THE KINGDOM OF THAILAND

ROYAL IRRIGATION DEPARTMENT

MASTER PLAN STUDY
ON
THE WATER MANAGEMENT SYSTEM AND MONITORING PROGRAM
IN
THE CHAO PHRAYA RIVER BASIN

FINAL REPORT

ANNEX-3 WATER MANAGEMENT MODEL PROJECT

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ANNEX-3 WATER MANAGEMENT MODEL PROJECT

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CHAPTER 1 BACKGROUND AND OBJECTIVES

RID has been making efforts to control appropriate gate operation at regulators for suitable water allocation and to propagate effective irrigation water use and execution of rotational irrigation in dry season. But, RID is now confronted with difficulties in irrigation operation and water allocation in the wide Chao Phraya basin.

Water management is barely significant at the time when the interacted activities be performed systematically in each irrigation project. But, the present activities are dependent on the operating staff's experience which should be succeeded and developed.

1.1 Approaches for Improvement of Water Management

Water management is an integrated series of performances of observation, collection, processing of data and diversion and delivery of proper amount of water at required time and places, so as to secure convenience and benefits, expectedly.

Present water management has many features and includes some constraints in the above series of processes. Some of them have to be improved based on future prospect of water management of RID.

There are three approaches for improvement of water management, as shown in Table 1-1.

- Approach from improvement of hardware (Structural measure)
- Approach from improvement of software (Non-structural measure)
- Approach from improvement of humanware (")

Approach from hardware means improvement of facilities including new installation/construction of:

- Monitoring facilities for better understanding of newest situation.
- Communication facilities for smooth transfer of information/data.
- Data management facilities for easily handling of collected data.
- Water use facilities for proper delivery of planned water flow.

Approach from software means improvement of technical aspects for handling the above improved facilities.

Approach from humanware means improvement in quality of activities among management organizations for maintenance and improvement of the above hardware and software.

Those approaches should be well balanced under the elaborated implementation programs.

1.2 Alternative Methods in Water Management Level

Improvement of water management requires time, funding, planning, training and implementation programming to go through the above three approaches. Therefore, four alternative "management level" is proposed for improvement. Level-1 is extensive management at basin level. Level-4 is more precise management up to on-farm level.

Level-1: The way of water management pay more attention to the water flow in river system at basin level than to any other water flow. Water flow at major regulators therefore be well distributed in this management level. Distributed water will then be well allocated by using existing facilities.

Level-2: The way of water management pay more attention to the water flow in main canal including river of Level-1 than to any other water flow. Number of structure site to be managed are more extended. Therefore, this level will increase volume of information/data for management activities than that at Level-1.

Level-3: The way of water management pay more attention to the water flow from river to FTO, including Levels-1 and 2. Accuracy of data/information and quick response will be more required, because of more extended coverage. Better qualities of hard, soft and humanware will also be gradually required.

Level-4: The way of water management covers upt to on-farm level, including from Level-1 to Level-3. More precise management will be involved in activities of water user's group. Distribution of water flow will be well controlled at zone level. Improvement of water use facilities will be more required, in order to secure delivery of proper amount of water to water users.

Introduction of hardware will be planned based on the above four levels of water management. Grade of hardware introduction will be selected in the menu as shown in Table 1-2.

In case of more construction/installation for hardware, higher quality of software technologies, and higher quality of human activities in management organizations are required.

1.3 Propose of Water Management Model Project

In selection of the level, it is necessary for required level to be considered characteristic of project area, capability of management staff and social needs. Implementation in every project area will face financial difficulty.

Quality of software and humanware of operation/maintenance after construction of hardware is also quite important, from viewpoint of future management system in RID.

Therefore, model project is proposed as a pilot area of water management. In this model project, each of the above levels will be practiced and necessary training activities for software and humanware will be also performed.

Improvement of water management system will then be extended based on the outcomes from the model project achievements.

1.4 Objectives

In order to materialize outcomes of the Master Plan Study, model project with the following objectives are proposed:

(1) To implement a project for improvement of water management system as a prototype project on trial basis.

(2) To establish methodologies and criteria for improved water management in conformity with local constraints.

(3) To facilitate dissemination and to develop understandings of water management concepts through demonstration to the concerned.

(4) To transfer and train technologies regarding water management system to staff-in-charge.

(5) To conduct a feasibility study for comprehensive project implementation based on outcomes of the above and to propose project implementation.

CHAPTER 2 MODEL PROJECT AREA

2.1 Basic Conception

- The model project will be equipped with two monitoring functions: one to monitor extensively from key stations in the whole Chao Phraya River basis (say "basin monitor function"), and another to monitor intensively at structures and fields in a specific area (say "local monitor function"). Both functions will integratedly be utilized.

- Basin monitor function will be at RID Head Office, while local monitor function be at a member of project O & M offices. These functions will, along with trial operations, be expanded and reinforced in stepwise way.

- For application of the above two functions, systemization of water management will be promoted in conformity with conception established by the Master Plan Study.

Taking account of the above conception, model project areas are selected as follows (shown in Figure 2-1).

- Water Management Center (RID Head Office)
- Regional 7 office, Chao Phraya Dam and five head regulators
- Regional 8 office, Khok Kathiem project area
- Rangsit Tai project office and project area
- Phasi Charoen project office and project area
- Bang Ban project office and project area

The irrigation/drainage characteristic in the model area are as follows.

2.2 Regional 7 Office, Chao Phraya Dam and five head regulators

The following five head regulators located upstream of the Chao Phraya Dam are having a role to adequately control the diversion water from the Chao Phraya River.

Regulator	Canal/River
Manorom	Chainat-Pasak Canal
Makamthao-Utong	Makamthao-Uthong Canal
Phonlathep	Suphan (Tha Chin) River
Borommathat	Noi River
Maharat	Chainat-Ayutthaya Canal

Water supply to the delta is integratively controlled at the above regulators including Chao Phraya Dam. Regional 7 Office is located near the Chao Phraya Dam and has been playing a very important role in the weekly and occasional instructions for water allocation at the above regulators.

Establishment of systematic gate operation is important for precise water allocation, monitoring the continuous water flow of each regulator.

2.3 Regional 8 Office and Khok Kathiem Project Area

Regional 8 Office has been playing an important role to control gate operation and to distribute irrigation water in east bank of Choa Phraya Delta. But, taking account of the present situation of water distribution, establishment of precise water distribution system along Chainat-Pasak Canal will be required in the near future.

Koke Kathiem project is gravity irrigation area. Irrigation water is supplied from the Chainat-Pasak Canal through regulators of which operation is controlled by Regional 8 Office. And then, water is supplied to the field via lateral, sub-lateral canals and FTO (farm turn-out). The plot-to-plot irrigation method is generally used at on-farm level. In dry season, water supply tends to be given priority to upperstream irrigation area. And, rotational irrigation is applied by year under limited amount of water. On the other hand, some irrigation area along terminal canal suffer from inundation caused by drainage of surplus water from upperstream area, in wet season. Therefore, it is desirable to establish systematic water allocation system along canal. This project area is selected as a trial area for improvement of gravity irrigation system.

2.4 Rangsit Tai Project Office and Area

Rangsit Tai project area is located in the lower east delta, and irrigation water is supplied from Raphiphatana canal which takes water by Rama VI Barrage located in the Pasak River. This project area applies conservation irrigation system to irrigation area, at where irrigation water is stored in the well-developed canal network so as to lift up to the field with portable pumps in dry season. In wet season, floods and excessive rainfall are forced to drain along the green belt in the lower east delta, but total capacity of existing drainage canals, water control regulators and pumping stations could not meet with the drainage requirement. It resulted in inundation damages every year.

This area is attended with urbanization and manufacturing in the Bangkok Metropolitan area. And, land use pattern are changing from paddy field to upland crops.

Under the above conditions, this project area is selected as a trial area for establishment of water management system in crop diversification area.

2.5 Phasi Charoen Project Office and Area

Phasi Charoen project area is located close by the Gulf of Thailand in the lower west delta, under Region 7, and is grouped into conservation irrigation area. Water operation is made in different concept from that of other project areas, in order to prevent inundation in wet season and to control salinity in dry season.

A large number of regulators and drainage pumps along the lower reaches of the Chao Phraya and Suphan Rivers are operated for protection of inundation.

In dry season, those regulators are all kept closed, so as to conserve water as much as possible and to keep water level within the area high for navigation and saline water intrusion from the sea or rivers.

This area's agriculture is being changed to upland crops, fish or prawn pond and orchard from traditional paddy forming, together with urbanization.

Under the above situation, this model area is selected to establish water management system in conservation area with salinity problem and agriculture in urbanization.

2.6 Bang Ban Project Office and Area

Bang Ban project area is located at the junction of Chao Phraya and Pasak rivers. Irrigation water is supplied by pumps located along the river to the canals in project area. Pumps are being operated for supplemental water supply during wet season, monitoring water levels in Chao Phraya river and canals. However, irrigation water could not be sometimes lifted from the river, due to salinity problems by tidal flow. There are twelve pump stations and one station covers one irrigation zone.

Surplus water is drained by head regulators through four drainage canal to Noi and Chao Phraya rivers. In case of heavy flood season, this area has been playing the part of flood retention for protection of inundation in Bangkok Metropolitan area. Farmers grow a floating rice in the area where inundation depth is deep in wet season. Upland crops are almost never planted.

Considering the above conditions, this project area is selected for establishment of irrigation/drainage system by pump operation.

2.7 Water Management Center

Water Management Center is located in RID Head Office, as the central control office of model project.

CHAPTER 3 PROPOSED PROJECT ACTIVITIES

3.1 Outline of Project Activities

In the model project area, each of management level shall be practiced and necessary training shall be also performed. Project activities are practiced based on the following concepts:

3.1.1 Issues Relevant to Water Resources Management

Basin development projects may cause serious natural and social problems and affect the long-term trend of run-off discharge in the basin. Proper countermeasures for conservation/development of water resources, therefore, are considered under the following conditions:

- Chao Phraya basin is divided into 14 sub-basins, taking account of regional boundary in RID and drainage basins. Water resources management is considered on these sub-basin basis.

- Every project related to water resources are reviewed in taking account of amount of water consumption.

- Development project plans are evaluated from viewpoints of effective use in limited water resources in the whole basin.

In order to examine the above problems, the following works are carried out for the time being:

- Collection of data/information on the water resources projects.

- Data compilation of the collected data/information, from viewpoints of water supply/demand, irrigation area and agriculture products.

- Hydrology analysis by the sub-basins and water balance study. (Water balance simulation program is useful for water balance calculation, if necessary).

Annual cropping and water release schedule from both reservoirs are planned based on the amount of reservoir storages at the end of wet season. Data processing way for annual cropping plan is shown in 3.3, as a first approach.

3.1.2 Issues Relevant to Water Distribution

Practices for water distribution are carried out at each model areas, considering irrigation characteristics in processes of observation, collection, processing of data and diversion/delivery of proper amount of water. Water allocation plan of management Level-1 is almost made by management center. The other model project offices practice each processes of management levels. An example of approach is given in 3.4.

3.1.3 Execution of Field Monitoring

Hydrology data such as water level/discharge and water quality are measured at required time and places. Gate calibrations are also made in accordance with type of gate.

3.1.4 Compilation of Data

Manner of data compilation is practiced through actual compilation of daily collected data and results of the above field monitoring. Data is compiled in the introduced computer files and compilation sheet/charts, in connection with the above water distribution plan. Handling of computer system is also practiced at each office.

Criteria for making of irrigation/drainage system diagrams is prepared based on the field monitoring and collected data, through actual practice of water distribution. In the selected model area, system diagrams are made based on the formulated criteria, at the same time.

3.1.5 Development of Software

Computer appli ion programs are developed step by step, so as to assist routine works such as data compilation in the above activities.

3.1.6 Training/Education

Training and education activities for water management personnel and farmer's groups are carried out at each office, which make them recognize the meaning and importance of their works.

The following training items are considered for management staff in project office level:

- Concepts of water management and management activities at each level.
- Operation/maintenance of irrigation/drainage facilities.
- Computer system and programming for data compilation.

And, the following trainings are carried out to water master, zoneman and gate keeper, etc.

- Appraisal methods of irrigation area and field moisture conditions in their coverage area.
- Operation and maintenance of introduced equipment and irrigation/drainage facilities.
- Water operation practice at on-farm level in accordance with growing stage of paddy.
- Precise gate operation based on gate calibration.

Education activities are undertaken to farmer's groups, as follows:

- Proper water allocation in unanimous cooperation.
- Proper maintenance and repair methods of farm turn-outs/inlets and ridges in paddy field, so as to reduce irrigation losses.
- Water management and farming practice by growing stages of paddy.
- Organization of farmers including water user's groups or irrigator's associations.

3.1.7 Public Information Service

Improved management system achieved in the model area is demonstrated and disseminated for understanding of given water use situation in the basin and meaning of effective use of limited water resources to concerned agencies and groups.

Project activities are summarized in Table 3-1.

3.2 Project Activities of each Model Project

3.2.1 Water Management Center

(1) Water resources management
- Evaluation on development/conservation of water resources.
- Coordination with related agencies.
- Recommendation of new water resources development.
- Recommendation of improved water management system project.
- Countermeasures for drought/flood.
- Examination on annual cropping plan.

(2) Practice for water distribution
- Annual water distribution plan to project area.
- Collection of monitored data by improved system.
- Water allocation plan to major regulators.
- Release plan from reservoirs.

- Request to EGAT and instruction to major regulators.
- Monitoring of water flow.
- Review of water allocation plan and actual operation.
- Modification of water allocation planning methods.

(3) Execution of field monitoring
- Water level/discharge, water qualities.
- Groundwater level.
- Gate calibration.

(4) Practice of data compilation
- Field monitoring data.
- Past records of intake water, irrigation area, reservoir release, etc.
- Daily collected data.
- Irrigation/drainage system diagrams.

(5) Development of software
- Design of data compilation sheet/chart.
- Review of past patterns of intake water, runoff discharge, etc.
- Development of computer program for data compilation and water distribution plan.

(6) Training/education to RID's staff and water user's groups
- Basic concepts of water management.
- Framework of water management activities.
- Operation/maintenance of introduced equipment and facilities
  - ° Telemeter, display panel.
  - ° Hydrology observation devices.
- Practice of water management at basin level.
- Practice of water management at main canal level.
- Practice of water management at FTO level.
- Practice of water management at on-farm level.
- Computer programming.
- Crop diversification and water use.

(7) Public information service
- Water use position in the basin.
- Demonstration and dissemination to concerned agencies and groups.

3.2.2 Regional 7 Office

(1) Practice for water distribution
- Water allocation plan to project area.
- Monitoring of water flow.
- Review of water allocation plan and actual operation.
- Modification of water allocation methods.

(2) Practice of gate operation
- Monitoring water level/discharge by telemeter.
- Monitoring intake water by display panel.

(3) Execution of field monitoring
- Water level/discharge.
- Groundwater level.
- Gate calibration.

(4) Practice of data compilation
- Field monitoring data.
- Daily collected data.
- Irrigation/drainage system diagram

(5) Development of software
- Review of water use pattern by project area.
- Computer program for data compilation and water distribution plan.

(6) Preparation of guideline/criteria
- Making gate calibration in accordance with type of gate.
- Operation/maintenance of gate and introduced equipment and devices.

(7) Training/education to RID's staff and water user's groups

- Framework of water management activities.
- Practice of gate operation.
- Practice of water management at main canal level.
- Practice of water management at FTO level.
- Practice of water management at on-farm level.
- Appraisal methods of field conditions and irrigation area.
- Computer system and programming.

(8) Public information service

- Water use position in Region area.
- Demonstration and dissemination to water user's groups.

3.2.3 Regional 8 Office

(1) Practice for water distribution

- Calculation of irrigation water demand.
- Water allocation plan to project area.
- Monitoring of water flow.
- Review of water allocation plan and actual operation.
- Modification of water allocation methods.

(2) Execution of field monitoring

- Water level/discharge, groundwater level
- Gate calibration.

(3) Practice of data compilation

- Filed monitoring data.
- Daily collected data.
- Irrigation/drainage system diagram.

(4) Study and investigation

- Calculation methods of irrigation water demand, considering physical characteristic in project area.
- Study and investigation for water balance in a selected area.

- Required organization for supervision and patrolling of canal and field.
- Countermeasure for illegal diversion.
- Farming practice, crop production cost, profitability.

(5) Development of software
- Review of past water use pattern.
- Computer program for data compilation and water distribution plan.

(6) Preparation of guideline/criteria
- Calculation methods of irrigation water demand.
- Appraisal methods of irrigation area, field condition.
- Operation/maintenance of introduced equipment and devices.
- Check of existing canal and structure capacity.

(7) Training/education to RID's staff and water user's groups
- Water use situation in Region area.
- Framework of water management activities.
- Practice of water management at main canal level.
- Practice of water management at FTO level.
- Practice of water management at on-farm level.
- Appraisal methods of irrigation area, field condition.
- Operation/maintenance of canal, turn-out and field.
- Computer system and programming.
- Importance and meaning of unanimous water use.

(8) Public information services
- Water use position in Region area.
- Demonstration and dissemination of management activities.

3.2.4 Rangsit Tai Project

(1) Practice for water distribution
- Calculation of irrigation water demand.
- Water allocation plan along canal system.
- Monitoring of actual water flow and field condition.

- Review of water allocation plan and gate/check operation.
- Modification of water allocation plan.

(2) Execution of field monitoring
- Water level/discharge, groundwater level, water quality.
- Gate calibration.
- Irrigation/drainage system diagram.

(3) Practice of data compilation
- Results of field monitoring.
- Daily collected data.

(4) Development of software
- Review of past water use pattern.
- Computer program for data compilation and demand calculation.

(5) Study and investigation
- Consumptive use of upland crop.
- Soil moisture and growing stage of upland crop.
- Crop production cost and profitability.

(6) Training/education to RID's staff and water user's groups
- Practice of water management at on-farm level.
- Operation/maintenance of farm turn-out, gate/check and field.
- Farming practice of upland crop.
- Appraisal methods of irrigation area and field water conditions.
- Data compilation of collected data by computer.

3.2.5 Phasi Charoen Project

(1) Practice of gate operation
- Monitoring of water level in creeks and river.
- Monitoring of water quality.

(2) Execution of field monitoring
- Water level/discharge, groundwater level
- Water quality
- Land use and networks of creeks.

(3) Practice of data compilation
- Results of field monitoring
- Daily collected data.

(4) Development of software
- Calculation of irrigation water demand in conservation area.
- Computer program for data compilation.

(5) Study and investigation
- Storage capacity of creeks.
- Amount of water supply to fish or prawn pond.
- Consumptive use of upland crop, orchard and other planted crops.
- Measures for water quality management.
- Effective use of storaged water in creeks.
- Review of design water level of creeks.

(6) Preparation of guideline
- Rehabilitation of creeks.

(7) Training/education to RID's staff and water user's groups
- Practice of gate operation.
- Water quality and crop.
- Data compilation of collected data by computer.

3.2.6 Bang Ban Project

(1) Practice of water distribution
- Water allocation plan in the project area.
- Monitoring of water level/flow.

- Review of water allocation plan and actual operation.
- Modification of water allocation plan.

(2) Practice of driving of pump
- Monitoring of water level in river and canal.
- Monitoring of field condition.
- Practice of proper pump driving.

(3) Execution of field monitoring
- Water level/discharge, groundwater level, and water quality.
- Gate calibration, capacity of pump and canal.

(4) Practice of data compilation
- Results of field monitoring.
- Daily collected data.
- Irrigation/drainage system diagram.

(5) Preparation of guideline/manual
- Operation/maintenance of pump.

(6) Study and investigation
- Drainage system.
- Measures for flood protection.
- Introduction of dry season crop.

(7) Training/education to RID's staff and water user's groups
- Practice of pump irrigation/drainage.
- Operation/maintenance of pump.
- Data compilation of collected data by computer.

3.3 Examination of Annual Cropping Plan

Annual cropping plan is examined based on the cropping plan proposed from each project, of which work flow is shown in Figure 3-1.

As a first approach for planning, the following way is considered (general work flow is shown in Figure 3-2).

3.3.1 Review of Past Records

Past data/information, such as irrigation area, crop, inflow/outflow at reservoirs, intake and flood/drought damage, etc., will be reviewed for cropping plan in this year.

Those data will have to be compiled on some forms prepared in advance, for the present. Data base system by computer will become useful finally for compilation of various data.

3.3.2 Planning of Cropping Area

Cropping area and schedule will be planned based on the proposed cropping plan and review of past records.

3.3.3 Reservoir Operation

Variation of reservoir storage will be simulated on a monthly basis, based on the planned cropping area and schedule.

Simulation study will be carried out in the following three cases:

1) Drought year
2) Ordinary year
3) Sufficient year

Past hydrology data in any year selected is used for simulation purpose.

Simulation period will be considered as follows:

- Case that simulation period is only dry season

  Simulation will be easily done by using inflow and sideflow data in selected year, considering delta to be one irrigation unit.

  After development of computer simulation program, the following case will be considered.

- Case that simulation period is a whole year

  Simulation will be done by using computer simulation model. In model, delta will be divided into some groups of irrigation area.

  Computer program has been prepared by study team, as a trial case.

3.3.4 Preparation of Annual Water Operation Schedule by Project

After decision of annual cropping area and schedule, tabulation of water operation schedule will be prepared by project area.

In this table, irrigation water requirement, cropping area, crops, and planting schedule, etc. will be scheduled by project area, in advance. This schedule will be prepared on a monthly basis in a whole year.

Weekly distribution management will be executed based on this schedule.

3.4 Data Processing for Water Distribution Management

3.4.1 Main Items of Data Processing

Water distribution will be planned after collecting of observed data through communication system. Main items for daily routine works of water distribution plan are considered as follows:

- Calculation of irrigation water requirement on a regulator basis.
- Forecasting of side flows from uncontrolled basins.
- Water allocation plan to regulators based on amount of available water.
- Simulation of reservoir operation based on forecasted inflow and outflow.

3.4.2 Outlines of Processing Methods

(1) Calculation of irrigation water requirement

Water demand is calculated theoretically by the following general equation:

$$\text{Water Demand} = \frac{\text{Consumptive Use of Crop} - \text{Effective Rainfall}}{\text{Irrigation Efficiency}}$$

Irrigation water is supplied from various sources as follows:

- Diverted water by regulators
- Return flow from upper area through drainage facilities.
- Groundwater.

Under the present situations such as seasonal variation of water use, hydraulic behavior and observation network, it will be difficult to estimate separatel, .he amount of each source.

Diverted water by regulator will be able to controlled by gate operation. Return flow will be also controlled to some extent. For that purpose, however, precise monitoring system will be required since water level/discharge has to be observed continuously in extended area. From viewpoint of daily routine works of water distribution, it is required to establish planning method involved in various water sources.

Taking account of actual water distribution by project area, past intake records of diverted water reflects the physical conditions of water use in the irrigation area. Calculation methods of irrigation water requirement, therefore, be considered as follows.

As a first step, diversion water requirement is estimated based on past record of intake water, which implies the present water use condition. And, water distribution is practiced based on estimated water requirement.

As a second step, actual intake water is observed. Observed one is compared with the past record and that of the other areas. Observed data of groundwater or waterflow may be used in this work, if necessary.

After the above procedures, diversion requirement will be adjusted for next water water allocation plan. And, inherent requirement will be estimated by project area, through this approach.

(2) Forecasting of Sideflow

Sideflow from uncontrolled river basin are available for irrigation water supply system. Following sideflows have to be forecasted for water allocation plan.

- Forecasting for next week

  Forecasting for water allocation to major regulators based on the available water.

- Forecasting for next + 1 week

  Forecasting for decision of release amount from reservoirs based on the water requirement by project area.

Forecasting of sideflow will be made in/at the following basins and locations:

- Sideflow above Nakhon Sawan
- Sideflow between Nakhon Sawan and Chainat Dam
- Sideflow at Pasak river
- Sideflow at Chainat-Pasak canal.

Forecasting methods are considered as follows:

(a) Forecasting based on past experience, monitoring the representative observation stations in the basin.

(b) Forecasting based on some analysis, using some charts made by past record and monitoring the representative observation stations in the basin.

(c) Forecasting based on continuous monitoring, using observed data in many stations and past trend of run-off.

(d) Forecasting based on computation, using both computer program model prepared in advance and observed data as a input data.

Sideflows have to be forecasted by taking account of various conditions in uncontrolled basins, such as consumptive use of crops, actual intake at regulator/pump stations and lag time of runoff. But many observation data will be necessitated, provided that forecasted sideflow consider every condition.

Forecasting, therefore, is done by simplified method based on past record involved in the above conditions until establishment of monitoring/data processing system such as above (c) or (d).

Computer program models will be developed, in connection with analysis of past runoff data and establishment of monitoring network system.

(3) Water Allocation Plan

In water allocation plan, many factors such as canal loss, direct intake water and lag time by travel of water flow, have to be considered. But, water allocation plan involved in each factor will be in difficulty, because these factors are dependent on seasonal hydraulic situation and actual gate operation.

Flexible method will be required, to meet with actual requirement condition.

As a first approach, actual water flow at regulator points is observed continuously. Second step is to calculate water balance between selected two regulators in same irrigation system, and to question major discrepancies including in water balance study. Results show amount of canal loss and lag time. After that, computer program model is prepared based on the above condition.

(4) Reservoir Operation

Reservoir operation is simulated based on the forecasted inflow and outflow by water requirement.

(5) Study and Investigation

The following investigation works in selected part of model area are conducted so as to establish for water demand calculation, if necessary.

- Measurement of crop consumptive use by tank, lysimeter and other methods, and relation between soil characteristic and percolation.

- Relation among growing stage of paddy, submergence, height of ridges retention of rainfall in field.

- Estimation of conveyance loss in canal by measurement of water flow at any point.

- Estimation of effective rainfall by measurement of field moisture condition, rainfall intensity and amount of inflow/outflow.

- Estimation of diversion water requirement by measurement of inflow/outflow, and water level in creeks.

- Estimation of water supply from groundwater by measurement of groundwater level and inflow/outflow at inlet/outlet.

In order to carry out the above investigations, automatic water level gauge, water flow meter and rainfall gauge will be introduced in the area. Parshall flume, notch or small weir will be installed to measure water flow, if necessary.

3.4.3 Water Distribution Work

Water operation has to be managed in four modes as follows:

Season	Mode	State
Dry	Normal	Water allocation for dry crops
	Emergency	River constraint, Drought countermeasures
Wet	Normal	Water control for wet crops,
	Emergency	Flood countermeasures

An example of data processing work for weekly water distribution is shown in Figures 3-3 to 3-5. Description of each work presented in Figures are as follows:

1-1. Forecasting of sideflow (next + 1 week)

(1) Sideflow above Nakhon Sawan

Sideflow appears as water loss along river including consumptive use of crops in the basins during dry season.

Sideflow will be forecasted by using the observed flow at Nakhon Sawan (C.2) and actual releases from Bhumibol and Sirikit reservoirs.

Available sideflow = Observed flow (C.2) in this week
at C.2 in this week - Releases in last week

Available sideflow in next + 1 week will be forecasted based on the available sideflow in this week, trend of water flow up to this week and past runoff patterns.

(2) Sideflow along Pasak river

Amount of sideflow will be examined based on continuous observed data at station S.9 for the present.

1-2. Calculation of reservoir releases

Amount of releases from reservoirs will be calculated as follows:

(1) Irrigation water requirement by project area in next + 1 week will be calculated from annual operation schedule and be summed up requirement.

(2) Available water will be forecasted in the above 1-1.

(3) Reservoir requirement will be calculated from available water, irrigation water requirement and other flow constraints.

1-3. Forecasting of available water

(1) Water flow at Nakhon Sawan

Available water at Nakhon Sawan will be forecasted by the following manners:

a) Available water in next week = Observed runoff discharges in river system (such as Y.3A, N.7, P.7 stations) + Sideflow from uncontrolled basin between Nakhon Sawan and each observed stations

b) Available water in next week = Reservoir releases in last week + Sideflow above Nakhon Sawan in next week (referred to 1-1).

(2) Water flow between Nakhon Sawan and Chainat Dam

Available water will be forecasted by observed data up to this week and past patterns. Difference between water flow at Nakhon Sawan (C.2) and that at Chainat Dam will imply canal loss and storage by dam. Water flow at Chainat will be calculated as follows:

Water flow at Chainat = Intake by reservoirs + Release from dam

(3) Water flow at Rama VI

Water flow will be forecasted by observed data at S.9 station.

1-4. Calculation of water allocation to regulators

Water allocation plan will be examined based on the forecasted available water and irrigation water requirements in water operation schedule. Computer program will be used for planning of water flow at major regulators.

2-1. Forecasting of sideflow

Same as the 1-1.

2-2. Calculation of reservoir operation

Reservoir operation will be simulated by using the following data:

- Reservoir requirement based on irrigation water requirement from water operation schedule and other demand.

- Forecasted sideflow.

- Forecasted inflow into reservoirs.

  Forecasting of inflow will be done by using past patterns between inflow and basin rainfall.

2-3. Examination of reduction of reservoir releases

Amount of releases from reservoirs will be reduced in the rule cruves of dams. Reduction rate will be decided by taking account of growing stage of crops, soil moisture conditions and social conditions. Reservoir operation may be calculated for case study on reduction rate, if necessary.

2-4. Forecasting of available water

Same as the 1-3.

2-5. Calculation of water requirement

Water requirement will be estimated based on irrigation water requirement in water operation schedule and other demands.

2-6. Examination of reduction for water allocation

Reduction rate of water allocation will be decided, considering natural conditions such as soil moisture, growing stage of crops and groundwater level and social conditions.

3-1. Forecasting of sideflow

Amount of sideflow in wet season are variable, dependent on basin rainfall. Forecasting is more difficult than in dry season. Following forecasting methods will be considered for the present:

- Basically same methods as that in dry season.
- Forecast by monitoring at as many stations as possible and past patterns between runoff and basin rainfall.

3-2. Modification of water requirement

Irrigation water requirement in water operation schedule will have to be modified in accordance with actual rainfall conditions, because irrigation water requirement has been estimated based on past long-term average rainfall by project area. Supplemental water requirement will be calculated as follows:

Storage depth in field (mm) = Present field storage (mm) + Forecasted rainfall in next and next + 1 week by long-term average rainfall - Consumptive use in next and next + 1 weeks.

Supplemental requirement = Optimum submergence - Storage depth

If available water is sufficient, the above calculation will not be needed.

3-3. Calculation of release from reservoirs

Reservoir requirement will be estimated as follows:

Reservoir requirement = Supplemental requirement + Other demand - Available water (3-1)

3-4. Forecasting of available water

Basically same as the 3-1.

3-5. Modification of water requirement

Supplemental irrigation water requirement will be estimated as follows:

Storage depth in field in next week (mm)	=	Present field storage (mm) + forecasted rainfall in next week by long-term average rainfall - Consumptive use in next week
Supplemental requirement	=	Optimum submergence - Storage depth

3-6. Calculation of water allocation

Water allocation to regulators will be planned based on water requirement. If available water is sufficient for water requirement, surplus water will have to be stored in field/canal as much as possible in order to reduce reservoir requirement in next + 1 week and to prevent inundation in downstream area, forecasting increase and decrease of sideflow.

Possibility of surplus water depth of storage in field will be considered at this water allocation plan.

4-1. Flood forecasting

Flood will be forecasted by monitoring data or computer simulation model.

4-2. Countermeasures of flood control

Proper measures will be planned in accordance with scale of flood and natural and social conditions.

CHAPTER 4 PROPOSED EQUIPMENT AND FACILITIES

For implementation of the above proposed activities, some equipments and facilities shall be furnished.

4.1 Monitoring/communication and data management facilities

- Telemeter equipment

  Water level observation stations with telemeter equipment are installed at major regulators as shown in Figure 4-1. Observed water levels are automatically transmitted to model project office.

- HF/SSB radio equipment

  HF/SSB radio equipment are introduced at water level observation stations in the middle basin as shown in Figure 4-1. Observed data are promptly transferred to Region 7 Office and Water Management Center by voice communication.

- Portable wireless telephone and patrol vehicle

  These are provided for smooth project activities in the model area. An example of communication system is shown in Figure 4-2.

- Hydrology observation devices

  In addition to the present observation stations, rainfall, water level, water discharge, water quality and soil moisture are measured at selected sites in the model area.

- Data management facilities

  Mini-computer and display devices are useful for data processing, arrangement of observed data and training for water management staff. An example of system configuration of data management facilities are shown in Figure 4-3.

4.2 Civil Works

- On-farm facilities

  Improvement of on-farm facilities is subject to those in the selected area for practice/training/demonstration of on-farm activities.

- Gate structures in canal system

  Improvement of gate structures of those required for precise gate operation for practice/training/demonstration purpose. For key structure, electrification and automation may be employed.

- Canal improvement to facilitate operation of structures along the canal.

- Improvement of pump operation system for efficient and economical operation practice.

4.3 Construction of Operation Room

Operation room is constructed for smooth management activities, taking account of the size of introduced equipment and space for required management activities.

Proposed equipment and facilities of each model project are shown in Table 4-1 and Figures 4-4 to 4-8.

CHAPTER 5 IMPLEMENTATION

Implementation of model project is divided into two stages:

(1) Construction of proposed equipments/facilities and civil works, and,

(2) Establishment of improved water management system based on the proposed activities.

5.1 Construction Stage

Construction work of proposed equipments and facilities is implemented in this stage. Considering the work volume of instroduction, installation and construction, construction work is implemented in three phases. In the first phase, water management center is constructed. Construction works in Regional Offices and related areas and sites is carried out in the second phase. The other model areas are in the third phase. (refer to Table 5-1)

Implementation period required in each phase is 1.0 year for preparation of construction including detailed design and is 1.0 year for construction and adjustment of equipments and facilities.

Total construction period is 5.0 years (refer to Figure 5-1).

Construction costs of each phase are 169.6, 203.0 and 227.4 million Baht, respectively, and required total cost is 786 million Baht (refer to Table 5-1).

5.2 Establishment Stage of Improved Water Management

Improved water management system is established, through execution of the proposed management activities. Those activities are practiced by some experts and RID's staff concerned, using the introduced equipments and facilities. And, transfer and training of technologies to staff-in-charge are carried out in this stage. Long and short term qualified experts in each phase are required in different fields. And, each management activities will be carried out by those qualified experts and RID's staff who are recruited from the related divisions in RID or the concerned agencies. (refer to Table 5-2 and Figure 5-2)

It is necessary to set up an executive organization in RID for systematic activities of this stage. The proposed organization is consisted of seven sections under the Director of Water Management Model Projet, as illustrated in Figure 5-3. Proposed activities will be carried out by some sections in which the recruited experts and RID's staff are assigned.

Total implementation period is 5.0 years, and required cost for this stage is 186.0 million Baht (refer to Table 5-1 and Figure 5-1).

Stage(2) may be carried out in parallel with Stage(1), because some of proposed activities may be commenced without new construction of facilities in Stage(1).

5.3 Example of Management Project in Japan

5.3.1. Outline of Irrigation Project in Japan

Irrigation Project has been implemented within the following basic frameworks in Japan.

Agricultural Infrastructure Development

(1) Land Improvement Project

(i) Irrigation Facilities
(ii) Land Consolidation
(iii) Farm Road
(iv) Disaster Prevention of Farm Land
(v) Maintenance of Completed Facilities

(2) Farm Land Reclamation Project

(3) Integrated Rural Development Project

(Note: items (i) and (v) above are related with the Study)

Legal background of the above Project is provided by Land Improvement Law. Bureau of Structural Improvement, Ministry of Agriculture, Forestry and Fisheries (MAFF) is the responsible executing agency of the Project.

The Irrigation Project can be classified into: (1) State-Operated Project, (2) Prefecture-Operated Project, and (3) Organization-Operated Project according to the scale of the Project. The State-Operated Project identical to the Large Scale Project in RID refers to beneficial area of more than 3,000 ha in case of paddy, while terminal commanding area of lateral canal is not less than 500 ha. Invested project cost is shared among State (60%), Prefecture (20%) and Farmers (20%) in principle.

After completion of the Project, irrigation facilities are transferred to and maintained by the Land Improvement Association in most cases, however, State or Prefecture herself undertakes operation and maintenance of the facilities as the case may be.

A concept of the basin-wise water resources management has been recently introduced in major river basins in Japan. There exist identical water management problems between both countries. An example of State-Operated and Prefecture-Managed Irrigation Project is presented in the next section for reference sake to the Model Project.

5.3.2. Example of Operation/Maintenance Project in Japan

(1) Background

Project area is a region with a mild climate and favorable expanse for agriculture, but, development of agriculture had been obstructed for a long time, because of flood inundation and lack of water source for irrigation. In order to overcome the above constraints, irrigation/Drainage Facilities Construction Project was taken up in 1947 under MAFF and the construction project was completed in 1965.

After completion of the project, constructed facilities was transferred to prefectural government. Since then, operation and management of the facilities are being executed by the prefectural government as well as the rural land improvement association.

(2) Operation/Maintenance organization

Irrigation and drainage facilities to be managed is shown in Table 5-3. Organization for operation and maintenance as shown in Figures 5-4 and 5-5 was established.

Operation and maintenance is carried out by Water Management Field Office which is one of branch offices of the prefectural government. And, in many operation and maintenance works, some parts such as management of lateral canal and FTO are entrusted by the prefectural Government to the Land Improvement District Association which was established for the purpose of managing these facilities in the same time that the construction project was taken up. Both organizations are carrying out stable water distribution and management of the facilities under their close supervision. Management system flow is shown in Figure 5-6.

Table 1-1 COUNTERMEASURES FOR WATER MANAGEMENT

Facility	Hardware	Software	Humanware
Monitoring facility	- Hydrology observation gauge Rainfall, Water level/ Discharge, Water quality Soil moisture, etc. - Display panel, Room - Vehicle Motorcycle, Patrol car	- Observation methods of data - Making of gate calibration - Operation/maintenance of new introduced equipments - Handling of display panel - Appraisal methods of field condition	- Stock management Spares, devices recording paper, etc - Regular check of equipment - Repair of facilities - Operation/maintenance cost - Training Handling of equipment Computer programing Operation of water use facilities
Communication facility	- VHF, HF and Rural radio - Private wire telephone - Portable wireless telephone - Operating room	- Operation/maintenance of facilities - Preparation of data file for operator	
Data management facility	- Mini computer system Computer, CRT display Printer, etc. - Facsimile - Cabinet for data storage - Data processing room	- Arrangement of data - Preparation of record file - Storage of collected data - Data processing for water distribution plan - Development of computer program	
Water use facility	- Structure for water control Gate, check, FTO - Canal, Pump - Maintenance road	- Operation of gate - Check of flow capacity Canal, Gate, FTO, etc	

Table 1-2 GRADE OF IMPROVEMENT METHOD (1)

Improvement Items	Option-1	Option-2	Option-3	Option-4
Hydro-observation				
Rainfall	Reserving gauge	Automatic gauge	Gauge with telemeter	Radar rain gauging
Water level (River)	Staff gauge	Automatic gauge	Gauge with radio house	Gauge with telemeter
- ditto - (Main canal)	Staff gauge	Automatic gauge	Gauge with telemeter	
- ditto - (Lateral)	Staff gauge	Automatic gauge	Gauge with telemeter	
Water quality (River)	Test by sampling	Portable meter	Fixed automatic gauge	Gauge with telemeter
- ditto - (Main canal)	Test by sampling	Portable meter	Fixed automatic gauge	Gauge with telemeter
- ditto - (Lateral)	Test by sampling	Portable meter	Fixed automatic gauge	
Submergence in paddy field	Judgement by visual	Measure by manual		
Soil moisture in up-land crop	Judgement by visual	Measure of sample	Fixed automatic gauge	Gauge with telemeter
Ground water	Observation by manual	Automatic gauge	Gauge with telemeter	

Table 1-2 GRADE OF IMPROVEMENT METHOD (2)

Improvement Items	Option-1	Option-2	Option-3	Option-4
Water flow (River)	Portable meter	Automatic gauge	Gauge with telemeter	
- ditto - (Main canal)	Portable meter	Automatic gauge	Gauge with telemeter	
- ditto - (Lateral)	Portable meter	Automatic gauge		
Monitoring method				
Water allocation (Head office)	Monitoring each other by voice	Display panel by manual	Display panel by telemeter	Video projector
Water allocation (Regional off.)	Monitoring each other by voice	Display panel by manual	Display panel by telemeter	Video projector
- ditto - (Project off.)	Monitoring each other by voice	Display panel by manual	Display panel by telemeter	
Condition of crop, irrigation area, water use	Judgement by patrol	Monitoring by area with map and file	Remote sensing	
Operating room (Head office)	Improvement inside off.	New building		
- ditto - (Reginal off.)	Improvement inside room	New building		

Table 1-2 GRADE OF IMPROVEMENT METHOD (3)

Improvement Items	Option-1	Option-2	Option-3	Option-4
Operating room (Project off.)	Improvement inside room	New building		
Vehicle for patrol, campaign, repair	Motor cycle	Patrol car	Campaign car	Car for repairing
Communication method	Mail, Memo by hand	Voice with VHF, HF radio -operator	Voice with telephone -direct talk	Telemeter Facimile
Data compilation (Head office)	File by manual and cabinet	Computer file	Data base	
- ditto - (Reginal off.)	File by manual and cabinet	Computer file		
- ditto - (Project off.)	File by manual and cabinet	Computer file		
Data processing (Head office)	Manual	Calculation by computer	Computer network	
- ditto - (Reginal off)	Manual	Calculation by computer	Computer network	
- ditto - (Project off)	Manual	Calculation by computer	Computer network	
Data dissemination	Mail, Memo by manual	Voice with VHF, HF radio -operator	Voice with telephone -direct talk	Remote control Facimile

Table 3-1 PROJECT ACTIVITIES IN MODEL PROJECT

Activity Items	Main Activities
Issues relevent to water resources management	- Identification of improved water managemet system project - Evaluation on development/conservation of water resouces - Countermeasures for drought/flood
Issues relevant to water distribution	- Collection of monitored data by improved system - Water allocation plan to irrigation area by management office level - Monitoring of water flow situation - Review of water allocation plan and actual operation - Modification of water allocation planning methods
Execution of field monitoring	- Water level/discharge, water quality, Gate calibration
Compilation of data	- Daily collected data and past records, Field monitoring data - Irrigation/drainage system diagrams
Development of software	- Design of data compilation sheet/chart - Review of past patterns of intake water, run-off discharge, etc - Development of computer program for data compilation
Training/Education	- Basic concepts of water management and activities for management - Practice of water management at each management level - Operation/maintenance of introduced equipments and facilities - Computer programing
Public information services	- Demonstration and dissemination to concerned agencies and groups

Table 4-1 REQUIRED FACILITIES/EQUIPMENT (WATER MANAGEMENT CENTER)

Facilities/Equipment	Quantity
1. Monitoring/communication and Data management Facilities	
(1) Radio facilities	
- Observation station with telemeter equipment	-
- Portable wireless telephone	-
(2) Observation devices	-
(3) Patrol/communication vehicle	
- Motorcycle	-
- Patrol car	3 units
(4) Data management facilities	1 sets
Telemetering equipment	
Display panel	
Operator control console	
Typewiter	
Data processing system	
(Data processing unit, I/O units, Software)	
Mini-computer system	
(Computer, CRT display, Printer, Auxiliary storage)	
2. Building for project activities	1,500 m²
Required room	
Communication equipment	
Computer machine, Data processing, Battery	
Maintenance, Spairs, Tools, Material	
Personnel, Meeting, Conference	
Training, Information service	

Table 4-1 REQUIRED FACILITIES/EQUIPMENT (REGIONAL 7 OFFICE)

Facilities/Equipment	Quantity
1. Monitoring/communication and Data management Facilities	
(1) Radio facilities	
- Observation station with telemeter equipment Nakhon Sawan (C.2), Manorom regulator, Makamthao-Uthong regulator, Phonlathep regulator, Maharaj regulator, Borommathat regulator, Chao Phraya Dam	7 stations
- Observation station with radio equipment Ping river (P.12, P.7) Wang river (W.4A), Yom river (W.4A) Nan river (N.7, N.12A, Naresuan Dam) Sakae Krang river	8 stations
- Portable wireless telephone	5 sets
(2) Observation devices	-
(3) Patrol/communication vehicle	
- Motorcycle	5 units
- Patrol car	3 units
(4) Data management facilities Telemetering equipment, Display panel, Operator control console, Typewriter, Mini-computer system (Computer, CRT display, Printer, Aux.storage)	1 sets
2. Building for project activities Required room Communication equipment, Computer machine, Data processing, Battery, Maintenance, Spairs, Tools, Material, Personnel, Meeting, Conference Training, Information service	800 m²

Table 4-1 REQUIRED FACILITIES/EQUIPMENT (REGIONAL 8 OFFICE)

Facilities/Equipment	Quantity
1. Monitoring/communication and Data management Facilities	
(1) Radio facilities	
- Observation station with telemeter equipment Koke Kathiem regulator, Phra Narai regulator RamaVI baragge	3 stations
- Observation station with radio equipment Pasak river (S.9)	1 station
- Portable wireless telephone	15 sets
(2) Observation devices Water level gauge, Water flow meter, Rainfall gauge, Soil moisture gauge	30 sets
(3) Patrol/communication vehicle	
- Motorcycle	15 units
- Patrol car	3 units
(4) Data management facilities Telemetering equipment, Display panel, Operator control console, Typewriter, Mini-computer system (Computer, CRT display, Printer, Aux.storage)	1 sets
2. Building for project activities Required room Communication equipment, Computer machine, Data processing, Battery, Maintenance, Spairs, Tools, Material, Personnel, Meeting, Conference, Training, Information service	800 m²
3. Civil works	
(1) Improvement in Koke Katiem regulator operation Automatic ON-OFF operation by water level Automatic digital recording	1 station
(2) Improvement of canal (18R, 19R)	16 km
- Concrete lining 8 Km	
- Reshaping 8 km	
(3) Improvement of water control structures	44 places
- Po-Ro-Bo (Regulator of box culvert type) 11 pcl	
- FTO 30 pcl	
(4) Improvement of on-farm facilities	20,000 rai

Table 4-1 REQUIRED FACILITIES/EQUIPMENT (RANGSIT TAI)

Facilities/Equipment	Quantity
1. Monitoring/communication and Data management Facilities	
(1) Radio facilities	
- Observation station with telemeter equipment	3 stations
Phra Sri Sao Waphak regulator	
Khlong Rangsit canal	
2E canal regulator	
- Portable wireless telephone	10 sets
(2) Observation devices	30 sets
Water level gauge	
Rainfall gauge	
Water flow meter	
Soil moisture gauge	
(3) Patrol/communication vehicle	
- Motorcycle	10 units
- Patrol car	2 units
(4) Data management facilities	1 sets
Telemetering equipment	
Display panel	
Typewiter	
Mini-computer system	
(Computer, CRT display, Printer, Auxiliary storage)	
2. Building for project activities	300 m²
Required room	
Communication equipment	
Computer machine, Data processing, Battery	
Maintenance, Spairs, Tools, Material	
Meeting, Training	
3. Civil works	
(1) Improvement in regulator operation	5 stations
(Chulalong Kron, Phra Thammaracha, Syhon, 13 Tail)	
Bang Kha Nak)	
Automatic ON-OFF operation by water level	
Automatic digital recording	
(3) Improvement of on-farm facilities	10,000 rai

Table 4-1 REQUIRED FACILITIES/EQUIPMENT (PHASI CHAROEN)

Facilities/Equipment	Quantity
1. Monitoring/communication and Data management Facilities	
(1) Radio facilities	
- Observation station with telemeter equipment	5 stations
Phra Pmimon regulator, Maha Sawat regulator,	
Bang Buathong regulator, Chimphli regulator,	
Memorial Bridge (C.4)	
- Portable wireless telephone	10 sets
(2) Observation devices	30 sets
Water level gauge, Water flow meter,	
Rainfall gauge, Soil moisture gauge	
(3) Patrol/communication vehicle	
- Motorcycle	10 units
- Patrol car	2 units
(4) Data management facilities	1 sets
Telemetering equipment, Typewriter,	
Display panel,	
Mini-computer system	
(Computer, CRT display, Printer, Auxiliary storage)	
2. Building for project activities	300 ㎡
Required room	
Communication equipment	
Computer machine, Data processing, Battery,	
Maintenance, Spairs, Tools, Material,	
Meeting, Training	
3. Civil works	
(1) Improvement in regulator operation	4 stations
(Maha Sawat, Chimpli, Lad Nang Chee, Kra Thum Baen)	
Automatic ON-OFF operation by water level	
Automatic digital recording	
(2) Improvement of canal near at regulators	0.8 km
Dredge canals of the above 4 regulators	
(3) Improvement of on-farm facilities	10,000 rai

Table 4-1 REQUIRED FACILITIES/EQUIPMENT (BANG BAN)

Facilities/Equipment	Quantity
1. Monitoring/communication and Data management Facilities	
(1) Radio facilities	
- Observation station with telemeter equipment	2 stations
Ayutthaya (S.5)	
Ang Thong (C.7A)	
- Portable wireless telephone	10 sets
(2) Observation devices	30 sets
Water level gauge, Water flow meter,	
Rainfall gauge, Soil moisture gauge	
(3) Patrol/communication vehicle	
- Motorcycle	10 units
- Patrol car	2 units
(4) Data management facilities	1 sets
Telemetering equipment, Typewriter,	
- Display panel	
- Mini-computer system	
(Computer, CRT display, Printer, Auxiliary storage)	
2. Building for project activities	300 ㎡
Required room	
Communication equipment, Maitenance, Spairs,	
Computer machine, Data processing, Battery,	
Tools, Material, Meeting, Training	
3. Civil works	
(1) Improvement in pump operation (NO.5, NO.6)	2 stations
Automatic ON-OFF operation by water level	
Automatic digital recording	
(2) Improvement of canal (1R-NO.5, 1L-NO.5)	24 km
- Concrete lining 10 Km	
- Reshaping 14 km	
(3) Improvement of water control structures	43 places
- To-Ro-Bo (Regulator of pipe culvert type) 9 pcl	
- FTO 34 pcl	
(4) Improvement of on-farm facilities	20,000 rai

Table 5-1 COST ESTIMATE OF MODEL PROJECT

(Unit ; Million Baht)

Cost Items \ Phase, Project site	Unit	Project Total		Phase-1		Phase-2				Phase-3					
				W. M. Center		Reginal 7 off.		Regional 8 off.		Rangsit-Tai		Phasi-Charoen		Bang Ban	
		Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
I. Construction Stage															
(1) Monitoring Facilities															
- Telemeter	site	20	52.4	8	21.0	-	-	3	8.0	3	7.8	4	10.8	2	4.8
- HF/SSB radio	〃	9	6.4	8	5.6	-	-	1	0.8	-	-	-	-	-	-
- Hydrology devices	set	120	31.2	-	-	-	-	30	7.8	30	7.8	30	7.8	30	7.8
- Motor cycle/radio	unit	50	5.0	-	-	6	0.6	14	1.4	10	1.0	10	1.0	10	1.0
- Patrol car	〃	15	9.0	3	1.8	3	1.8	3	1.8	2	1.2	2	1.2	2	1.2
Sub-total			(104.0)		(28.4)		(2.4)		(19.8)		(17.8)		(20.8)		(14.8)
(2) Data management Facilities	set	6	132.0	1	58.6	1	22.4	1	22.4	1	11.2	1	11.2	1	11.2
Sub-total (1 to 2)			(236.0)		(82.0)		(24.8)		(42.2)		(29.0)		(32.0)		(26.0)
(3) Building	site	6	160.0	1	60.0	1	32.0	1	32.0	1	12.0	1	12.0	1	12.0
(4) Civil works	site	4	105.2	-	-	-	-	1	38.2	1	12.6	1	11.2	1	43.2
Sub-total (1 to 4)			(501.2)		(142.0)		(56.8)		(112.4)		(53.6)		(55.2)		(81.2)
(5) Engineering services	set	3	98.8	1	27.6	1	11.4	1	22.4	1	10.6	1	10.8	1	16.0
Sub-total (1 to 5)			(600.0)		(169.6)		(68.2)		(134.8)		(64.2)		(66.0)		(97.2)
Total			(600.0)		(169.6)		(203.0)				(227.4)				
II. Establishment Stage	set	3	186.0		60.0		63.0				63.0				
Grand total (I to II)			(786.0)		(229.6)		(266.0)				(290.4)				

Table 5-2 PROJECT ACTIVITIES BY MODEL PROJECT AND EXPERT (1)

Project Activities	Model Project Area						Long-term Expert						
	①	②	③	④	⑤	⑥	A	B	C	D	E	F	G
1. Management of Water Resources Planning													
- General coordination of project activities	○						○						
- Planning/evaluation on water resources	○						○	△					
- Countermeasures for drought/flood	○	○	○				○	△			△	△	
- Examination on annual cropping plan	○						○	△				△	
2. Practice of Water Distribution													
- Water allocation plan to irrigation area	○	○	○	○	○	○	△	○					
- Release plan from reservoirs	○						△	○					
- Monitoring of water level/flow	○	○	○	○	○	○		○	△				
- Review of water allocation plan and actual operation	○	○	○	○	○	○		○	△			△	
- Modification of water allocation planning	○	○	○	○	○	○		○	△			△	
3. Practice of Gate Operation													
- Monitoring of water level by telemeter	○	○	○	○	○	○			○	△			
- Monitoring of water level/quality by manual			○	○	○	○			○			△	
- Monitoring of water flow/field condition			○	○	○	○		△	○			△	
- Monitoring of water flow by display panel	○	○	○	○	○	○			△	○			
- Practice of proper gate operation		○							○		△		
- Practice of proper pump operation						○			○		△		
4. Execution of Field Monitoring													
- Water level/discharge, gate calibration Ground water level		○	○	○	○	○			○		△		

Note ① ; Water management center. ② ; Reginal 7 office, Chao Phraya Dam and Five head regulators.
③ ; Reginal 8 office, Koke Kathiem project area. ④ ; Rangsit Tai project.
⑤ ; Phasi Charoen project. ⑥ ; Bang Ban project.
A ; Team leader (Water resources planning). B ; Irrigation eng.(Water operation).
C ; Hydraulic eng.(Field monitoring). D ; System eng.(Data management). E ; Design eng.
(Irrigation facility). F ; Agronomist(On-farm management). G ; Coordinator(Training program).
○ ; Main-assignment, △ ; Sub-assignment.
Short-term experts are also required in accordance with each activity, if necessary.

Table 5-2 PROJECT ACTIVITIES BY MODEL PROJECT AND EXPERT (2)

Project Activities	Model Project Area						Long-Term Expert						
	①	②	③	④	⑤	⑥	A	B	C	D	E	F	G
4. Excution of Field Monitoring													
- Water quality				○	○	○		△	○				
- Irrigation/drainage facilities/functions		○	○	○	○	○		△	△		○		
5. Practice of Data Compilation													
- Filing of field monitoring and daily collected data	○	○	○	○	○	○		△	△	○			
- Past records of intake water, irrigation area, reservoir release, etc	○								△	○			
- Irrigation/drainage system diagrams		○	○	○	○	○		△			○	△	
6. Practice of Software Development													
- Design of data compilation sheet/chart	○	○	○						△	○			
- Review of hydrological patterns	○	○							○	△			
- Review of water use pattern	○	○	○	○	○	○		○	△	△			
- Computer program for data compilation and water allocation planning	○	○	○					△	△	○			
7. Investigation and Research													
- Proper calculation methods of water allocation	○	○	○					○	△	△			
- Countermeasure for illegal diversion	○		○					△				○	
- Required organization for supervision and patrolling of canal and field			○	○	○			△				○	
- Farming practice for planted crop			○	○	○	○		△				○	
- Crop production cost and profitability			○	○	○	○		△				○	
- Cosumptive use of upland crop				○	○			△				○	

Note ① ; Water management center, ② ; Reginal 7 office, Chao Phraya Dam and Five head regulators.
③ ; Reginal 8 office, Koke Kathiem project area. ④ ; Rangsit Tai project.
⑤ ; Phasi Charoen project. ⑥ ; Bang Ban project.
A ; Team leader (Water resources planning), B ; Irrigation eng.(Water operation),
C ; Hydraulic eng.(Field monitoring), D ; System eng.(Data management), E ; Design eng.
(Irrigation facility), F ; Agronomist(On-farm management), G ; Coordinator(Training program).
○ ; Main-assignment, △ ; Sub-assignment.
Short-term experts are also required in accordance with each activity, if necessary.

Table 5-2 PROJECT ACTIVITIES BY MODEL PROJECT AND EXPERT (3)

Project Activities	Model Project Area						Long-term Expert						
	①	②	③	④	⑤	⑥	A	B	C	D	E	F	G
7. Investigation and Research													
- Soil moisture and growing stage			○	○	○			△				○	
- Storage capacity of creeks and effective use of storaged water in creeks					○			○			△	△	
- Amount of water supply to fish pond					○			△				○	
- Measures for water quality management					○			○			△	△	
- Measures for flood protection						○		△	△		○	△	
8. Preparation of Guideline/Criteria													
- Making of gate calibration		○							△		○		
- Operation/maintenance of introduced equipment and device	○	○							△	△	○		
- Calculation methods of water allocation	○	○	○					○		△			
- Appraisal methods of field conditions	○		○	○	○			△	△			○	
- Rehabilitation of creeks					○			△	△		○	△	
- Repair/maintenance methods of irrigation facilities		○				○		△			○		
9. Execution of Training/Education													
- Basic concepts of water management	○						○						○
- Framework of management activities	○						○						○
- Operation/maintenance of facilities	○	○								△	○		○
- Water management at basin level	○						○						○
- Water management at main canal level		○	○					○			△		○
- Water management at FTO level		○	○					○			△		○

Note ① ; Water management center. ② ; Reginal 7 office, Chao Phraya Dam and Five head regulators.
③ ; Reginal 8 office, Koke Kathiem project area. ④ ; Rangsit Tai project.
⑤ ; Phasi Charoen project. ⑥ ; Bang Ban project.
A ; Team leader (Water resources planning). B ; Irrigation eng. (Water operation).
C ; Hydraulic eng. (Field monitoring). D ; System eng. (Data management). E ; Design eng. (Irrigation facility). F ; Agronomist (On-farm management). G ; Coordinator (Training program).
○ ; Main-assignment, △ ; Sub-assignment.
Short-term experts are also required in accordance with each activity, if necessary.

Table 5-2 PROJECT ACTIVITIES BY MODEL PROJECT AND EXPERT (4)

Project Activities	Model Project Area						Long-term Expert						
	①	②	③	④	⑤	⑥	A	B	C	D	E	F	G
9. Execution of Training/Education													
- Water management at on-farm level		○	○	○	○	○		△			△	○	○
- Computer system and programming	○	○	○							○			○
- Crop diversification and water use	○			○				△				○	○
- Appraisal methods of field conditions			○	○	○	○		△				○	○
- Farming practice and water management				○	○			△			△	○	○
- Importance and meaning of unanimous water use		○	○				△					○	○
- Data compilation by computer system	○	○	○						△	○			○
- Repair and maintenance of irrigation and on-farm facilities			○	○				△			○		○
10. Public Information Services													
- Water use position in the basin	○						○						○
- Water use position in the region area	○	○	○				○						○
- Demonstration and dissemination to concerned agencies	○						○						○
- Demonstration to water user's groups	○	○	○	○	○	○	○	△				△	○
- Demonstration and dissemination of management activities	○	○	○	○	○	○	○	△	△	△	△	△	○

Note ① ; Water management center. ② ; Reginal 7 office, Chao Phraya Dam and Five head regulators.
③ ; Reginal 8 office, Koke Kathiem project area. ④ ; Rangsit Tai project.
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A ; Team leader (Water resources planning). B ; Irrigation eng.(Water operation).
C ; Hydraulic eng.(Field monitoring). D ; System eng.(Data management). E ; Design eng.
(Irrigation facility). F ; Agronomist(On-farm management). G ; Coordinator(Training program).
○ ; Main-assignment, △ ; Sub-assignment.
Short-term experts are also required in accordance with each activity, if necessary.

Table 5-3 IRRIGATION/DRAINAGE FACILITIES TO BE MANAGED

(Example in Japan)

1. Irrigation area

	Paddy	Upland	Total
- Irrigation area (ha)	13,500	6,400	19,900
- Annual rainfall	1,500 - 1,600 mm		
- Unit water requirement	Av. 9.1 mm/day		
- Irrigation period	March to September (paddy)		

2. Irrigation facilities

- Water gate	3.0(W)×4.0(H)×2 units	(Roller gate)
	3.0(W)×3.0(H)×2 units	(〃)
- No.1 Pump station	1,200 mm × 5 units	
- No.2 Pump station	1,200 mm × 4 units	
- No.3 Pump station	300 mm × 2 units,	400 mm × 1 units
- Weir	8.0(W)×2.5(H)×4 units	(Roller gate)
- Main Canal	Feeder canal	3,200 m
	River	18.900 m
	Open canal	25,000 m
	Tunnel	21,900 m
	Siphon	4,500 m
	Aqueduct	300 m
	(Total)	(73,800 m)
- Lateral Canal	24 canals	185,300 m
- Main Turn-out	89 sites	

2. Drainage facilities

- Water gate	Same as the irrigation facility
- No.1 Pump station	1,500 mm × 2 units, 1,200 mm× 2 units
- No.2 Pump station	600 mm × 1 units
- Drainage canal	4,000 m

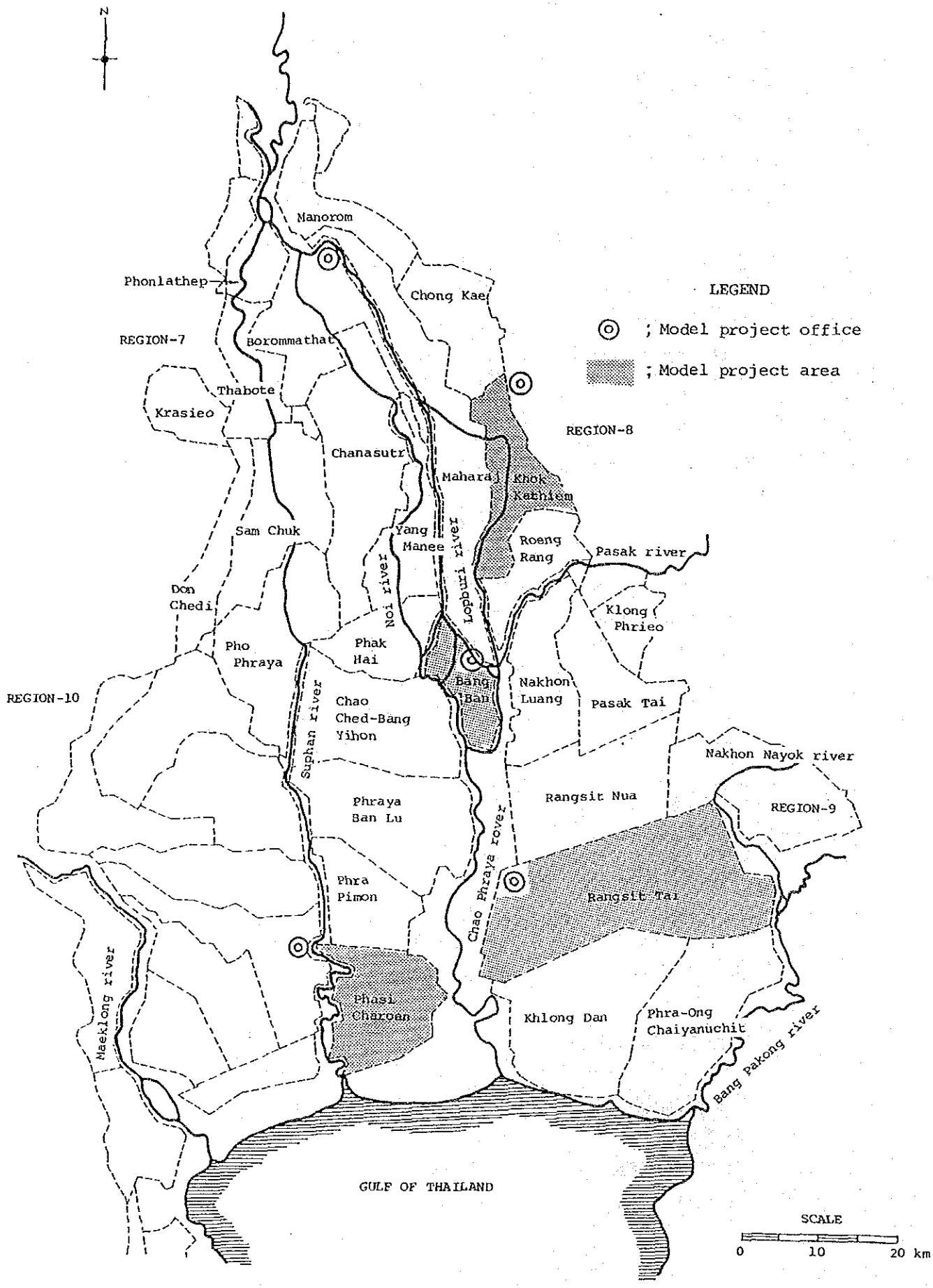


Figure 2-1 LOCATION OF MODEL PROJECT AREA

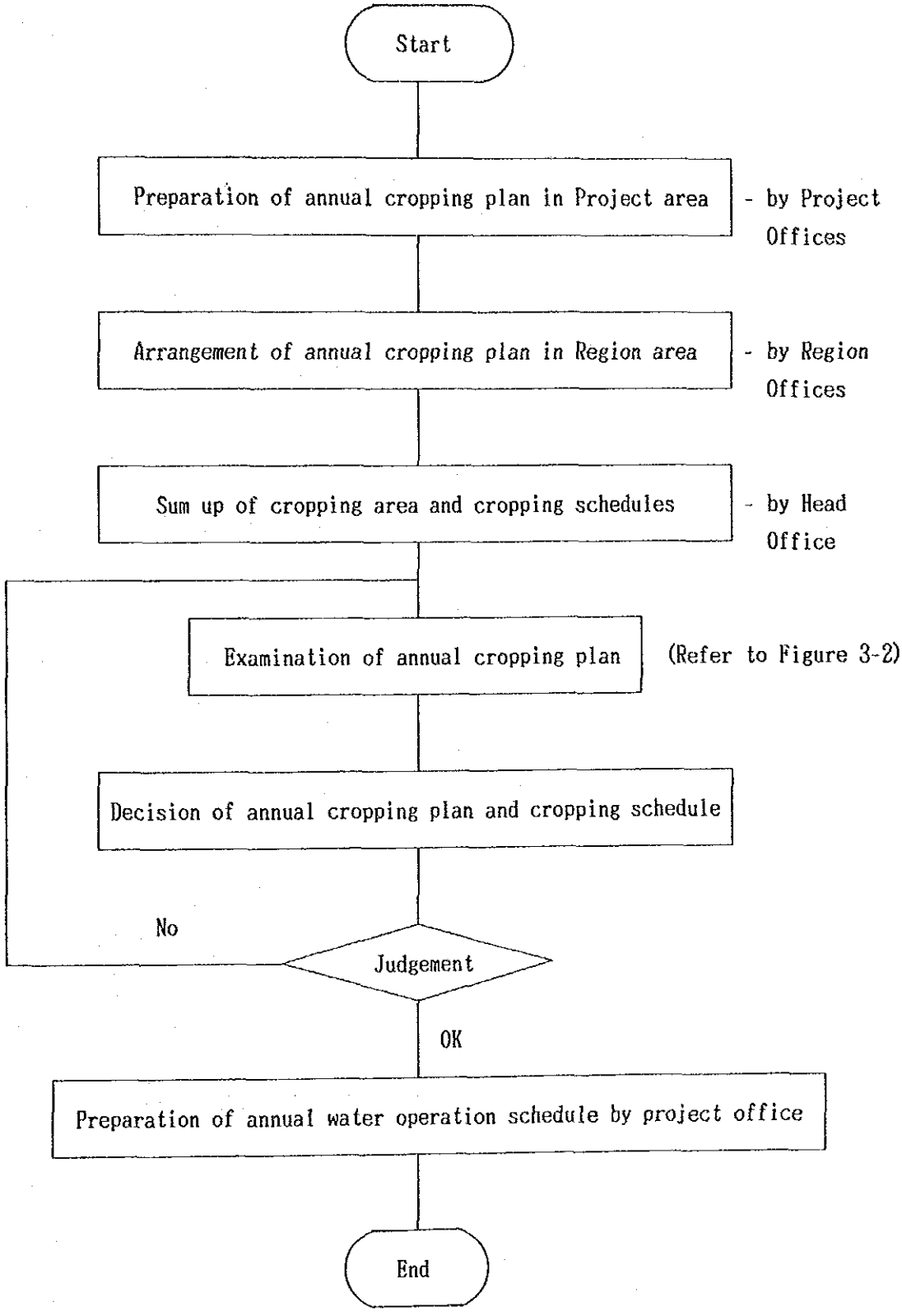


Figure 3-1 DATA PROCESSING FOR ANNUAL CROPPING PLAN

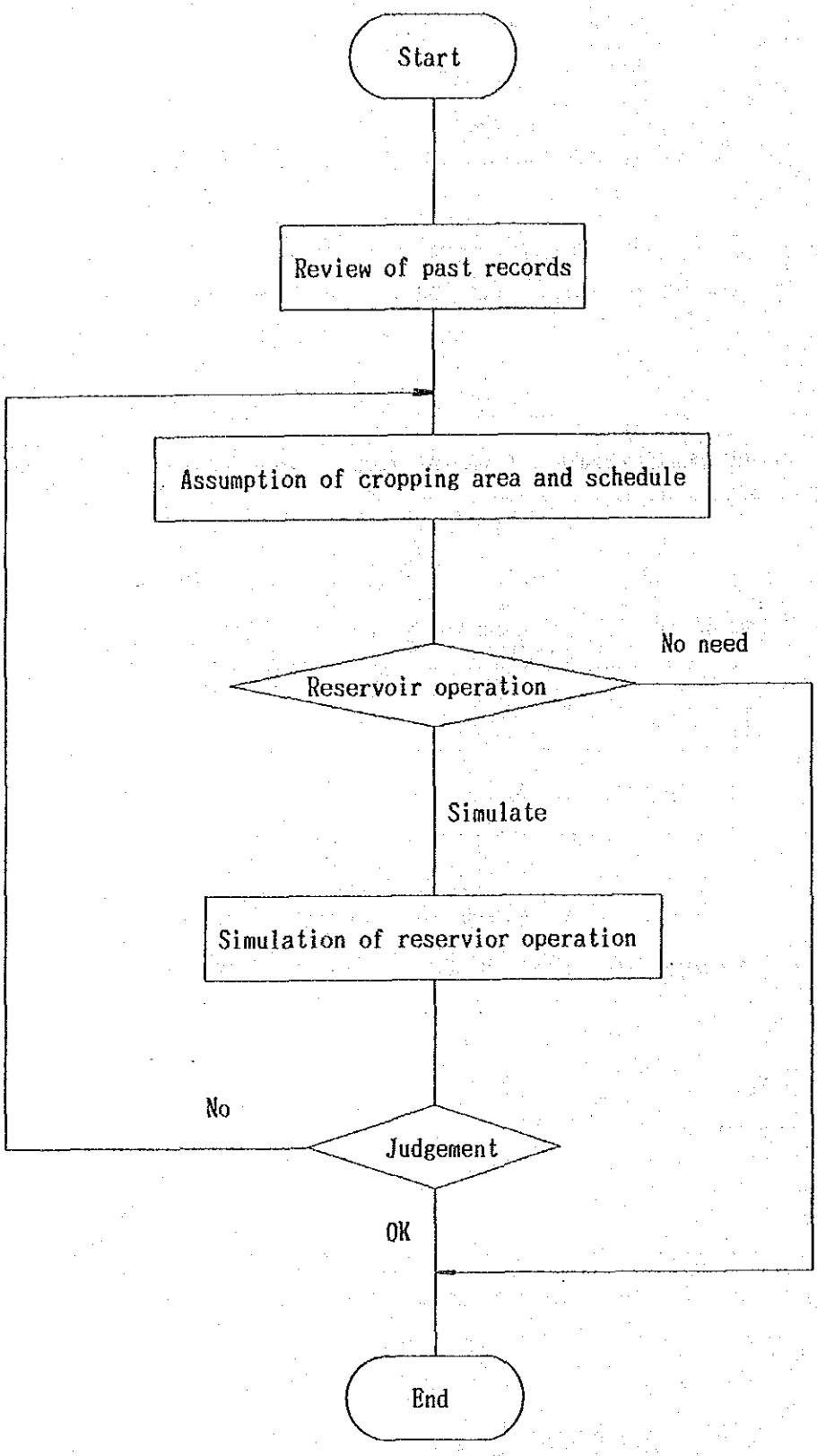


Figure 3-2 EXAMINATION OF ANNUAL CROPPING PLAN

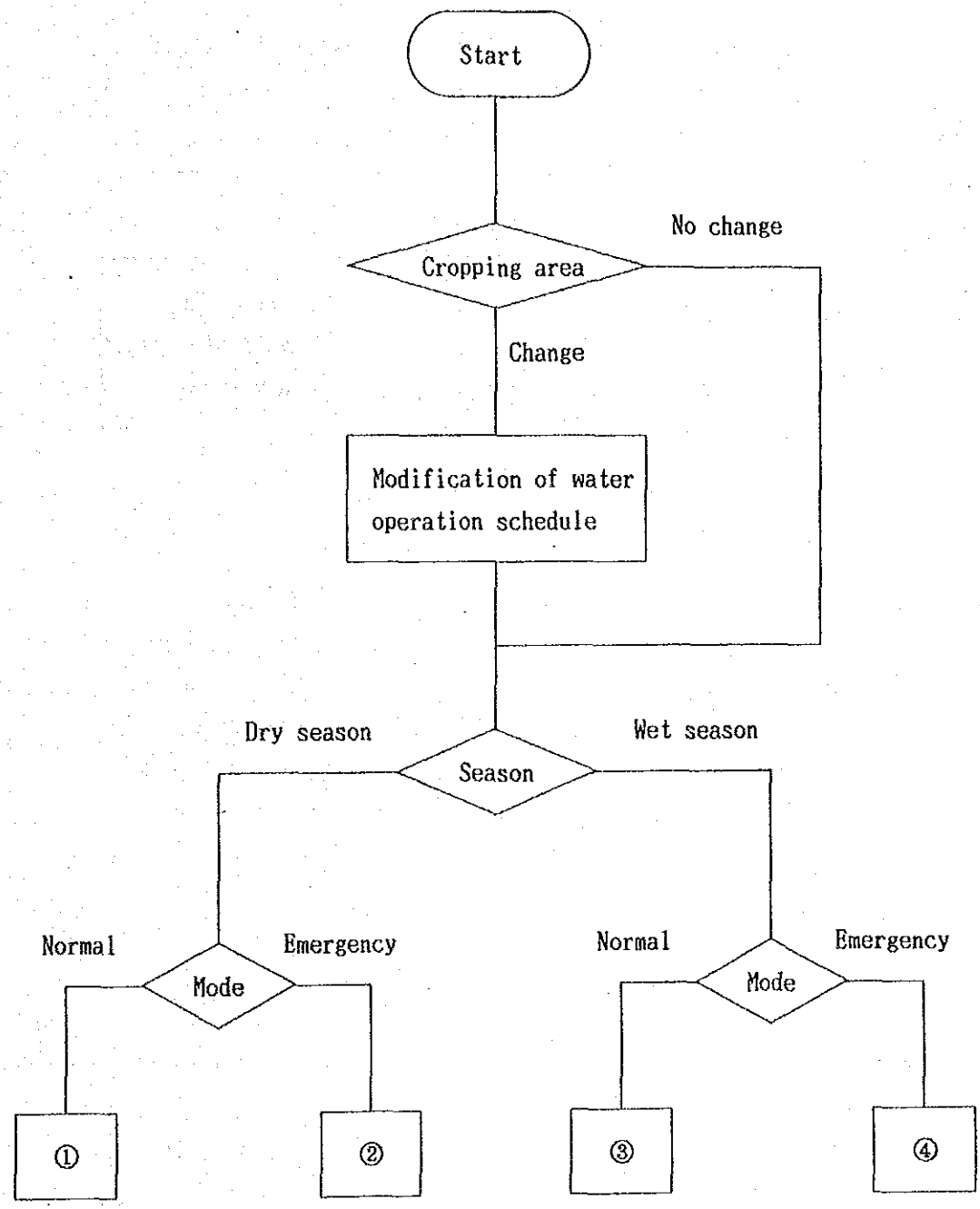


Figure 3-3 DATA PROCESSING FOR WEEKLY WATER MANAGEMENT (1)

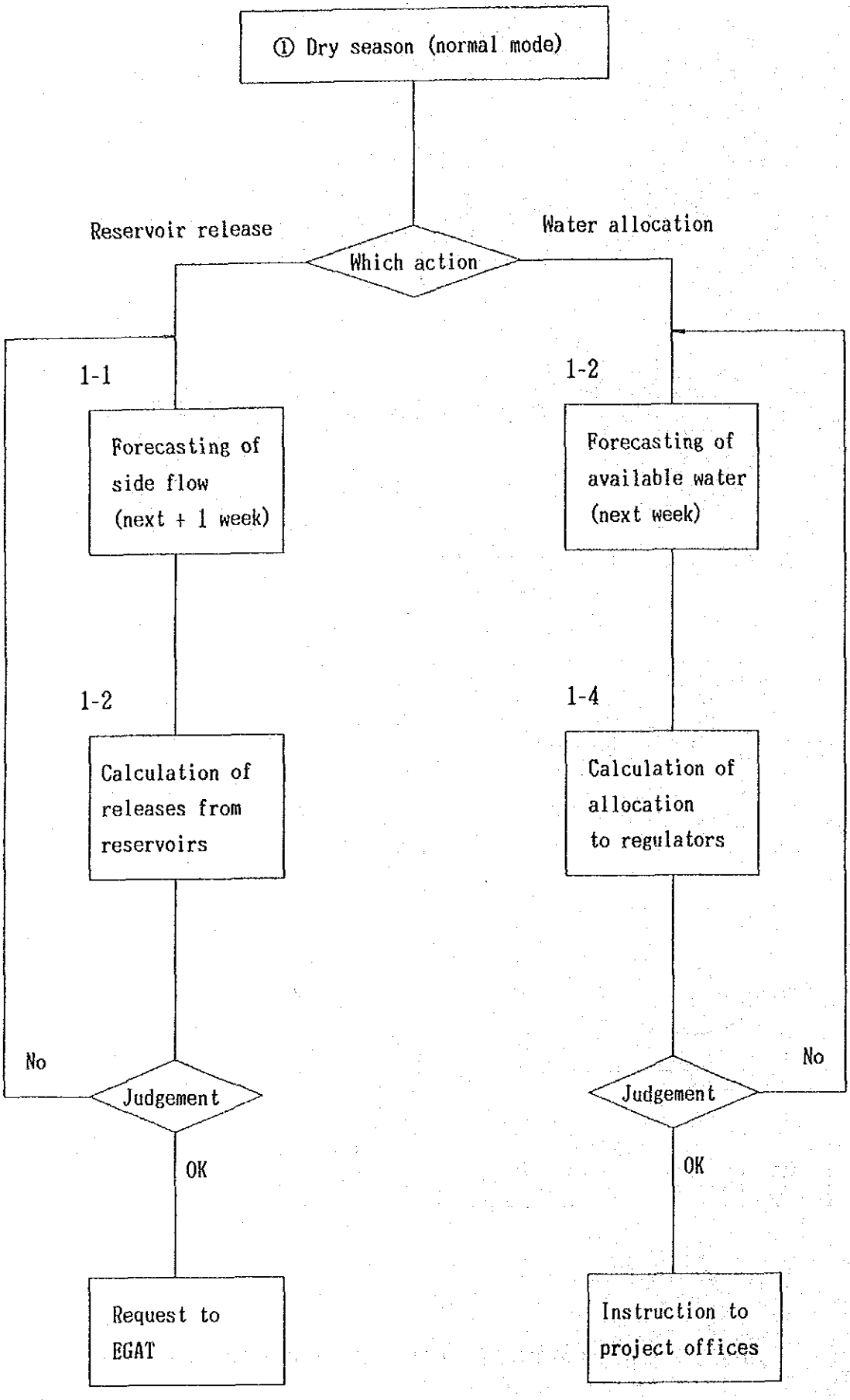


Figure 3-3 DATA PROCESSING FOR WEEKLY WATER MANAGEMENT (2)

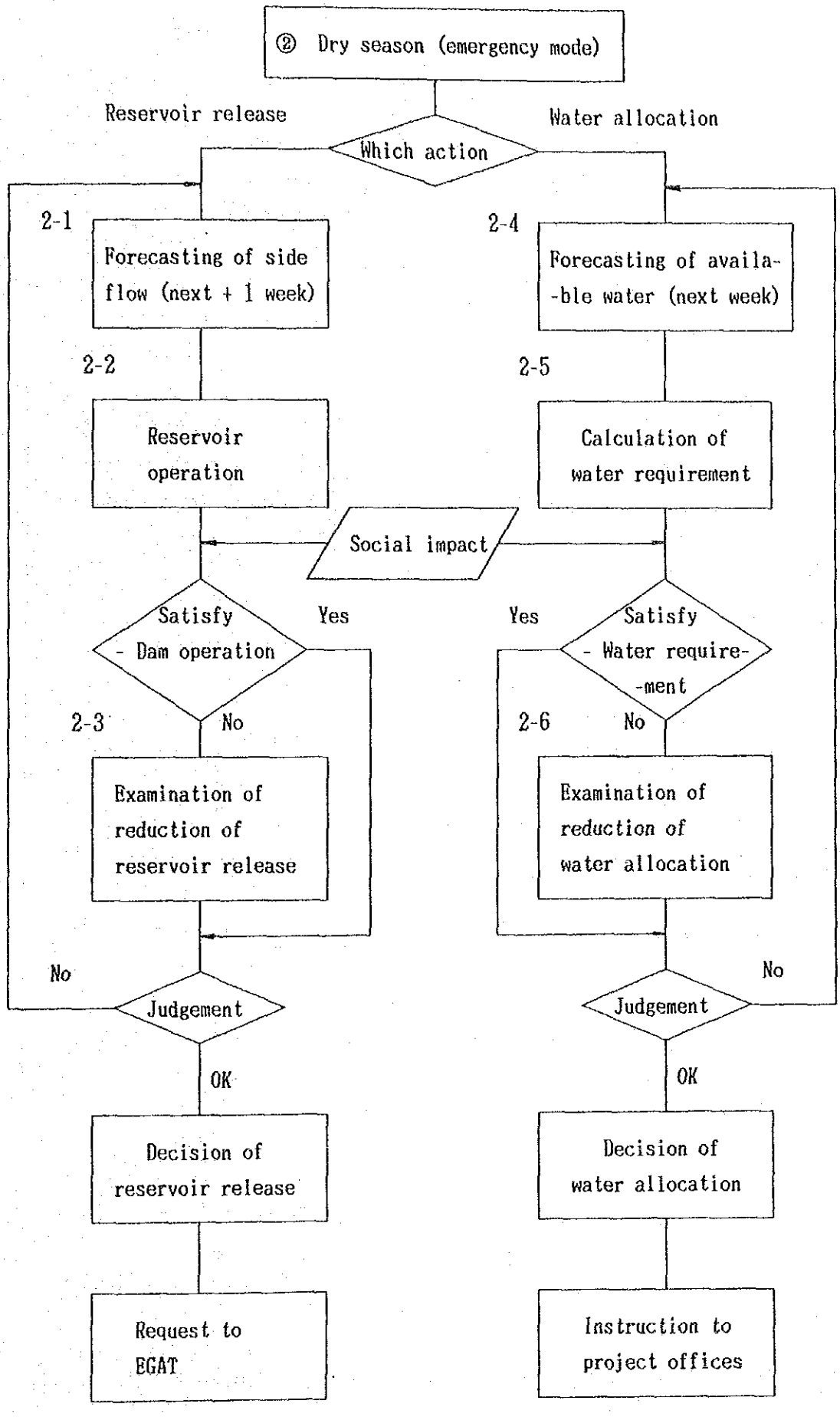


Figure 3-3 DATA PROCESSING FOR WEEKLY WATER MANAGEMENT (3)

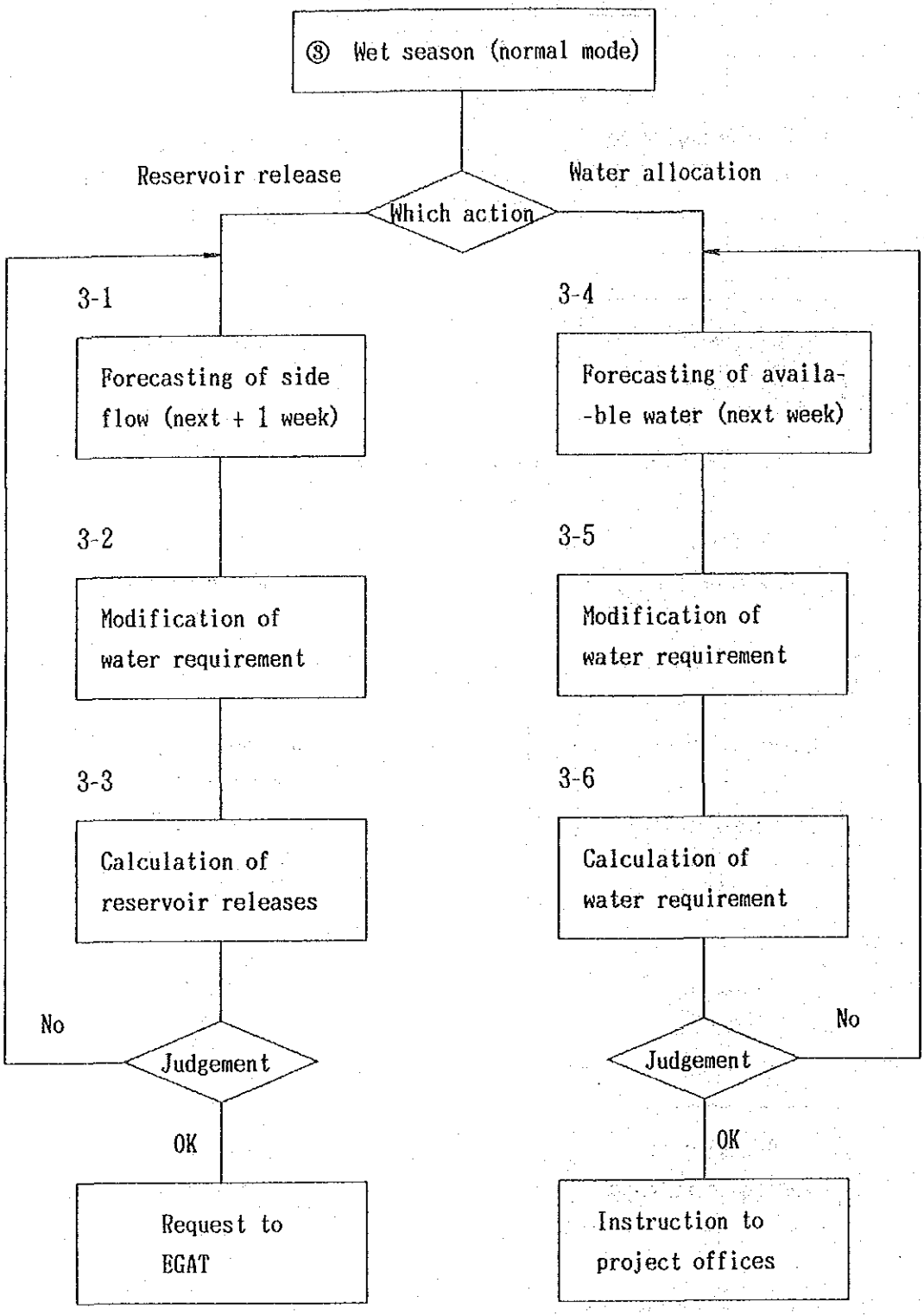


Figure 3-3 DATA PROCESSING FOR WEEKLY WATER MANAGEMENT (4)

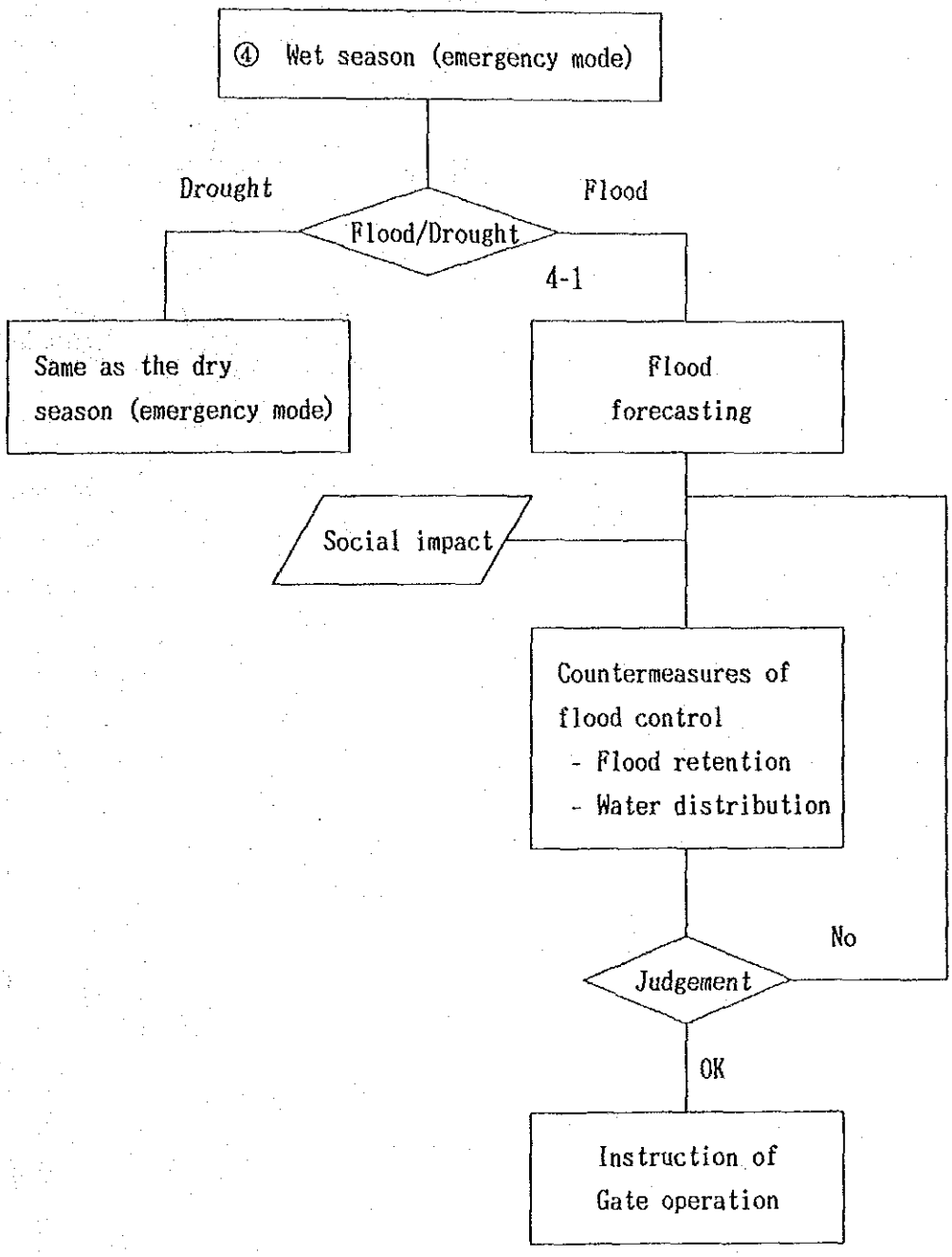


Figure 3-3 DATA PROCESSING FOR WEEKLY WATER MANAGEMENT (5)

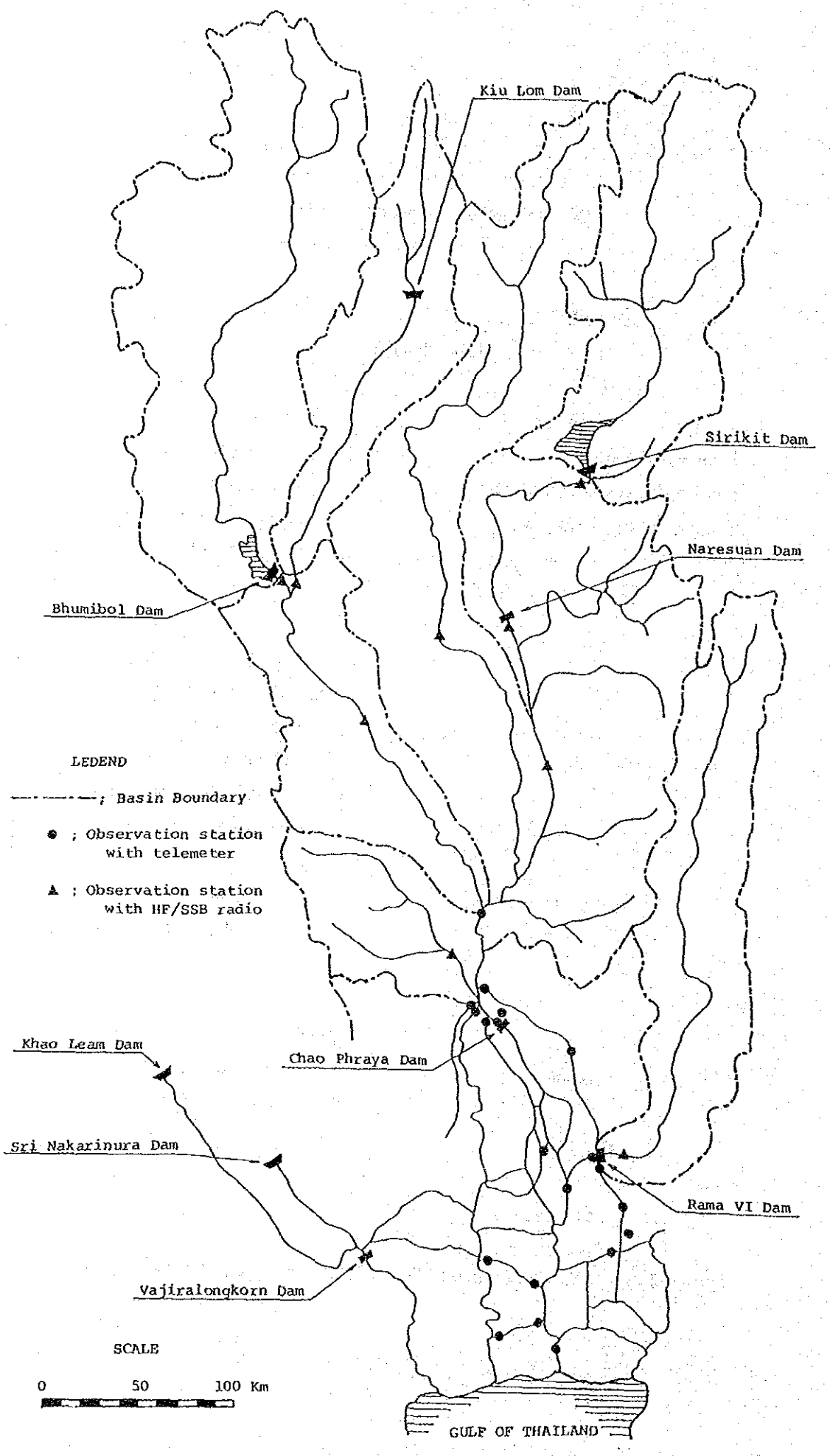


Figure 4-1 WATER LEVEL OBSERVATION STATION IN MODEL PROJECT

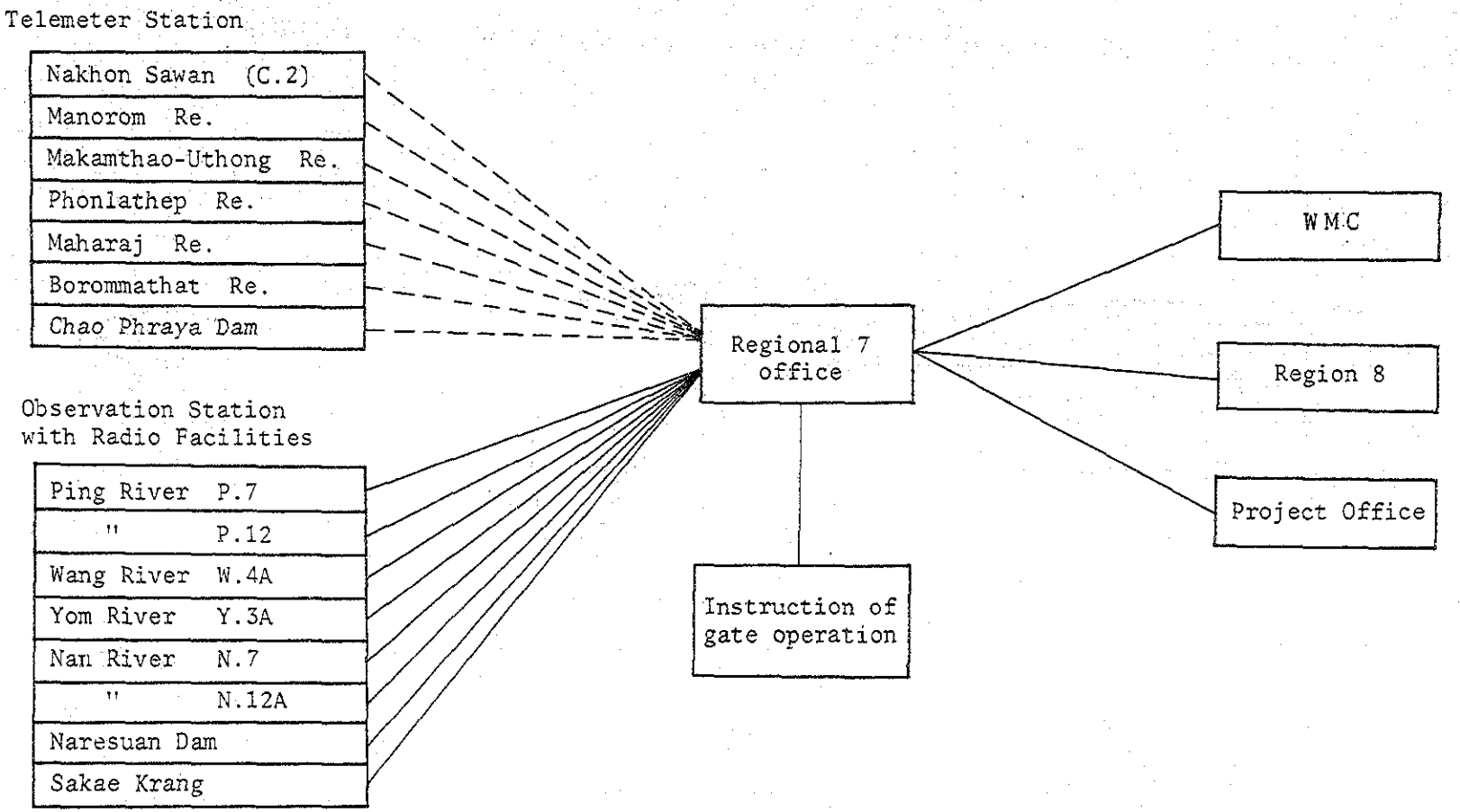


Figure 4-2 DATA COLLECTION SYSTEM (REGIONAL 7 OFFICE)

-------- Communication telemeter

_____ Communication by voice

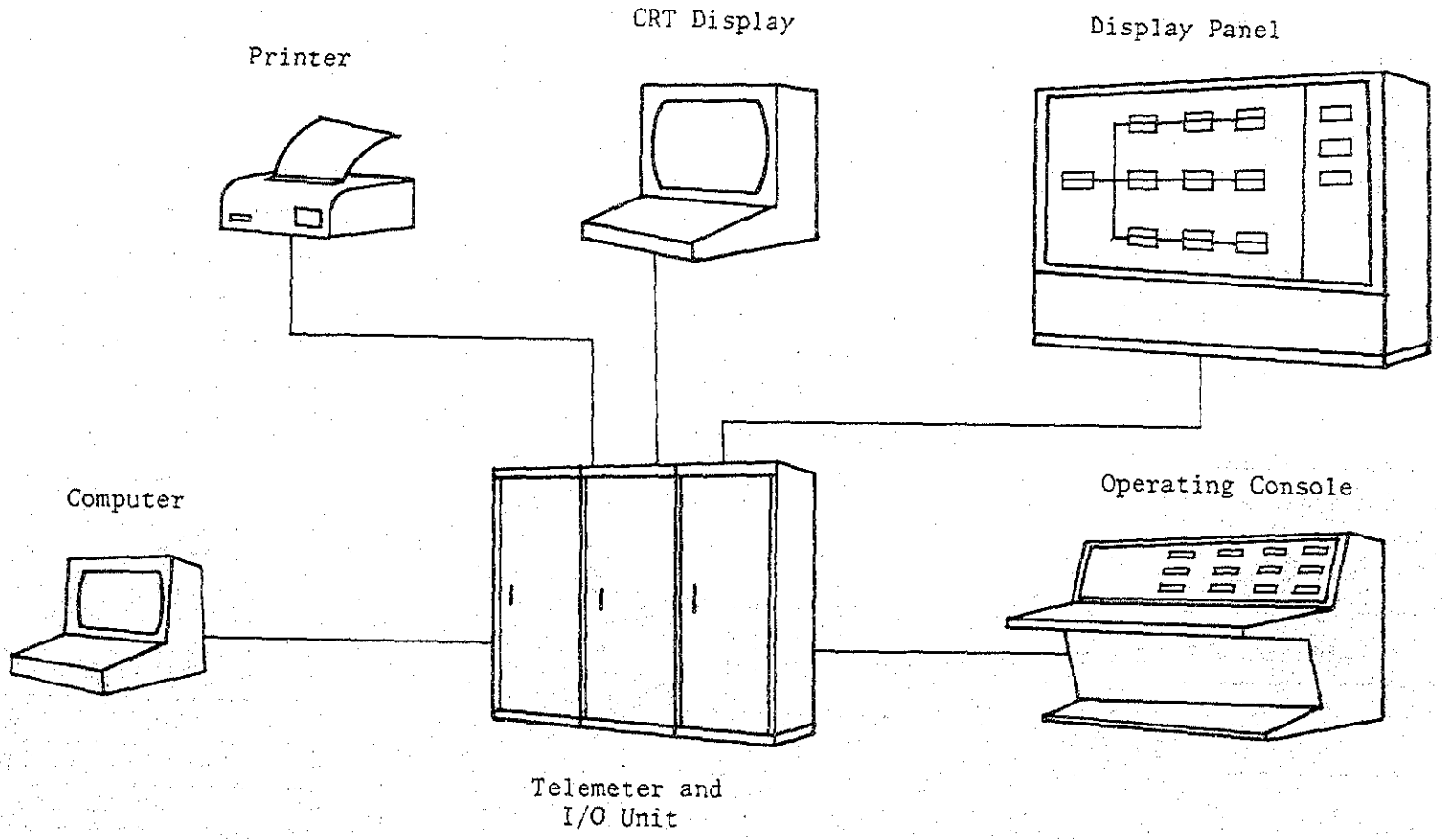


Figure 4-3 SYSTEM CONFIGURATION IN MODEL PROJECT OFFICE (CENTER)

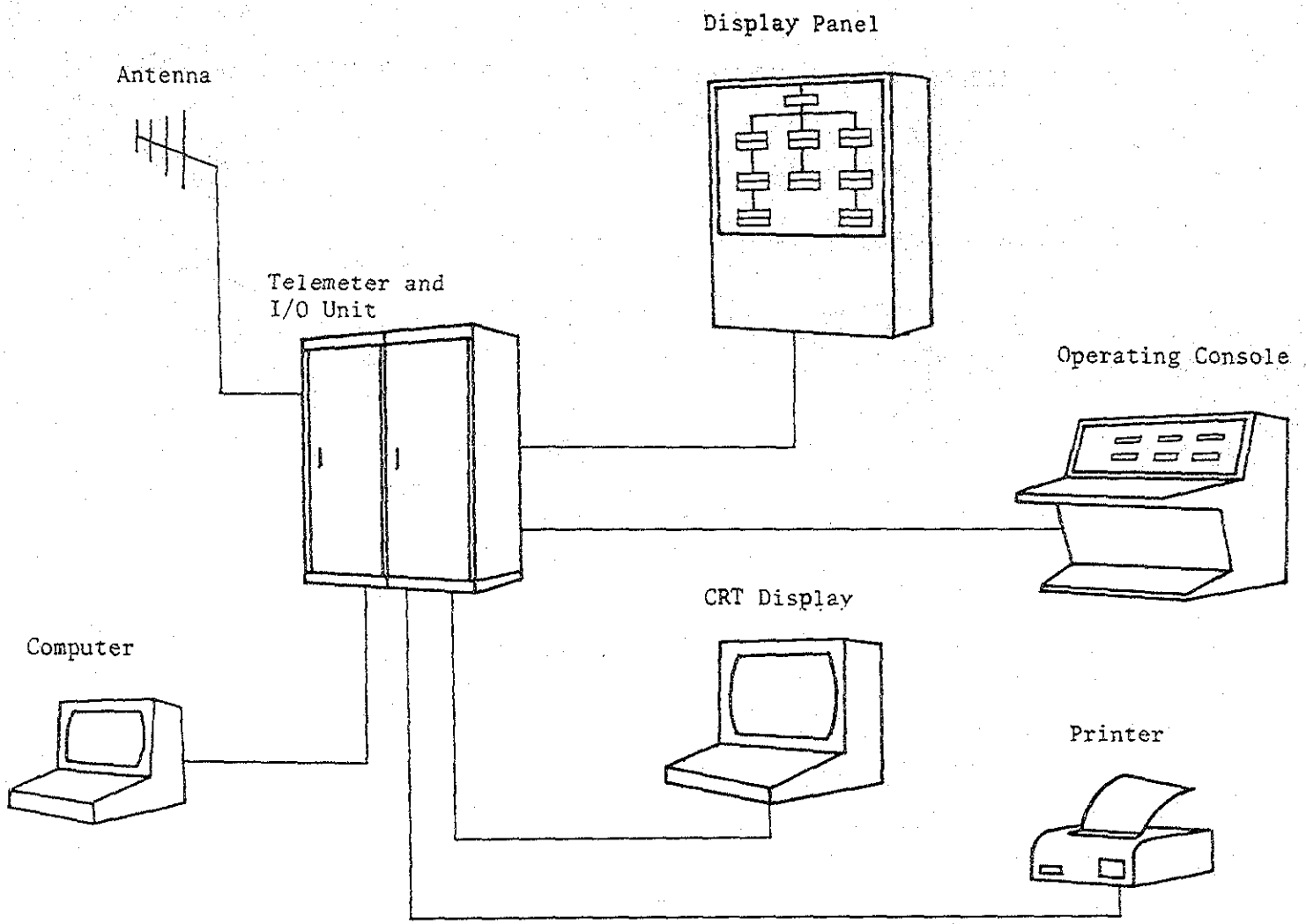


Figure 4-3 SYSTEM CONFIGURATION IN MODEL PROJECT OFFICE (REGION OFFICE)

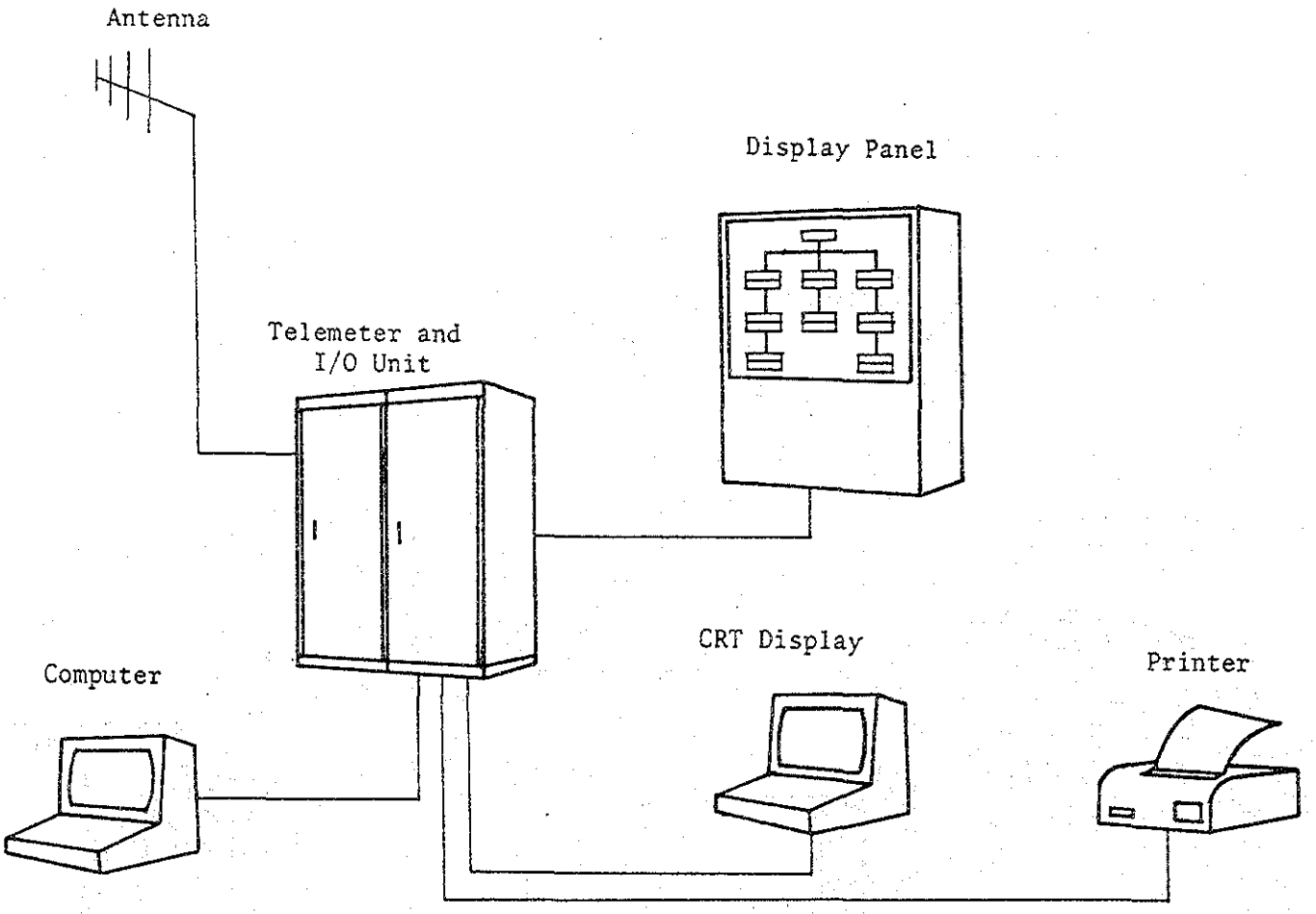


Figure 4-3 SYSTEM CONFIGURATION IN MODEL PROJECT OFFICE (PROJECT OFFICE)

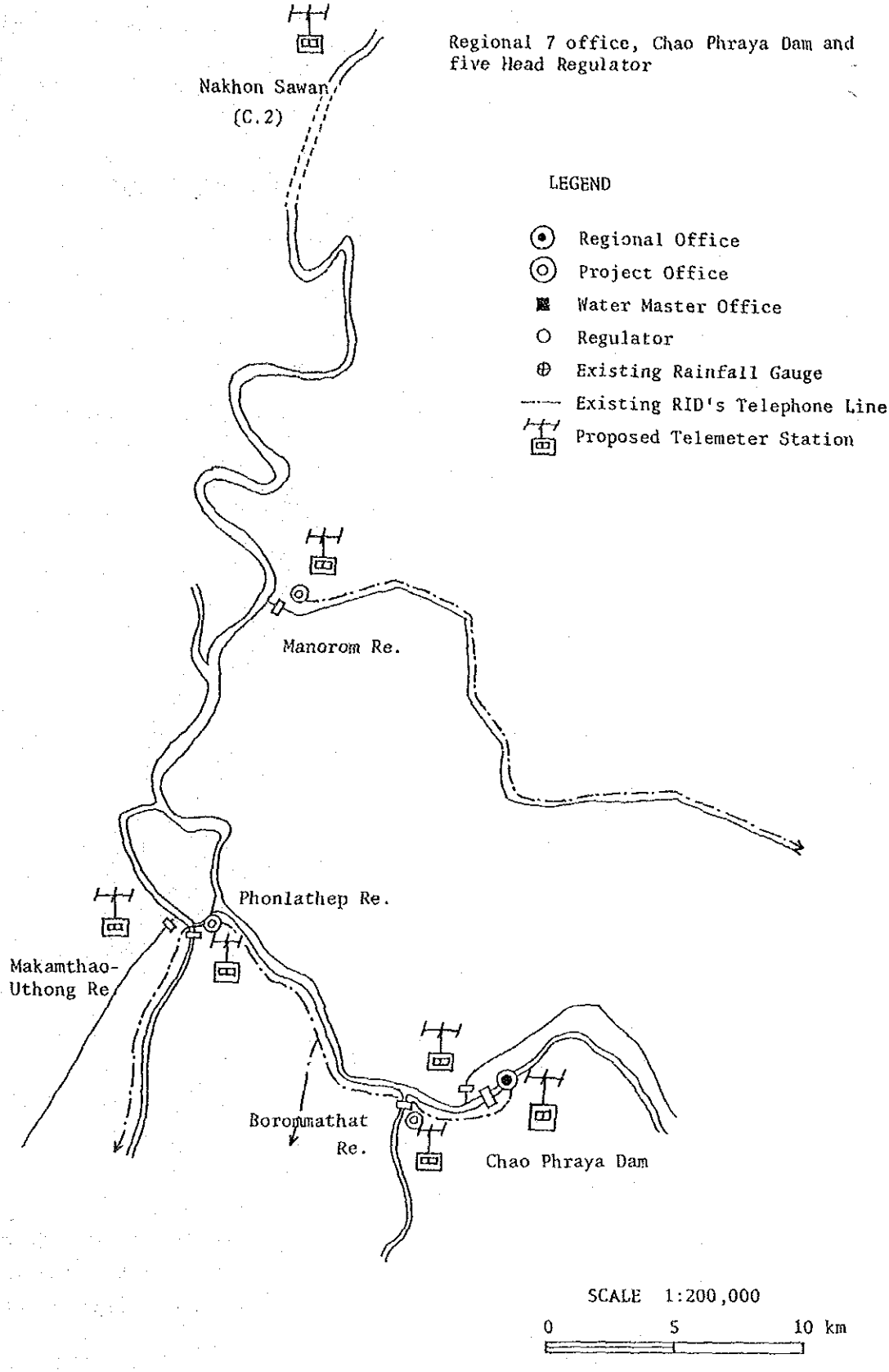


Figure 4-4 LOCATION OF TELEMETERING STATION (REGIONAL 7 OFFICE)

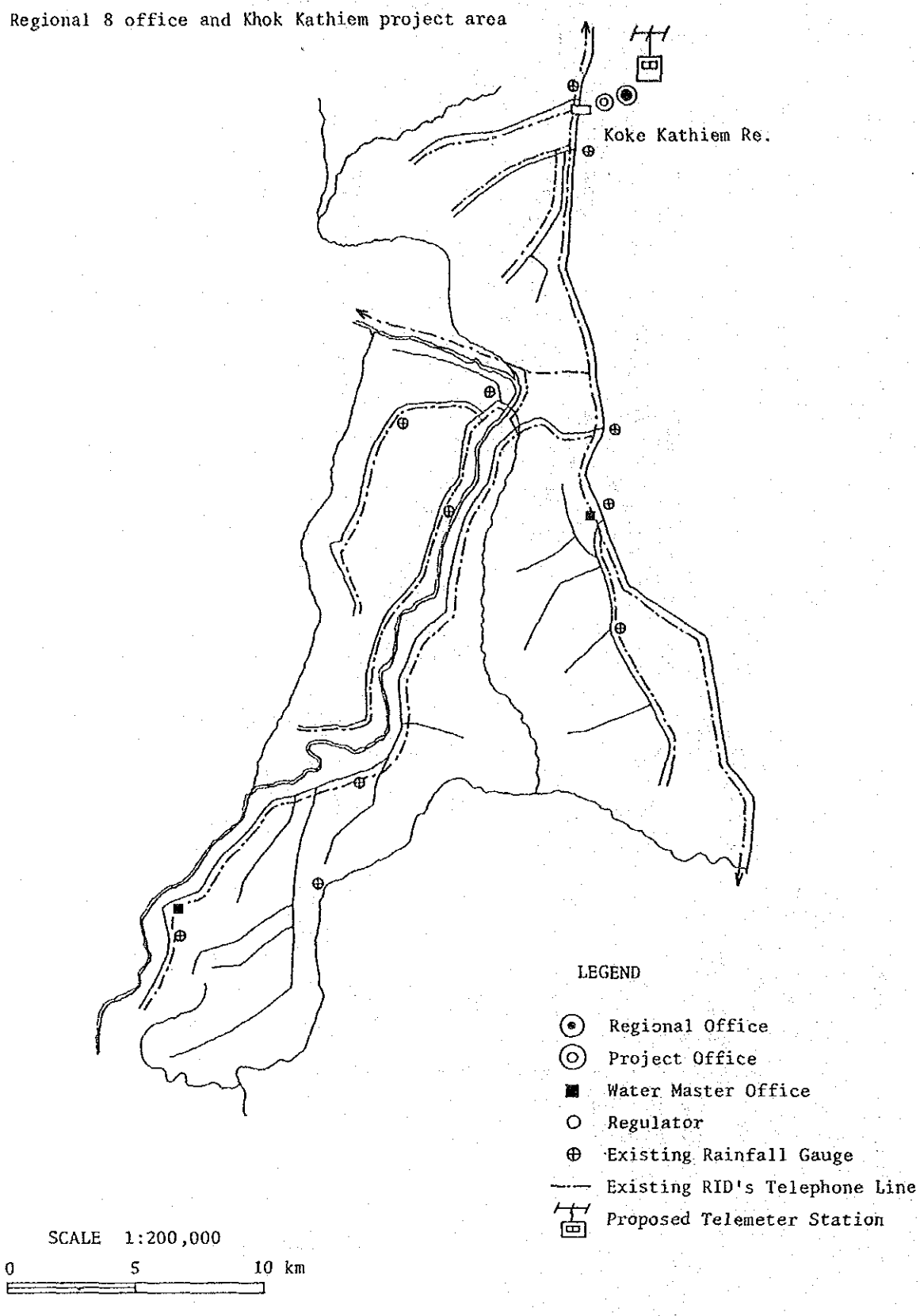


Figure 4-5 LOCATION OF TELEMETERING STATION (REGIONAL 8 OFFICE)

Regional 8 office and Khok Kathiem project area

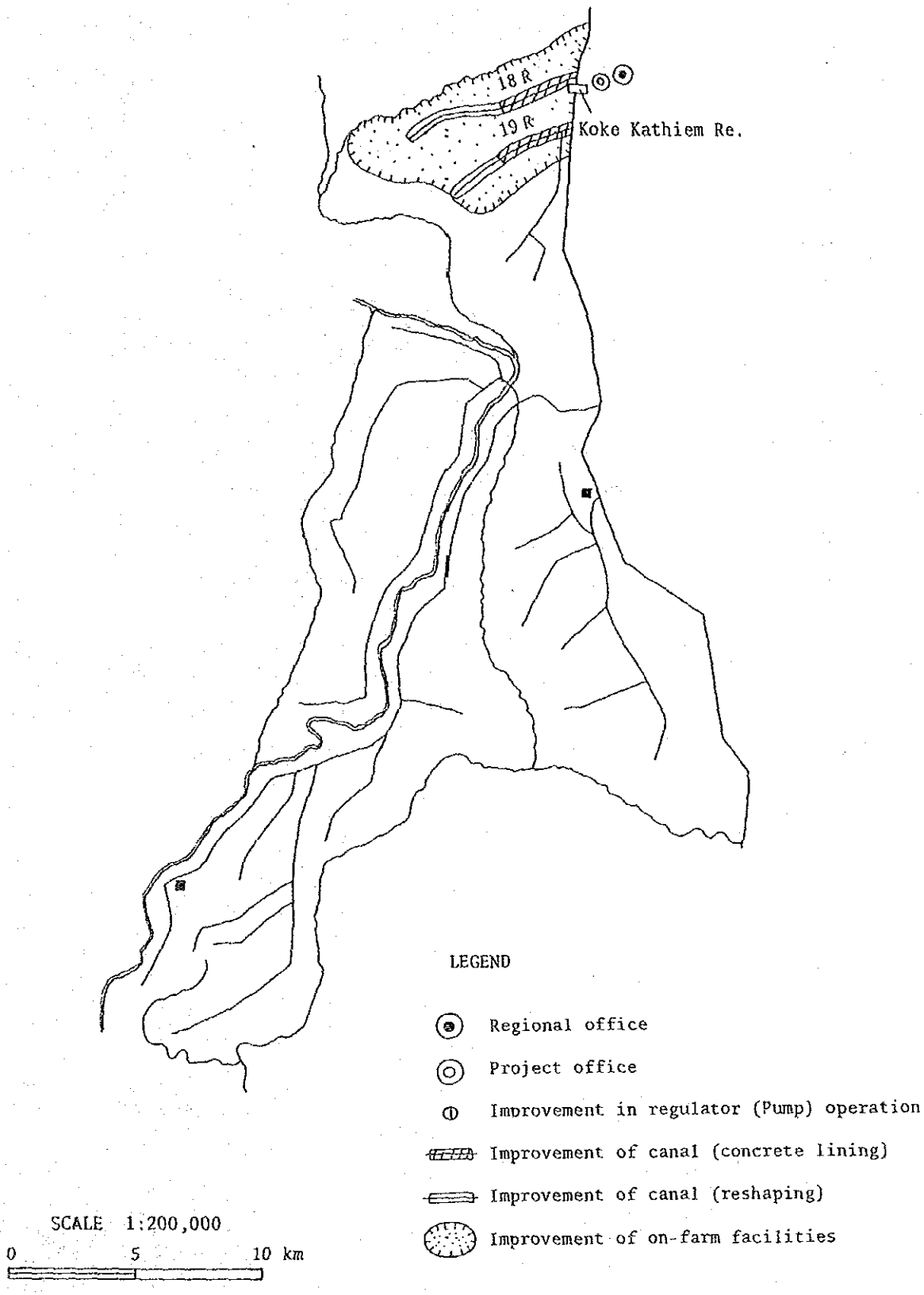


Figure 4-5 LOCATION OF CIVIL WORKS (KOKE KATHIEM PROJECT AREA)

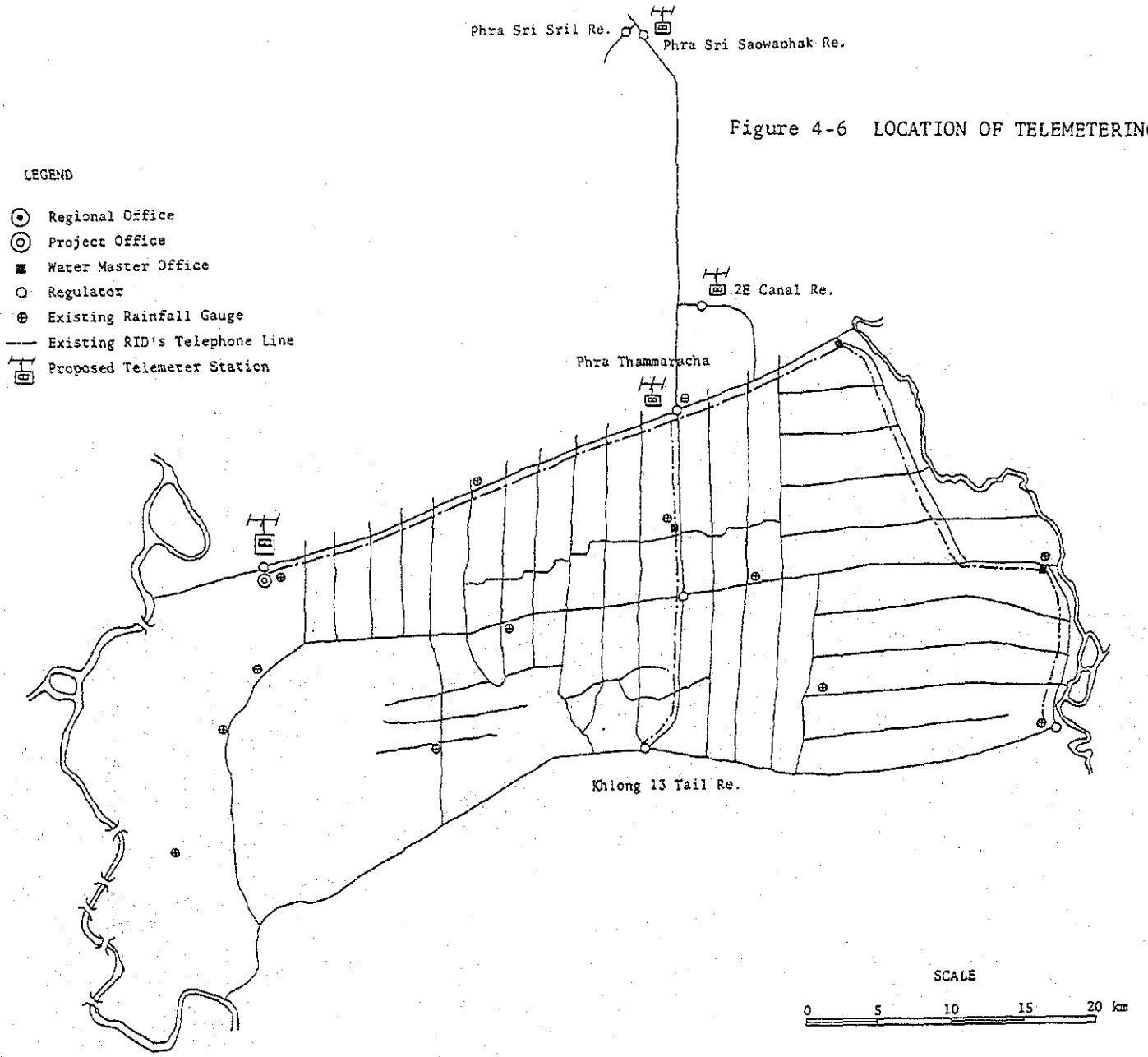


Figure 4-6 LOCATION OF TELEMETERING STATION (RANFSIT TAI)

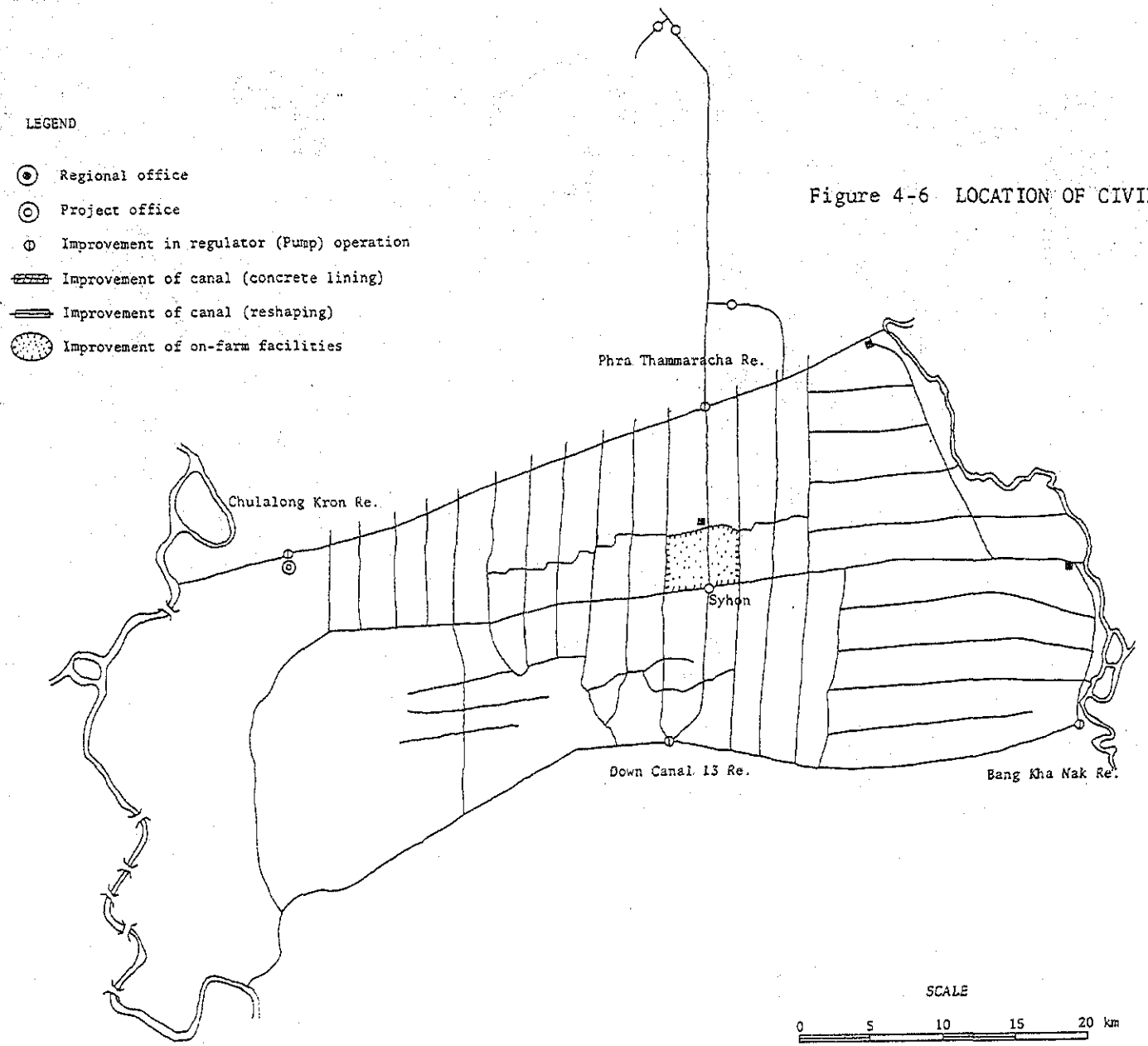


Figure 4-6 LOCATION OF CIVIL WORKS (RANGSIT TAI)

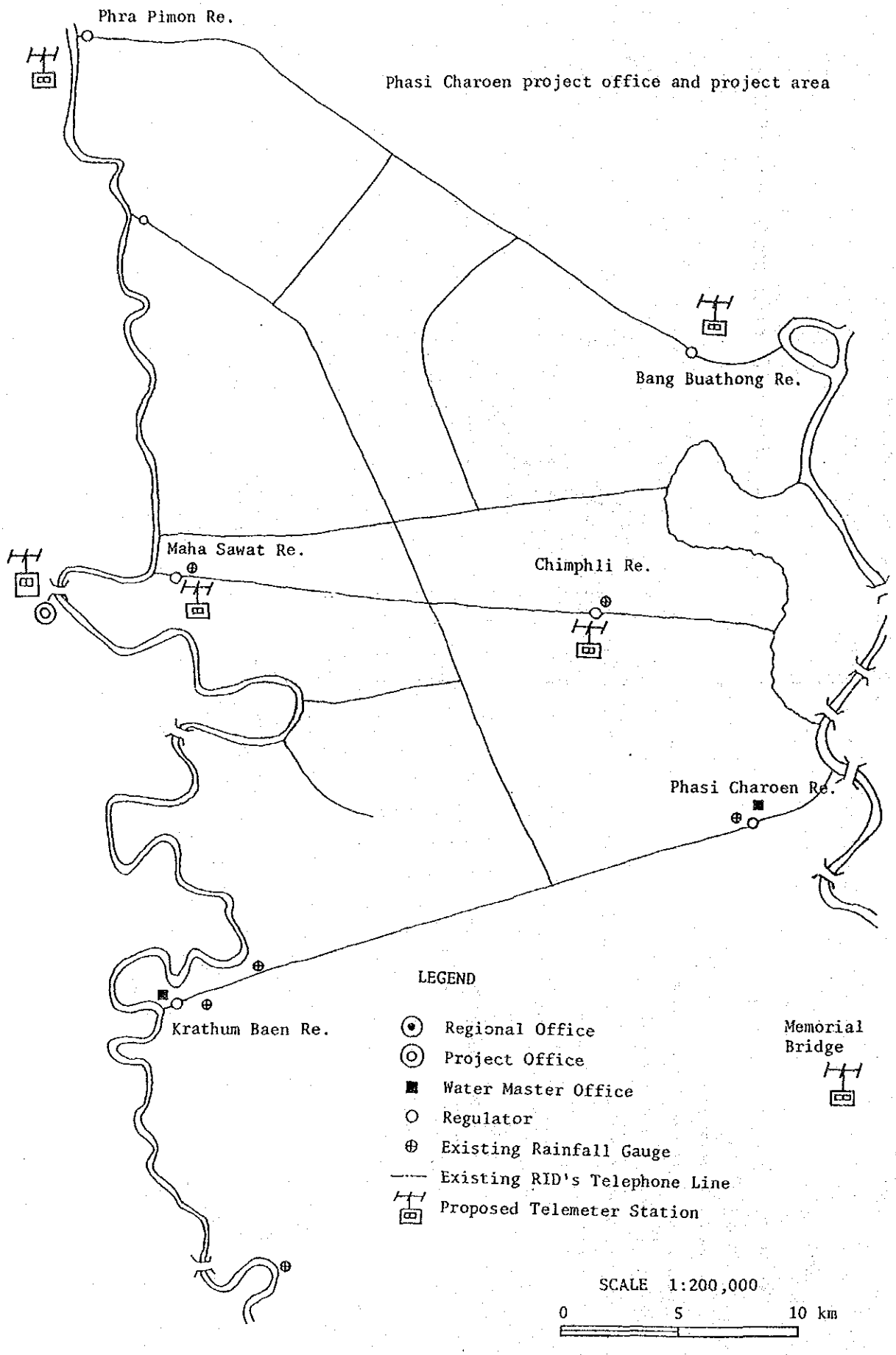


Figure 4-7 LOCATION OF TELEMETERING STATION (PHASI CHAROEN)

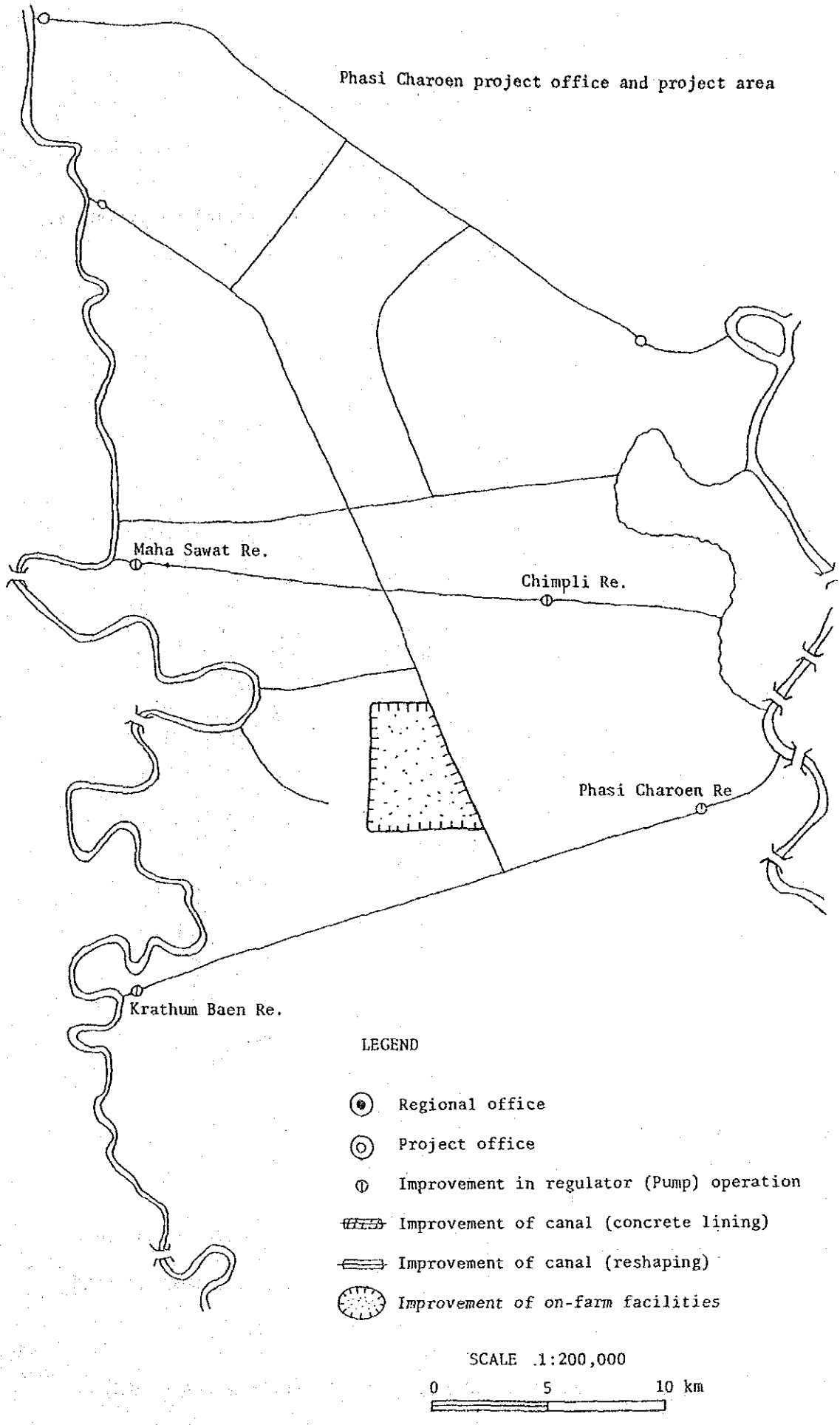


Figure 4-7 LOCATION OF CIVIL WORKS (PHASI CHAROEN)

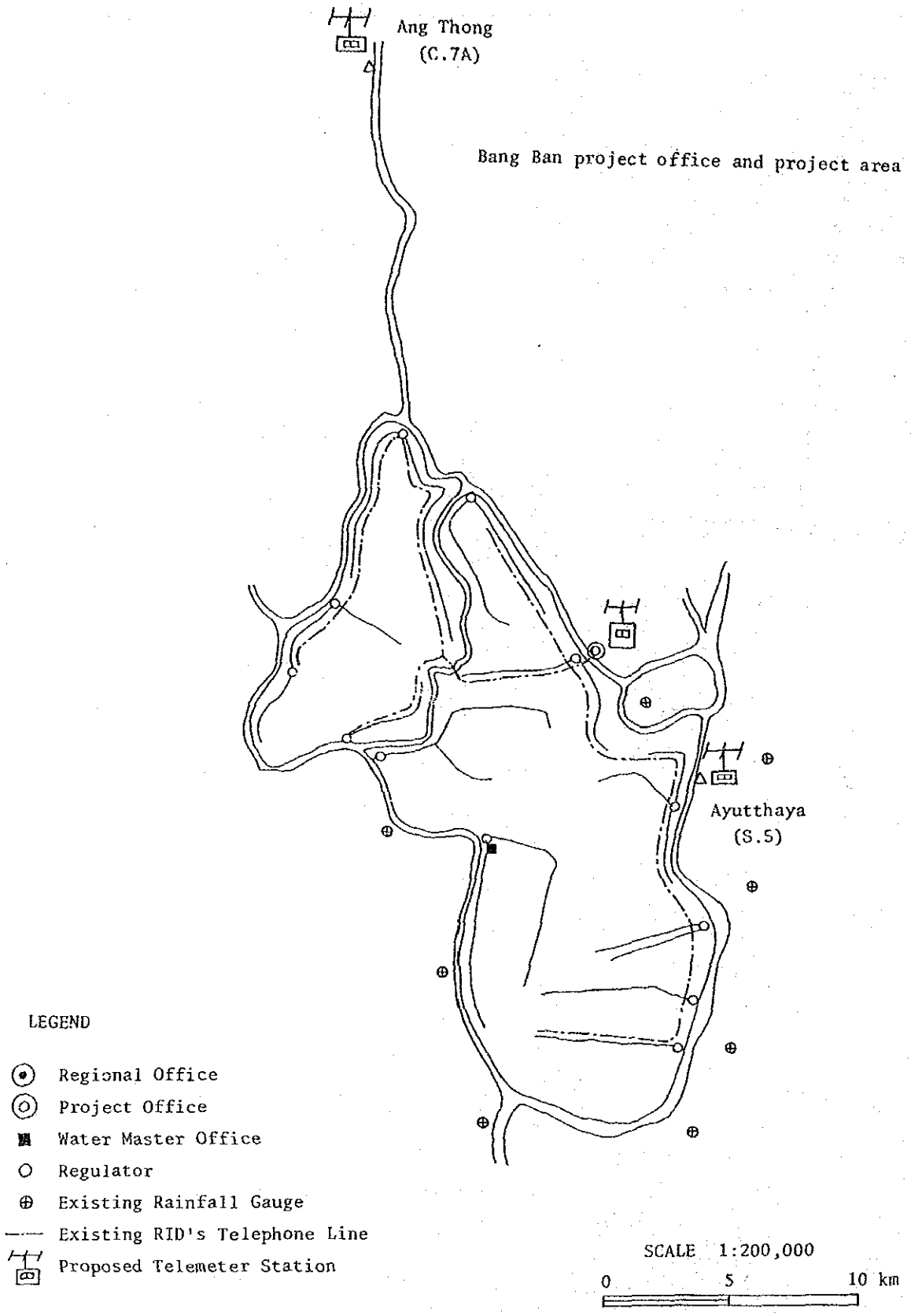


Figure 4-8 LOCATION OF TELEMETERING STATION (BANG BAN)

Bang Ban project office and project area

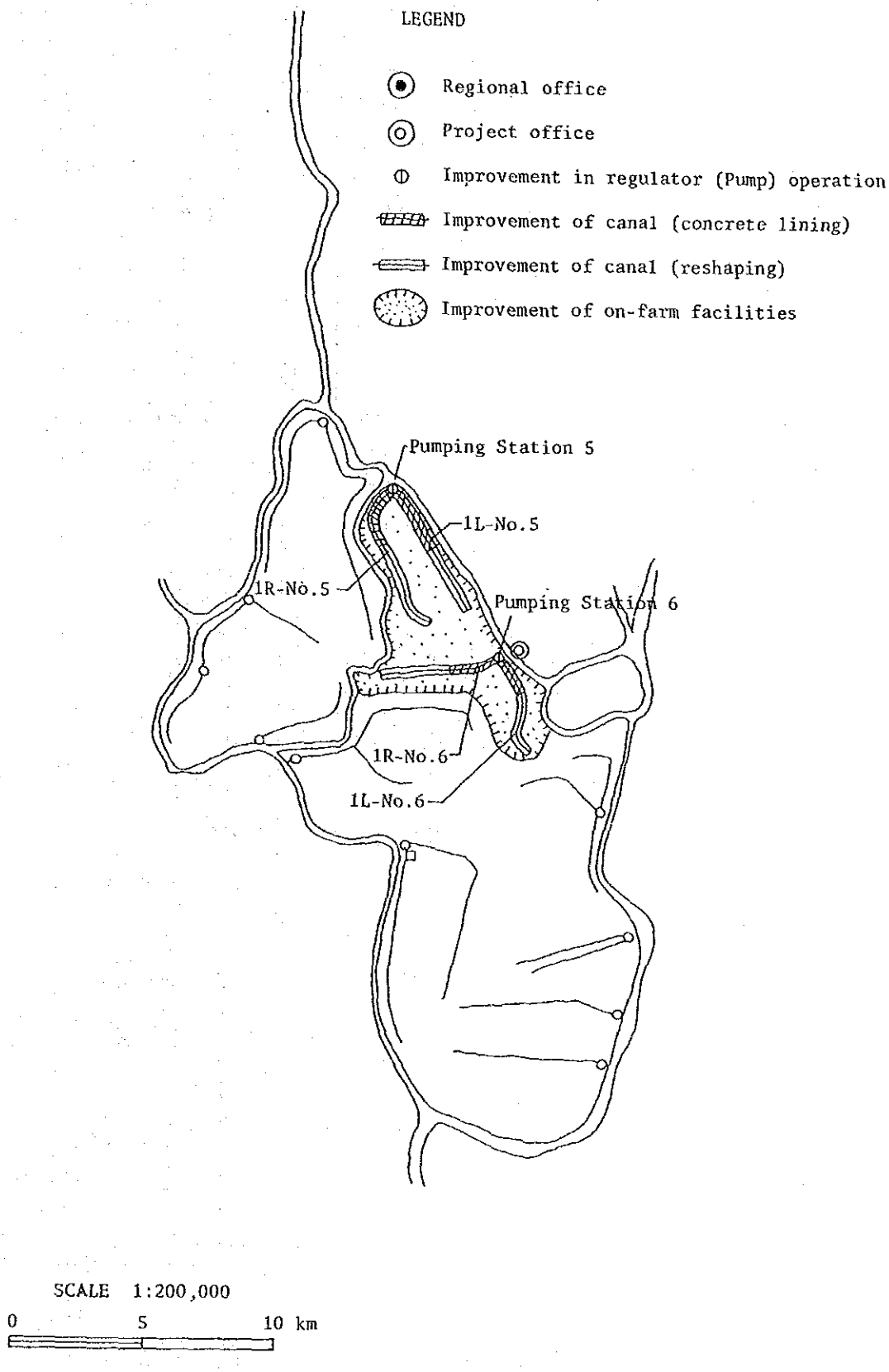
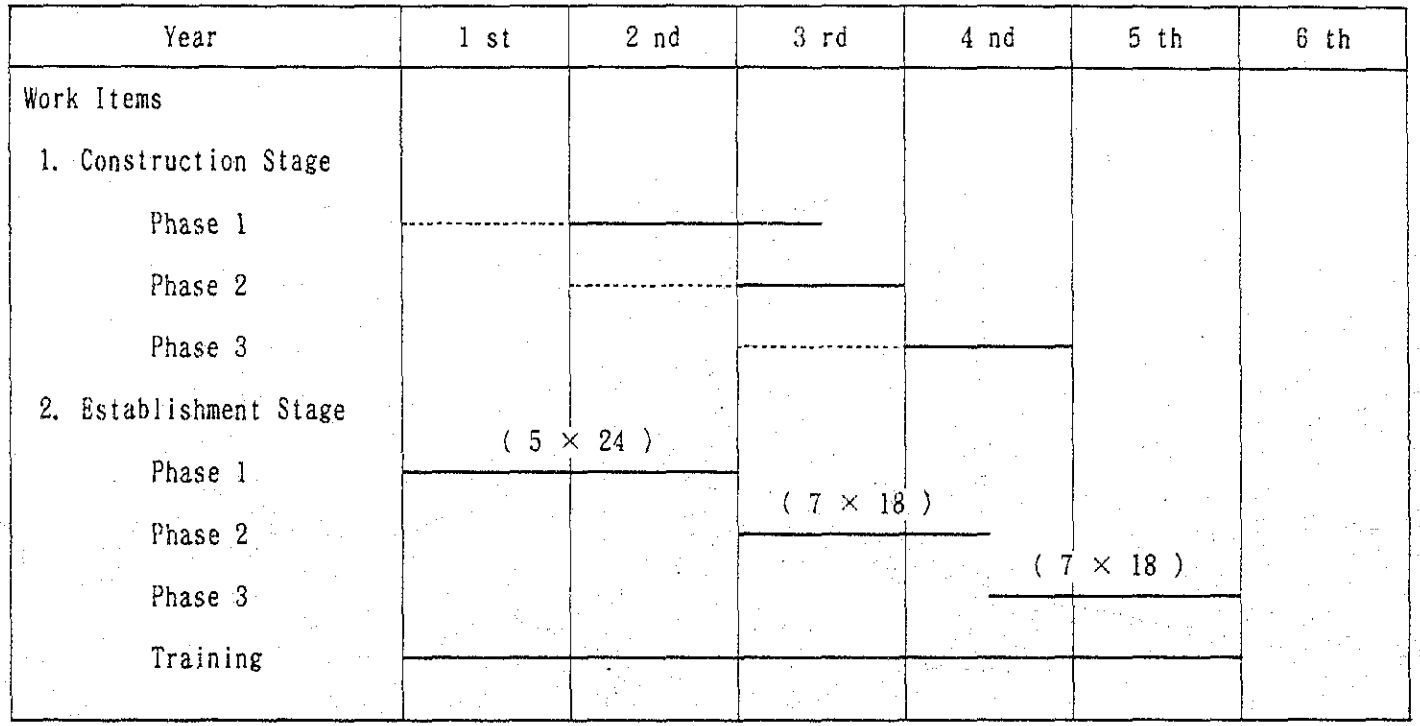


Figure 4-8 LOCATION OF CIVIL WORKS (BANG BAN)

Figure 5-1 IMPLEMENTATION SCHEDULE OF MODEL PROJECT



Note -------- ; Preparation for construction stage, detailed design and other necessary works.

( ) ; Expert (man-months)

Figure 5-2 REQUIRED EXPERTS AND WORK SCHEDULE

Required Expert and Year	1 st	2 nd	3 rd	4 th	5 th
Establishment stage					
Phase-1					
Phase-2					
Phase-3					
Long-term expert					
A. Team leader (Water resources planning)					
B. Irrigation eng. (Water operation)					
C. Hydraulic eng. (Field monitoring)					
D. System eng. (Data management)					
E. Design eng. (Irrigation facilities)					
F. Agronomist (On-farm water management)					
G. Coordinator (Training program)					
Short-term expert					
- Hydrologist					
- Hydrological observation facilities					
- Hydraulic model					
- Design of irrigation facilities					
- O/M of irrigation/drainage facilities					
- Computer system and programming					
- Computer programmer					
- O/M of telecommunication facilities					
- Agro-economist					
- Institution					
- Land-use					
- Specialist (as required)					

Note ; Long-term experts are stationed at the model project areas during the implementation of model project.
Short-term experts are employed at required times for specific fields necessitated in water management practices by the above long-term experts.

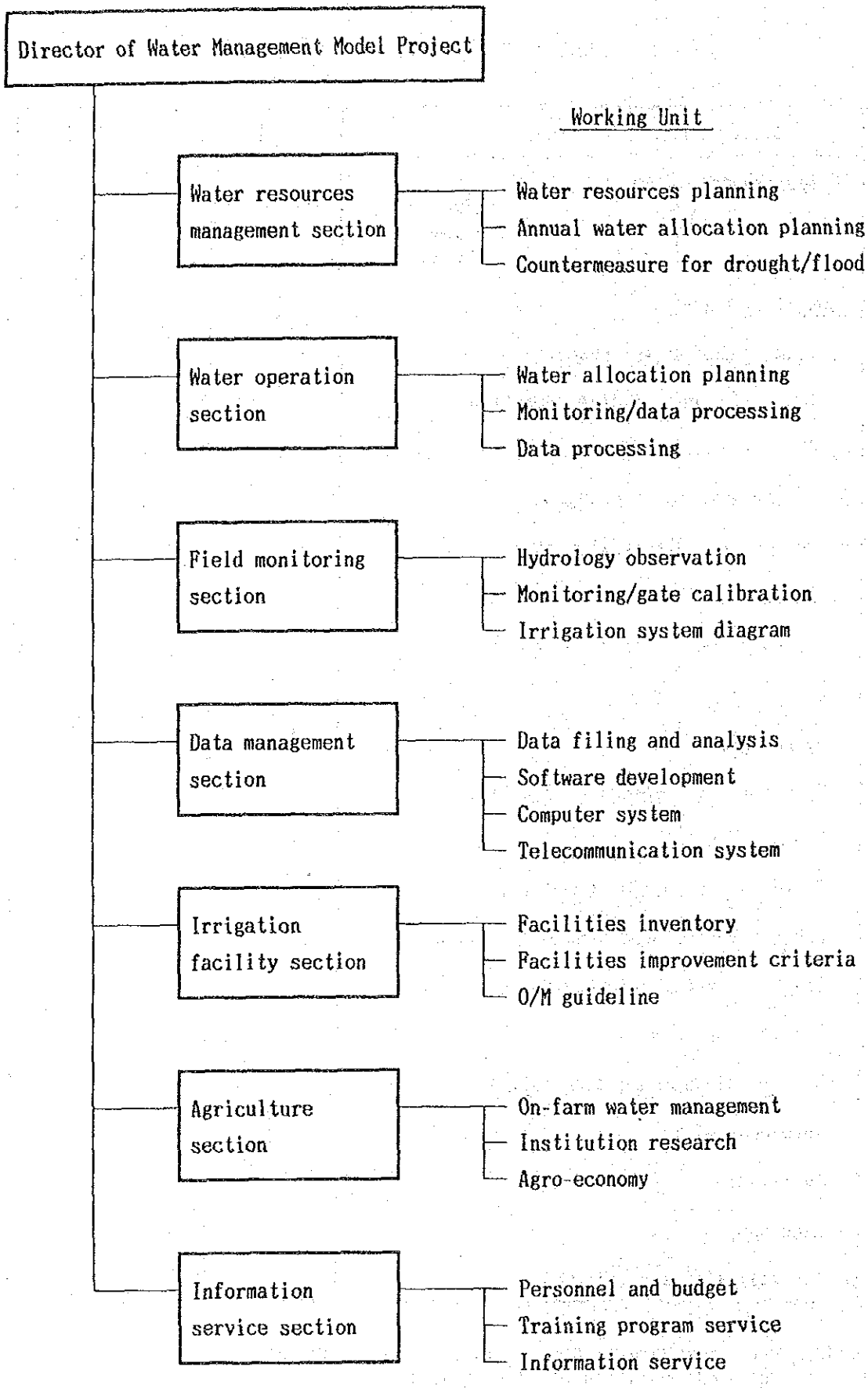


Figure 5-3 ORGANIZATION CHART OF MODEL PROJECT

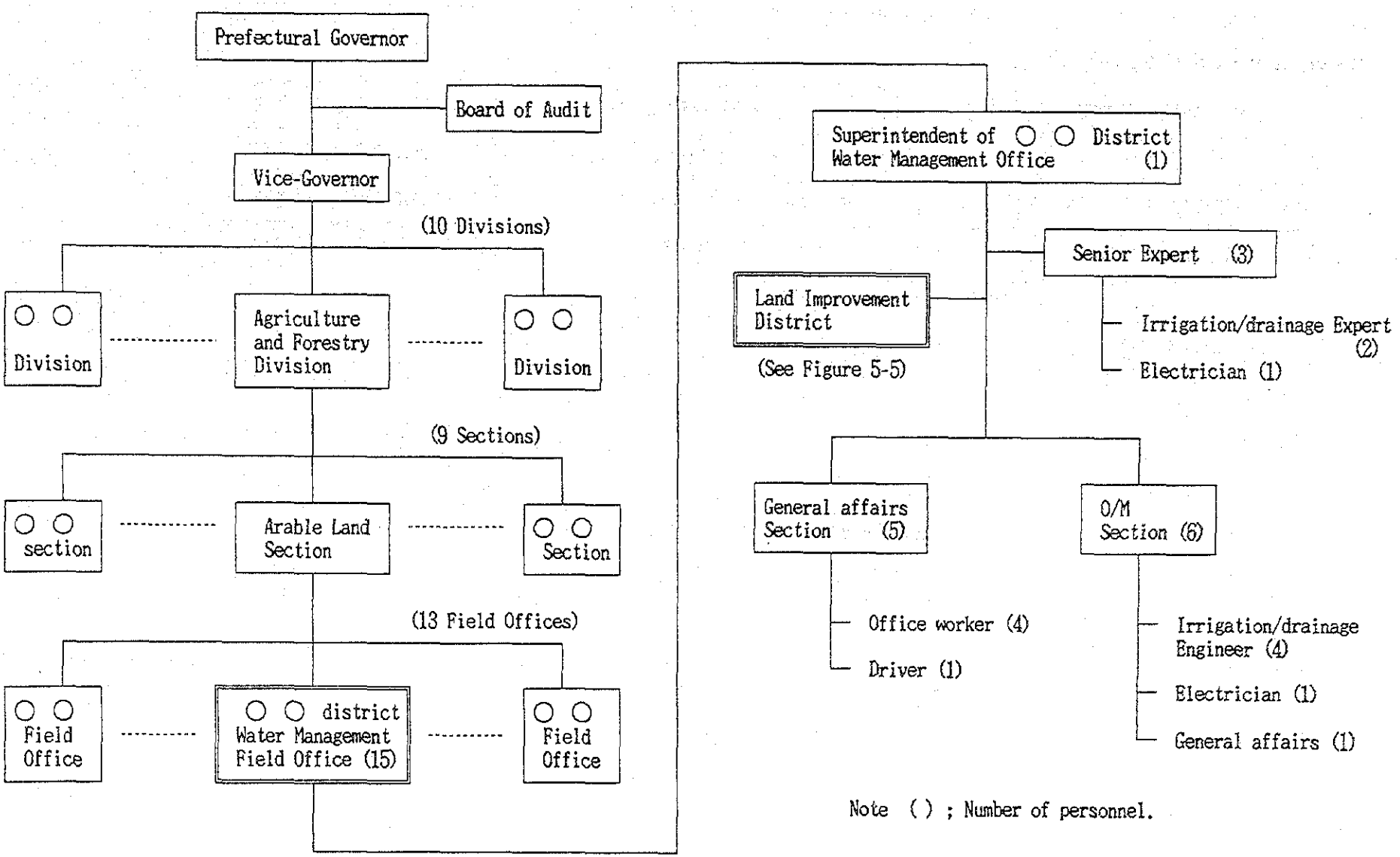


Figure 5-4 EXAMPLE OF ORGANIZATION CHART OF WATER MANAGEMENT PROJECT IN JAPAN

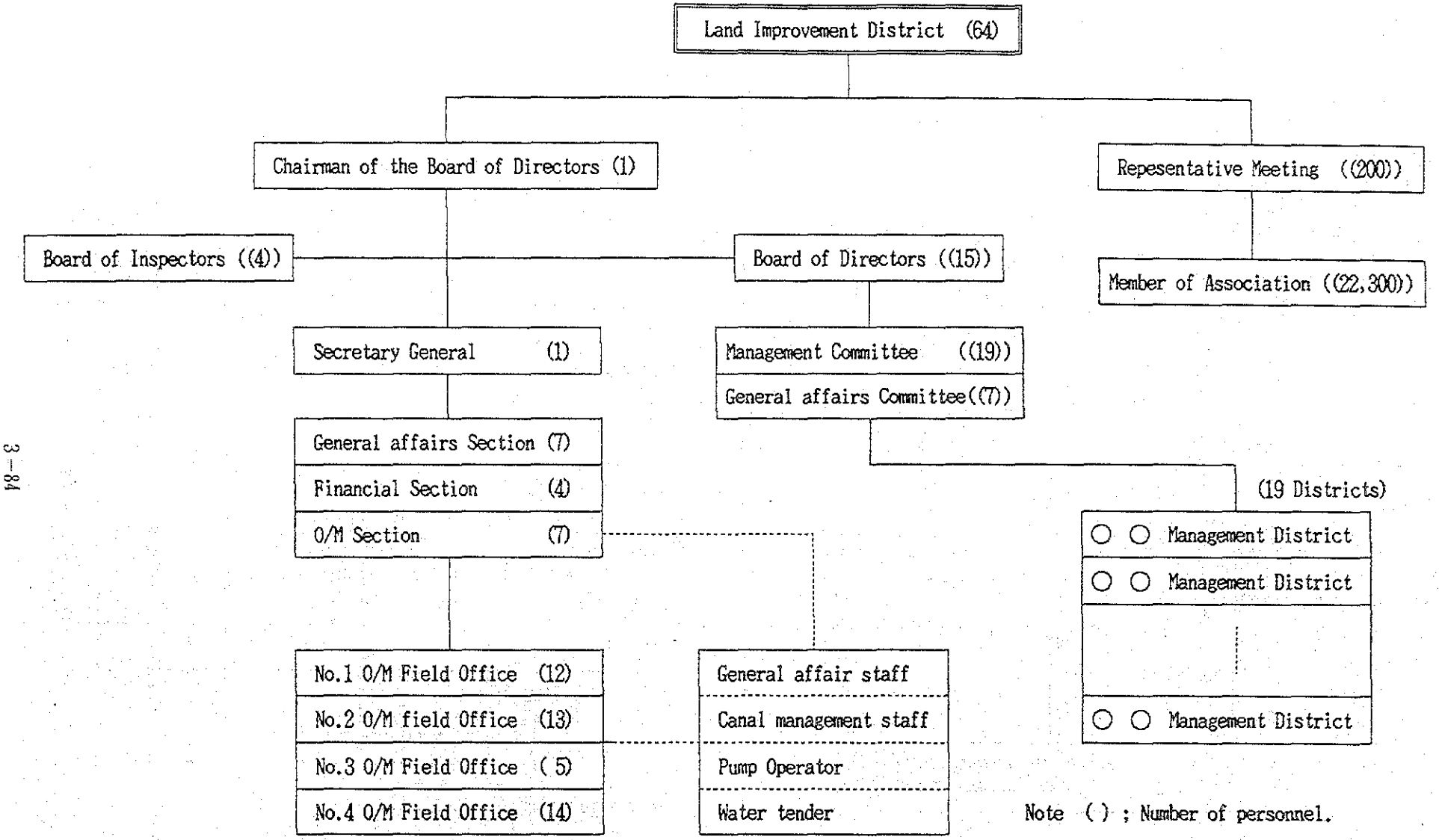
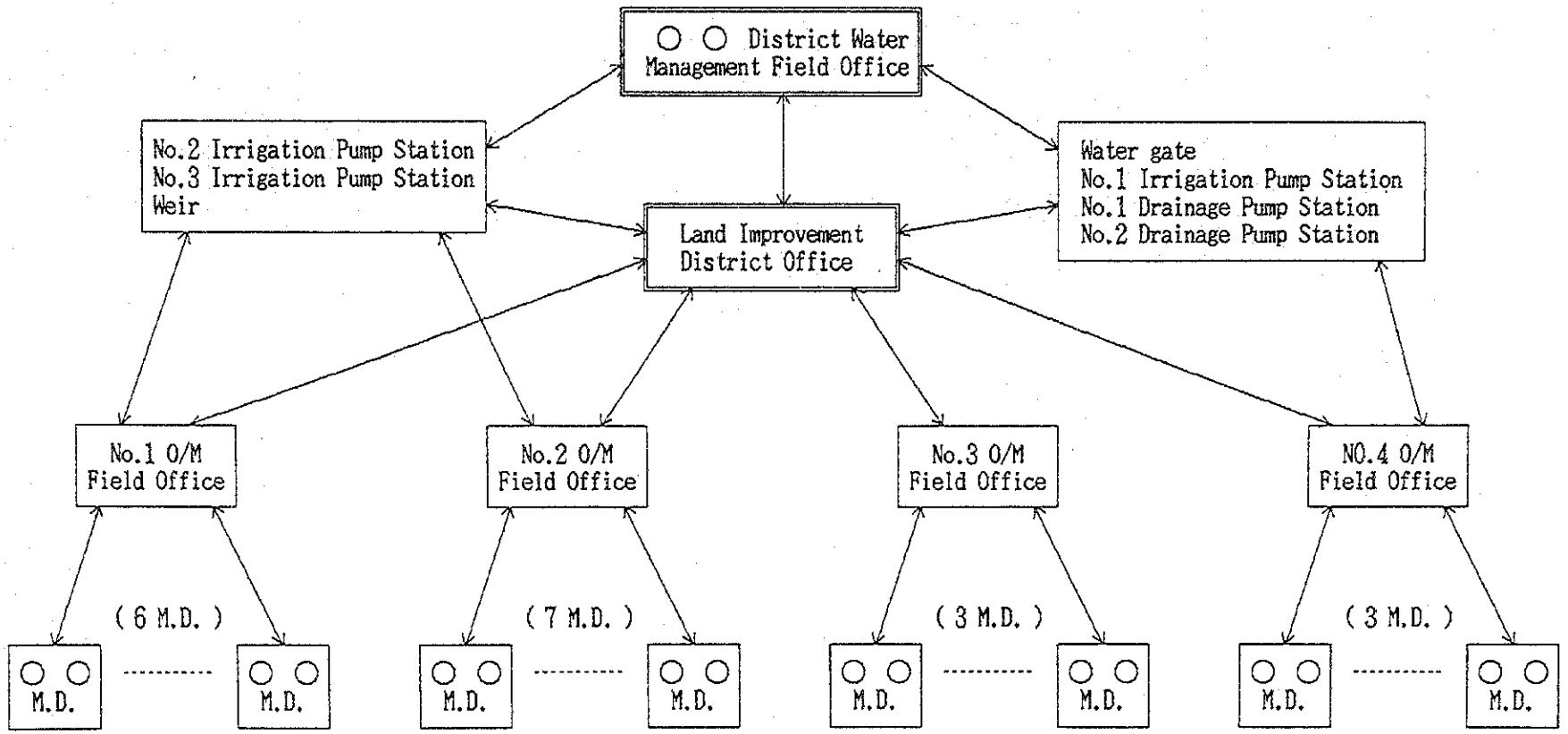


Figure 5-5 EXAMPLE OF ORGANIZATION CHART OF LAND IMPROVEMENT DISTRCT IN JAPAN



Note M.D. ; Management District

Figure 5-6 EXAMPLE OF INFORMATIONFLOW IN MANAGEMENT ORGANIZATION IN JAPAN