGURES

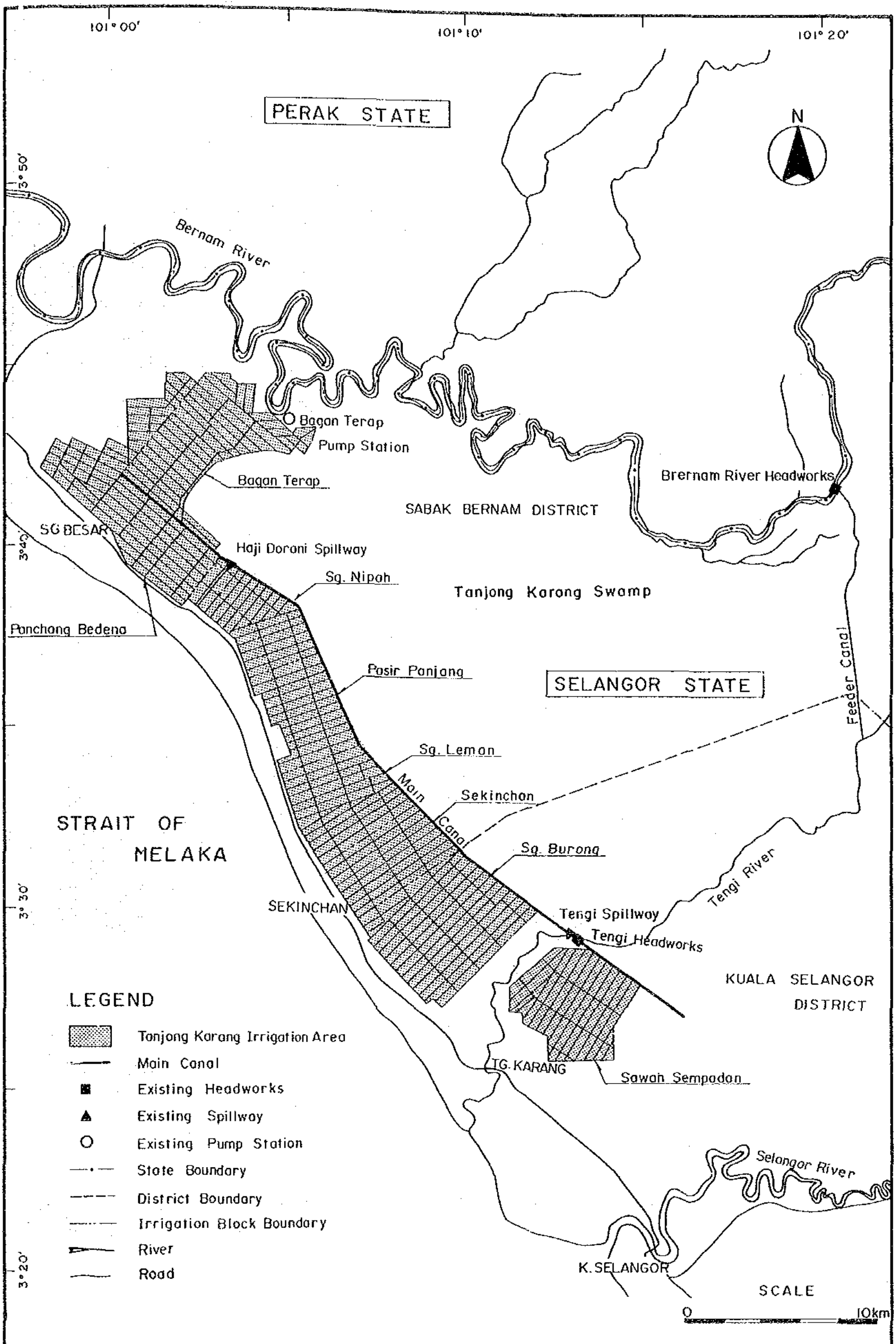

Fig. 1 Location of Project Area

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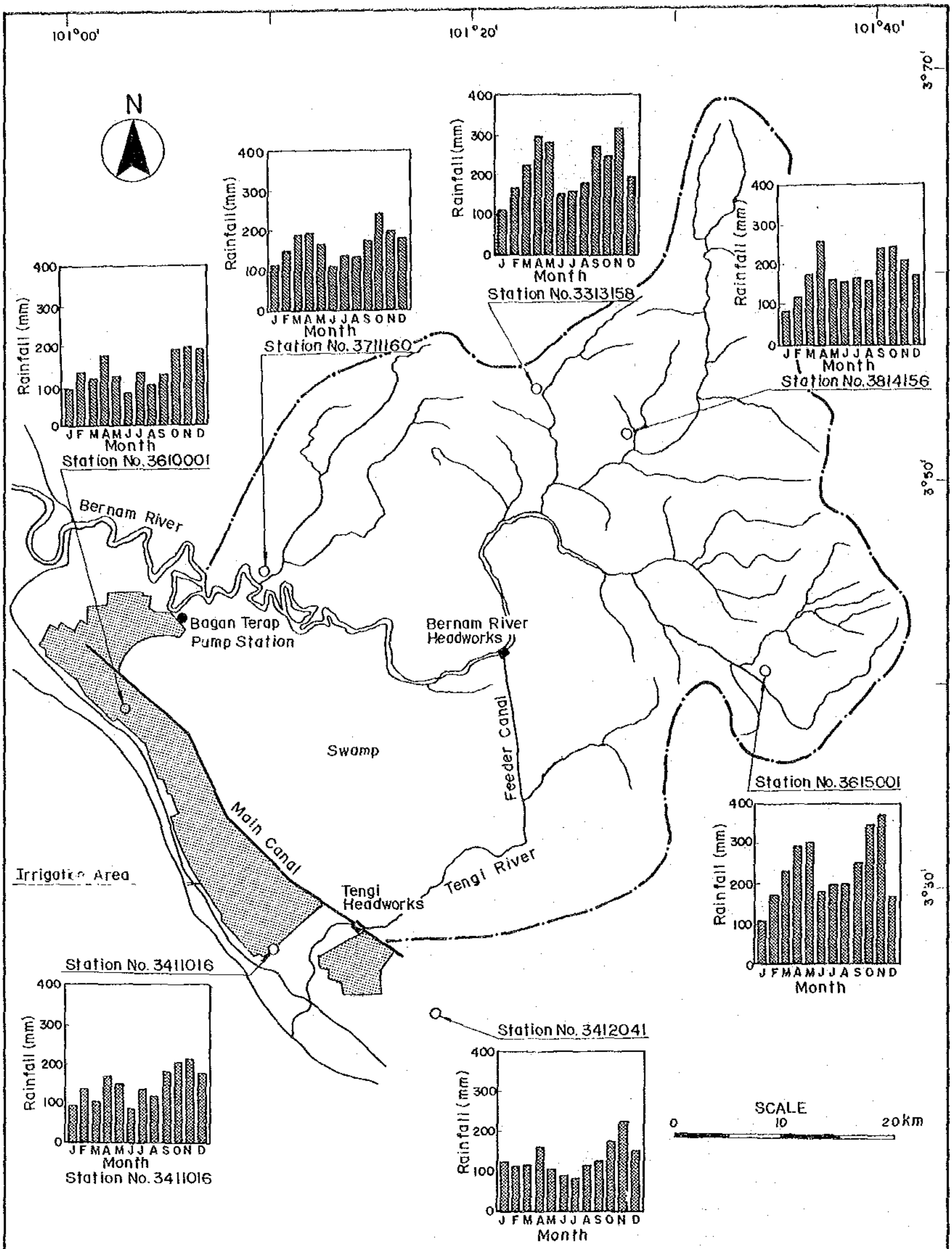
FEASIBILITY STUDY ON THE TANJONG KARANG IRRIGATION DEVELOPMENT AND MANAGEMENT PROJECT

Japan International Cooperation Agency



Note : Data at Station No. 3615001, 3814156 and 3313158 are mean values for recent 9years from 1975 to 1983. Others are mean values for recent 10 years from 1975 to 1984.

Fig. 2 Monthly Distribution of Rainfall

Government of Malaysia
FEASIBILITY STUDY ON THE TANJONG KARANG IRRIGATION DEVELOPMENT AND MANAGEMENT PROJECT
Japan International Cooperation Agency