with the inter-institutional agreement between CEDEGE and CRM signed in December 1986 and fully endorsed by the Ministry of Agriculture and Livestock, CRM is entitled to divert water from Daula-Peripa up to 500 MCM/year for water use of Chone and Portoviejo basins.

4) IEOS is the agency for the planning, executing and supervising works and projects related to potable water and sewerage water in the country. It has also the authority to control the quality of potable water.

5) JRH is an institution of private law with social and public functions financed by its own funds, budget appropriation, and patrimonial properties, located in Jipijipa, southern part of Manabi Province. Its objectives are to provide potable water to urban and rural areas in Jipijapa and Pajan, to construct sanitary sewerage and drainage system, to pave roads and sidewalks of the cities, to provide irrigation water, to develop productive activities, thereby ultimately leading to the realization of the economic and social development for Jipijapa and Pajan.

3.7.3 Recommended Institutional Arrangements and Support Programs

(1) CRM's Roles with the Transbasin Project

CRM is the executing agency for the implementation, operation and maintenance of the Transbasin Project. Without successful operation and maintenance of the works, the objectives will be never achieved. Thus, it is no exaggeration to say that the realization of the socio-economic development of the Province heavily depends upon the success of the Transbasin Project.

To this end, CRM's institutional reinforcement is essential. In view of the institutional analysis on the present CRM and on the basis of the requirements to be addressed for the desired operation and maintenance of the Project, alternative institutional arrangements are proposed hereinafter.

(2) Proposed Organizational Structure

CRM's organizational structure is designed to capture the present program tasks and activities, and to respond to the operation and maintenance activities particularly for the Transbasin Project. For this, three alternative organizational structures are proposed for Operative Level, depending upon both the roles and responsibilities among respective Directorates, and the roles and functions of the Transbasin Project contemplated during the operation and maintenance stage.

1) Alternative 1

Alternative 1 is designed to divide the present Directorate for Physical Infrastructure into two new Directorates according to the functions and responsibilities. It is proposed that under the Vice Executive Director, three Directorates are organized: the Directorate for Study and Design, the Directorate for Implementation, Operation and Maintenance, and the Directorate for Socio-Economic Development. The organization chart of alternative 1 is presented in Figure 3.7.3.

(a) Directorate for Study and Design

The Directorate for Study and Design is created from the present Department of Study and Design to reinforce study and design capability and planning competence. The Directorate is responsible for study and design ranging from preliminary study, master plan study, pre-feasibility study to detailed design. The Directorate is composed of six Departments: Planning, and Design, Engineering, Socio-Economic Analysis, Project Evaluation, Finance and Laboratory. Each Department is designed to specialize in sole tasks and duties.

(b) Directorate for Implementation, Operation and Maintenance

The proposed Directorate for Implementation, Operation and Maintenance is principally formed by transferring the tasks and functions belonging to the present Departments under the Directorate for Physical Infrastructure other than the Department of Study and Design. The main functions of the Directorate are to deal with not only project implementation comprising construction and its supervision, but also operation and maintenance activities. The present Department of Construction and the Department of Supervision are reformed and restructured into the new Departments according to projects. Three Regional Water Supply Systems are overseen and controlled by the new Directorate in order to undertake the efficient operation and maintenance of the facilities as well as resource allocation and management.

The Transbasin Project (hereafter the Project Department in this section) is also under the Directorate, functioning as one of the departments. The tasks and functions of the Project Department specifically deal with the operation and maintenance of all the facilities. The Project Department has six work Units: Water Management, Operation, Monitoring and Inspection, Procurement Services, Maintenance and Field Offices. Water Management Unit manages and monitors water flow and balance for: (i) Daule-Peripa to La Esperanza, (ii) La Esperanza to Poza Honda, (iii) Poza Honda to Mancha Grande, and (iv) river flows for irrigation, water supply and river maintenance. Operation Unit controls operation activities in accordance with directions and instructions from the Water Management Unit as well as standards and criteria to be established. Monitoring and Inspection Unit undertakes monitoring and inspection for pumping system, inlet and outlet facilities, and diversion tunnels according to monitoring and inspection regulations and criteria. Procurement Services Unit deals with inventory, ordering, purchase, and shipping of parts, equipment and materials necessary for the operation and maintenance. Maintenance Unit undertakes repairs and maintenance work for the facilities. Lastly, Field Offices are primarily responsible for daily or regular operation at sites in strict accordance with instructions and directions administrated by the Operation Unit. Its duties possibly cover daily and minor inspection for the facilities.

Programming and Control Department, directly under the Directorate, has the responsibilities for planning of the optimal water allocation and water management among the projects including the Transbasin Project. The Unit is also in charge of review and evaluation for water tariff rate for water supply systems, and is given the authority to propose new tariffs at least so as to cover the operation and maintenance expenses of the water supply systems.

(c) Directorate for Socio-Economic Development

The proposed Directorate for Socio-Economic Development is almost the same as the present organization, except for the inclusion of Department of Environment. The Department has three Units: Environmental Management Unit, Environmental Monitoring Unit, and Laboratory. The functions of environmental monitoring belonging to the Department of River Basin Management under the present organization is fully transferred to the new Department of Environment. The new functions and duties of the Department of Environment is, as proposed in environmental studies: (i) to conduct overall management of Environmental Management and Monitoring Plan (EMMP), (ii) to formulate plans and programs as well as to execute them, and (iii) to develop effective analysis methods and to conduct basic studies for the establishment of environmental standard and criteria.

Three Rural Development Departments for Poza Honda, Carrizal-Chone and Marginal Areas have active roles. These Departments are directly responsible for operation and maintenance of irrigation facilities and provision of various technical guidance to farmers in line with the promotion of rural development. The Departments are also in charge of collection of water charges for irrigation while assisting to organize farmers' cooperatives and associations.

Programming and Control Department has the responsibility for planning of the optimal water allocation and water management for irrigation use. This Unit is responsible for review and evaluation of water charge for irrigation use and has the authority to propose new rate for cost recovery of the irrigation facilities.

2) Alternative 2

Alternative 2 is intended to divide the Operative Level according to the functions by Directorate. Four Directorates constitute the Operative Level under the Vice Executive Director: the Directorate for Study and Design, the Directorate for Construction and Supervision, the Directorate for Operation and Maintenance, and the Directorate for Socio-Economic Development. Recommended organization chart of Alternative 2 is prsented in Figure 3.7.4.

(a) Directorate for Study and Design

The Directorate for Study and Design has six Departments and its functions are also the same as presented in Alternative 1.

(b) Directorate for Construction and Supervision

The proposed Directorate for Construction and Supervision is responsible for the construction and its supervision of all the works and projects, which belong to CRM. For the time being, the Directorate consists of four Departments by project, and Departments are acting as the executing agencies responsible for the construction and supervision for respective projects: Poza Honda Project, Carrizal-Chone Project, Water Treatment Project, and other Projects.

Programming and Control Unit is responsible for planning of resources allocation of all the projects under the Directorate. The Unit is in charge of monitoring and inspection for the projects under construction.

(c) Directorate for Operation and Maintenance

The Directorate for Operation and Maintenance is primarily responsible for the project management for all the projects and programs in operation. The Directorate has seven Departments, which all deal with the operation and maintenance of respective projects, comprising three Regional Water Supply Systems (Poza Honda, Chone and La Estancilla), two irrigation systems (Poza Honda and Carrizal-Chone), Other Projects and Transbasin Project.

Three Regional Water Supply Systems are respectively operated by each Department under the Directorate so as to bear the full operation and maintenance expenses. Two Departments responsible for irrigation systems has not only the functions and duties for the operation and maintenance of the irrigation facilities but also the responsibility for assisting farmers by extending various kind of technical guidance. The Department of Transbasin Project has the same structure and functions as presented in Alternative 1.

Programming and Control Unit is responsible for planning of the optimal water allocation and water management for the entire projects in operation and maintenance. The Unit is also in charge of review and evaluation for water tariff rates for water supply and irrigation use, and has the authority to propose new tariff rates according to its evaluation for cost recovery of the operation and maintenance.

(d) Directorate for Socio-Economic Development

The Directorate for Socio-Economic Development deals with economic and socially oriented projects and programs, which are specifically designed to promote social well-beings and to improve the living standard of the Province. The Directorate has five Departments: Enterprise Development, River Basin management, Environment, Rural Development and Programming & Control.

The first two Departments and Programming & Control have the same functions and duties as assigned under the present organization. The newly created Department of Environment has the same organization and functions as presented in Alternative 1. The Department of Rural Development is responsible for planning and program design intended to promote sicial well-beings and to improve the living standard for the purpose of self-reliant rural development.

3) Alternative 3

Alternative 3 is specially designed to establish new Directorate, which is responsible for the comprehensive management associated with the Transbasin Project. Once the Project is completed and ready for operation, the comprehensive management including the operation and maintenance of the Transbasin Project, reservoir operation of La Esperanza and Poza Honda, will be required. This is truly beyond the mere operation and maintenance of the facilities, but demands an integrated management system in consideration of the optimal water allocation among water users such as water supply, irrigation and other potential users including shrimp farmers. The alternative 3 fully considers the above functions and recommended organization chart of this alternative is shown in Figure 3.7.5.

(a) Directorate for Study and Design

The Directorate for Study and Design has six Departments: Planning and Design, Engineering, Socio-Economic Analysis, Finance, Project Evaluation, and Laboratory. Its functions and duties are the same as presented in Alternative 1.

(b) Directorate for Construction and Supervision

The proposed Directorate for Construction and Supervision is primarily responsible for the construction and its supervision of all the projects as is the case with Alternative 2. The Directorate has five Departments: Poza Honda Project, Carrizal-Chone Project, Water Treatment Project, Programming & Control and Other Projects.

(c) The Directorate for Socio-Economic Development

The Directorate for Socio-Economic Development has the responsibility for project planning and programming design with economic and social orientation serving for the improvement and promotion of social well-being and living standard for the

Province. The primal functions and duties are quite the same as the Directorate presented in Alternative 2, except for the Department of Environment.

(d) Directorate for Transbasin and Water Management

The proposed Directorate for Transbasin and Water Management has the full responsibility for overall management not only of the Transbasin but also reservoir operation of La Esperanza and Poza Honda including the water management for water use downstream. In order for CRM to manage and undertake its functions and duties effectively and rationally, the Directorate is formed with two Divisions: the Transbasin Operation and Maintenance Division and the Water Supply and Management Division.

The former Division is responsible for the operation and maintenance of all the facilities for the Transbasin, La Esperanza and Poza Honda. This Division is composed of seven Departments. Out of them, six Departments, i.e., Water Management, Operation, Monitoring and Inspection, Procurement Services, Maintenance and Field Offices, have in principle the same functions and duties as is the case with Alternative 1. They are all reinforced in organizational structure, personnel and technical competence. The Division also has the Department of Environment, which is assigned the same functions and duties proposed in Alternative 1. This is because most of the environmental concern will be possibly associated with the operation of the Transbasin Project as a whole.

On the other hand, the latter Division has five Departments: Poza Honda Irrigation, Carrizal-Chone Irrigation, Poza Honda Water Supply System, Chone Water Supply System and La Estancilla Water Supply System. They are responsible for the operation and maintenance of the respective facilities, billing water charge from water users, and provision of technical assistance and guidance to farmers in case of irrigation operation.

Programming and Control Department is in charge of water demand forecast by water users, planning of the optimal water allocation, and program design for the effective and efficient water management. The Department is responsible for review and evaluation of water tariff rates for irrigation and water supply, and has the authority to propose new rates.

4) Establishment of Committee for Water Resources Allocation and Management

In Ecuador, several authorities and agencies are involved in water management and use. However, no operational inter-institutional coordination among the authorities concerned exists presently. It is, therefore, proposed that before the Transbasin Project is completed, the competent Committee for Water Resources Allocation and Management (tentative) be established with objectives as follows:

(a) to formulate plans and programs for the better use and management of the valuable water resources, one of the national assets in an effective and efficient way;

(b) to undertake the optimal water resources allocation among the water users;

(c) to coordinate among the institutions concerned for the water resources allocation and management, and

(e) to assist each institutions to disseminate and develop various water management promotion activities for better understanding to the public.

The Committee will be organized with such institutions as: (i) the National Development Council (CONADE), (ii) the Ecuadorian Institute of Water Resources (INERHI), (iii) the Ecuadorian Institute of Sanitary Works (IEOS), (iv) the Manabi Rehabilitation Center (CRM), (v) Provincial Council, (vi) municipalities, and (vii) other parties including the Chamber of Shrimp Producer (CPC) and farmer's associations or cooperatives.

(3) Required Training Programs

To implement the effective operation and maintenance of the facilities of the Transbasin Project and other related facilities, CRM needs sufficient skills and knowledge base which scarcely exist at the moment. Training programs, which will devote to the establishment of the competent skills and knowledge base for CRM's staffs to carry out new roles and functions by developing their human resources, are proposed. The program will benefit CRM by ensuring that the proposed management, technical and administrative skills necessary to manage and operate the overall functions are retained in CRM's staff members. Along with the training programs, senior management must secure that other factors will be also in place in order for staff to undertake their duties and tasks adequately, including: (i) adequate staff academic backgrounds, (ii) enough number of staff members to perform functions effectively, (iii) well-defined functional and operational duties, (iv) adequate salary levels, and (v) fair treatment and adequate personnel appointment without political intervention.

1) Training Program Development

Extensive efforts should be directed towards the development of training programs aimed at increasing CRM's organizational functional skills of all professional, technical, administrative staffs and skilled labors. The training and professional development programs should encompass all the technical and administrative activities to reinforce the performance of all levels of human resources from managerial , senior class, middle class as well as staff level. The Directorate for Human Resources should first take initiative to work out training programs development on the basis of the extensive and overall evaluation of CRM's present level of technical competence, availability of human resources and required fields of professions and skills.

(a) On-the-Job Training

This type of training aims to develop staff skills at given level of proficiency. It can be flexibly implemented as short-term, routine, continuous, in-house, or on-the-job training for the existing and new staff members according to the technical backgrounds and competence. The objectives of this type of training is to strengthen the technical skills of staff.

(b) Formal On-Site Courses

Formal on-site courses are often appropriate mechanism to strengthen individual skills. This type of training can be provided to rectify the specific skill deficiencies of a certain department or a group of staff with similar technical backgrounds and job assignment.

(c) Workshops and Seminars

Workshops and seminars are less effective for individual training, but can be used to improve the effectiveness of a certain group. Workshops are an excellent way to train managerial, senior, and middle-level technical staff.

(d) Study Trip

Study trip is a conventional training activities. This type of training should be appropriately designed to avoid misuse and to cover specific fields such as engineering, operations, management, financing and tariff analysis.

(f) Internships

Internships can provide extended in-service training with other institutions. CRM should consider placing junior staff as intern, who are not in critical positions, i.e., to CEDEGE or other institutions in foreign countries where similar operation and management such as river basin management or watershed management are in place.

2) Proposed Training Courses

To implement CRM's functions effectively, CRM requires additional staff with proper training which will proceed hand-in-hand with various functional responsibilities. In the course of construction and subsequent operation and maintenance stage, fields and areas which require the reinforcement of CRM staff capabilities are as follows.

(a) Engineering Field

Training in engineering field includes structural design, construction plan, construction supervision, river improvement, water management, river basin management, soil mechanics and so forth. The purpose of this field of training is to strengthen planning capability, to improve operational manageability, and to upgrade supervisory capacity in particular for the Operative Level to build up the firm technical base.

(b) Socio-Economic Field

Training in socio-economic field covers rural development and regional planning, agriculture-related areas (crop and livestock, agronomy and agro-industry), ecology, industrial promotion and the environment-related areas (EIA, environmental management and environmental monitoring). This type of training aims to build up planning and program design capabilities which enable CRM to formulate plans, programs and projects towards the harmonized socio-economic development of Manabi Province.

(c) Field of Operation and Maintenance

Training for operation and maintenance involves operation, maintenance and control for pumping station, dam and related facilities, irrigation and water supply facilities. This training is intended to upgrade the operation and maintenance skills, and to improve work performance of routine activities and tasks.

(d) Managerial Field

Training in managerial field includes project management, finance, accounting, project evaluation, and water rate strategy. This type of training will be provided for managerial, professional, and senior personnel to develop managerial capability for CRM to attain institutional strength and self-financing institution.

(4) Establishment of Transbasin and Reservoir Management System (TRMS)

Once the Transbasin Project is completed, CRM requires the comprehensive management techniques and skills comprising the operation and control of the Transbasin itself, and reservoir operation for La Esperanza and Poza Honda dams, in due consideration of water use and allocation. This may lead CRM to establish a comprehensive Transbasin and Reservoir Management System (TRMS) as an integrated system. TRMS will be developed to serve for the prompt management decision-making purposes as well as to secure the reliable operation and control of the overall facilities as a management tool.

If desired, TRMS will be the centralized computer information and management system, which monitors real-time information such as water inflow from Daule-Peripa, water level observation of respective reservoirs, water flow for river maintenance and water use downstream. In practice, however, TRMS may be progressively upgraded according to the improvement of the technical base, availability of human resources, development of database and financial requirement.

TRMS may be made up of central office and field offices. Based upon the information transmitted from each field office to the central office where data are simultaneously processed, and proper instructions and directions will be returned back to the field offices for the operation and control.

TRMS, for the time being, is a proposed idea and will be elaborated further if deemed to be necessary.

3.7.4 Proposed Institutional Programs and Implementation Schedule

(1) Proposed Institutional Programs

Proposed programs are developed on the basis of an integrated set of principles with which CRM's institutional capability will be reinforced. They are largely classified into: (i) institutional infrastructure development, (ii) human resources development and training, and (iii) operation and maintenance plan development.

1) Institutional Infrastructure Development

Institutional infrastructure development is intended to build up CRM's organizational capacity so as to meet the increasing and demanding roles and functions particularly in the operation and maintenance stage of the Transbasin Project and possibly dam facilities. Strength of the institutional infrastructure depends largely upon: (i)suitability of organizational structure, (ii) authorities given to CRM, in which CRM undertakes its functions, (iii) functions, duties, and tasks assigned to directorates, departments and units, (iv) availability of human resources, i.e., degree of proficiency of professions and technical skills, and (v) eligibility and effectiveness of system configuration.

For the time being, CRM's organizational structure in the operation and maintenance stage is still under study as proposed in Alternatives. In view of this, programs and activities for the institutional infrastructure development are listed in broad sense, and will be well defined in the course of the study.

(a) Assessment of Present Institutional Capacity

CRM should first assess its own institutional capacity. CRM is presently undertaking part of this program through temporary Institutional Reinforcement Planning Unit (PFI). However, due to limited personnel in PFI, its activities are rather restrained.

This program aims to evaluate the institutional strength, weakness and drawbacks, to assess institutional constraints, and to clarify crucial problems and issues to be rectified. This task is proposed to be collaborated with the Directorate for Human Resources to evaluate the availability of human resources in CRM.

(b) Study for Institutional Development

Study for institutional development follows the assessment of the present institutional capacity. The purpose of the study is to propose the most appropriate CRM's institution including organizational structure, personnel allocation, and clarification of functions, duties, and tasks to respective directorates, departments and units. To carry out this program, it is proposed that CRM either sets up committee comprising representatives from each Advisory, Auxiliary, and Operative Levels, or reinforces the present PFI.

(c) Administrative Procedures

Following the study for institutional development, a series of administrative procedures are required to officially revise the institutional settings. CRM needs to take due administrative actions to higher and legitimate authorities to obtain official approval. CRM also needs to devise its internal regulations and rules.

2) Human Resources Development and Training

Human resources development is a vital segment to reinforce and upgrade the institutional capacity. In this sense, training programs must be well designed and the programs must be also effectively implemented.

(a) Assessment of CRM's Present Human Resources

This program is designed to capture the whole facets of CRM's human resources in an objective way. Assessment includes levels and degrees of professional competence, technical skills and their proficiencies. The program also intends to clarify the availability and distribution of human resources or professions in CRM.

(b) Examination of Personnel Staff Needs and Fields of Professions

Personnel staff needs and fields of professions are closely examined on the basis of the fine assessment of CRM's human resources and future requirements. This program clarifies the eligibilities of personnel requirements in need, and also evaluates the possibility of efficient use of existing human resources, i.e., by means of inputs of adequate training or job transfer. This is also the case with fields of professions. Possible fields of professions are listed in the proposed training programs in the previous section. This program is designed to be implemented in parallel with the institutional development.

(c) Development of Training Programs

On the basis of the examination of personnel staff needs and fields of professions, necessary training programs are developed. This program also assesses the financial requirements, and the availability of domestic and foreign training resources. As proposed, the combination of the fixed types of training will be implemented according to the requirements, urgency and financial constraints.

(d) Implementation of CRM Personnel Training

Following the development of training programs, intensive training is implemented to technical and administrative staff. Training covers all the personnel in respective levels of administrative hierarchies.

(e) Establishment of Recruitment System and Employment Regulation

Even though CRM undertakes training to upgrade the capacity of the existing human resources, it may encounter the absolute shortage in workforce. Presently CRM has no rules and systematic procedures for staff recruitment. Moreover, political intervention has been practiced frequently in personnel appointment or transfer.

In view of this, CRM needs to establish systematic recruitment system for new staff employment. In addition, CRM is to establish employment regulation which secures fair and transparent staff treatment.

3) Operation and Maintenance Plan Development

Well designed operation and maintenance plan is essential to manage the overall facilities and to make the best of the water resources in an effective and efficient way. This program includes the establishment and development not only for the Transbasin and dam reservoir operation, but also for the water supply and irrigation systems. This is because CRM is required to become self-financing institution by the new law No. 18. To this end, CRM needs to manage and supervise all the systems not only from the technical but also from the financial viewpoints.

(a) Development of Water Resources Allocation and Management Plan

This program is of vital importance to take advantage of the water resources effectively. For this, the Committee for Water Resource Allocation and Management is to be set up as a steering committee, to coordinate water allocation, use and management. CRM, the executing agency of the Transbasin Project and dam operation, works out the practical and operational water resources allocation and management plan in coordination with the authorities concerned.

(b) Establishment of Management Plan for Transbasin and Reservoir Operation

Following the development of the water resources allocation and management plan, CRM is exclusively in charge of devising the comprehensive operation and maintenance plan. For this, operation and maintenance criteria and regulations must be first formulated. Also worked out is the practical operation scheme, i.e., centralized remote operation system, central control - site operation system, or independent on-site operation system. Transbasin and Reservoir Management System (TRMS) may serve for the efficient and accurate operation if designed and established appropriately.

(c) Establishment of Management Plan for Water Supply Systems

This program is intended to establish the effective management plan to control the operation and maintenance of the Regional Water Supply Systems. In addition, this program aims to reinforce the administrative capacity such as reporting, accounting, billing and bill collection.

(d) Establishment of Management Plan for Irrigation Systems

CRM needs to establish the practical and comprehensive management plan for two irrigation systems. Management plan includes the physical operation and maintenance of the irrigation facilities, provision of the technical assistance and guidance, and sub-programs to increase agricultural productivity.

(2) **Implementation Schedule**

All the programs and activities are tentatively scheduled in consideration of the commencement of the operation and maintenance activities in the beginning of year 2000. Tentative implementation schedule is shown in Figure 3.7.6.

3.7.5 Reformative Law to the Constitutive Law of CRM

From July 5, 1994, CRM has a new law, namely, Law 57 or " Reformative Law to the Constitutive Law of the Manabí Rehabilitation Center". This Law defines the Manabí Rehabilitation Center as an institution of Public Right with legal capacity with a social and public purpose, with domicile in the city of Portoviejo and with jurisdiction in the Province of Manabí; having as objective the following;

Art.2

a) To attain the entire socio-economic development of the Province of Manabí;

b) To prepare development plans, programs and projects in Manabí province in conformity with the national plan, in coordination with public and private institutions of the region to optimize the use of available resources;

c) To plan and execute water resources development project, especially the Daule-Peripa~La Esperanza~Poza Honda~Río Chico transbasin project; environmental conservation including water supply and sewerage systems for wastewater and rain water; programs for control and management of the ecological systems, especially the flora and fauna, toxic waste from industries, river cleaning, mangrove recovery; and urban planning and road paving in the province of Manabí;

d) To organize groups of provincial people for an efficient use of irrigation systems, control and care of the ecological system by the zones of the province, to participate together with the municipal councils and other public and private institutions involved in them, with the purpose to make a centralized operation and administration avoiding the duplication of the bureaucracy in each municipality and waste of economic resources; and,

e) To advice municipalities on urban development.

Art. 4:

The directive structure of the Centro de Rehabilitación de Manabí is as follows: Board of Directors, General Manager and Technical and Administrative Departments.

Art. 5:

The Board of Directors of the Centro de Rehabilitación de Manabí is the top authority of Directory level of the institution and shall be composed of the following members:

a) A representative of the Constitutional President of the Republic, who will lead the Board and shall be a resident of the province of Manabí;

b) The Secretary General of Planning of the National Development Council "CONADE" or his delegate, a citizen of Manabí with ample knowledge of National Development Planning;

c) The Governor of the province, or by delegation, the Deputy Governor;

d) The Chairman of Manabí Provincial Council or in his absence the Vice-Chairman of the Provincial Council.

e) The representative of the Catholic Church of higher hierarchy with residence in Manabí;

f) A representative nominated by the municipalities of Manabí;

g) A representative elected by the Industries, Commerce and Construction Chambers;

h) A representative of the Provincial Agricultural Center;

i) A representative of the universities of Manabí; and

j) A representative of workers and farmers organizations with legal capacity duly acknowledged in Manabí.

One of the duties of the Board of Directors is to know, to approve and to authorize the celebration of contracts, agreements, local or foreign loans and legal acts that means a commitment for the institution (Article 9, literal f).

The administration of CRM shall be under charge of the General Manager to be nominated by the Board of Directors, top executive level, who will be the legal representative of the institution.

One of the duties of the General Manager is to act as Secretary of the Board of Directors of CRM (Art. 11)

The Technical and Administrative departments are the operative level of the institution and are composed of:

a) The Technical Department with the hydraulic, sanitation, ecosystem and planning sections;

b) The Administrative Department with the sections of secretariat, finances, legal, communications, press, human resources and internal auditing. (Art. 12)

The CRM is authorized to enter into contracts for local and foreign loans, as well as to carry out any kind of financial transactions authorized by the laws. The National Government will guarantee loans directly contracted by CRM. (Art. 14)

The CRM shall be exempted from general and special tax, rates and prevailing levies including the duties and rights to import equipment, machinery, spare parts, accessories and other materials necessary for a better compliance of its objectives, as well as the aggregated value tax (IVA) on services rendered. (Art. 16)

CRM can enter into contracts or agreements for the execution of studies and works with natural and juridical persons of Public or Private Right, national or international, in accordance with the provisions of the pertaining laws. (Art. 17)

A organization chart based on the interpretation of the Law 57 and its regulation, has been prepared by the JICA Study Team and is shown in the Fig. 3.7.7

3.7.6 Project Organization during Construction

A transbasin project office is planned to be organized towards the construction of the Project. The proposed organization of the transbasin project office during the construction of the Project facilities is shown in Fig. 3.7.8. Project Manager will be appointed by the General Manager of CRM for the construction supervision of the Project.

The main project office is planned to be located at the Severino pumping station site and the branch offices will be located at the Conguillo tunnel inlet site and the Poza Honda tunnel inlet site. These three offices will be interconnected by a telecommunication system together with CRM's headquarters in Portoviejo. An international consultant as well as an Ecuadorian Consultant will be employed by CRM to assist CRM in construction supervision of the Project. The consultants will work as an integral part of the CRM staff for construction supervision.

Project organization during the operation and maintenance of the Project is discussed in Section 4.7 hereafter.

Chapter 4

DESIGN

Chapter 4 DESIGN

4.1 General

The basic design has been made in order to determine the type and basic dimensions of the permanent facilities of the Project. Taking into account the design criteria and the data collected by the field investigation, comparative studies of various cases have been carried out to determine the optimum scale, location and elevation of the structures from the technical and economic points of view so as to meet the requirements in quality and function of the Project.

The main components of the Project studied in the basic design are as follows:

(1) Daule Peripa ~ La Esperanza Transbasin

- Conguillo Inlet
- Diversion Tunnel
- Membrillo Outlet
- Conguillo Work Adit
- El Guasumo Work Adit
- Membrillo Work Adit
- Conguillo Access Road
- El Guasumo Access Road
- Membrillo Outlet Access Road

(2) La Esperanza Poza Honda Transbasin

- Severiono Pumping Station
- Severiono Penstock
- Severino Head Tank
- Severino Open Channel
- Severino-Caña Dulce Inspection Road
- La Esperanza Poza Honda Diversion Tunnel
- Los Cuyuyes Outlet
- Severino Access Road
- Caña Dulce Access Road
- Los Cuyuyes Access Road
- Severino Substation
- Daule-Peripa ~ Severino Transmission Line

(3) Poza Honda ~ Mancha Grande Diversion Tunnel

- Poza Honda Inlet
- Poza Honda ~ Mancha Grande Diversion Tunnel
- Mancha Grande Outlet
- Poza Honda Work Adit
- Los Cuyuyes Access Road
- La Seca Access Road
- Poza Honda Inlet Access Road

4.2 Daule-Peripa ~ La Esperanza Transbasin

4.2.1 Conguillo Inlet

(1) Present Site Conditions

A part of the tunnel inlet structure was constructed in 1990 at the Conguillo site with the bottom level of the open approach channel at EL. 66.0 m where the original riverbed level was EL. 69.0 m. Field survey in early 1994 revealed that the approach channel had already be sedimented up to around EL. 70 m in six years after creation of the reservoir.

Water hyacinths have densely covered the reservoir surface in and around the inlet site which may hamper a smooth water intake into the tunnel.

(2) Location of Tunnel Inlet and Intake Water Level

To avoid possible sedimentation problem, shifting of the inlet site to downstream of the Conguillo river was first studied and concluded that the shifting would increase the tunnel length and necessitate a large scale coffering for construction, and not economically feasible.

The next idea was to set the intake water level at higher level than the existing EL. 66.6 m, providing a barrier wall in front of the constructed tunnel inlet structure to protect sediment from blocking the tunnel inlet. This idea has also finally rejected because of the following considerations.

(i) It is almost impossible to reduce the Daule-Peripa water level down to EL. 66 m, which requires a large scale coffering for construction in front of the existing inlet structure or an under-water construction. Both are technically difficult and economically costly.

(ii) If the intake water level is elevated from the existing EL. 66.6 m, water transbasin from Daule-Peripa to La Esperanza is made more frequently impossible taking into account LWL of Daule-Peripa of EL. 60 m. It is of vital importance to secure water transbasin from Daule-Peripa as longer time as possible not to cause water deficit in the project area.

It was, therefore, decided finally to utilize the existing inlet structure as it is with the following countermeasures.

(i) To avoid sedimentation problem, the existing sedimentation in and arround the 36 m long approach channel is removed by dredging to the original bottom of EL. 66 m. The cleaned approach channel is to be kept by maintenance dredging after construction of the tunnel.

(ii) To protect the tunnel inlet from water hyacinths, a trash-boom with wire net is provided around the inlet. Water hyacinths entering over or under the trash-boom should be removed manually.

(3) Inlet Tunnel and Valve Chamber (Inlet Shaft)

The inlet tunnel of 15 m long having a diameter of 4.6 m in circular shape is designed as a connection tunnel between the existing inlet structure and the valve chamber. In order to prevent the leakage water from the reservoir, the inlet tunnel is plugged with concrete after steel pipes and valves have been installed.

The valve chamber is designed as vertical shaft structure of an oval shape having a dimensions of 20.0 m in length, 16.0 m in width and 25.1 m in depth from the roof level of EL. 90.2 m. Size of the valve chamber is determined taking account of the spaces for providing the pits of cone sleeve valves and butterfly valves. The oval shape valve chamber is adopted to better withstand against rock and water pressures acting around it. The valve pits of 5.2 m x 5.2 m x 10.4 m in size are designed beneath the valve chamber to dessipate energy of water discharged from the cone sleeve valves.

Floor slab is provided at El 74.0 m for the purpose of operating the cone sleeve valves. Its elevation was set taking account of the maximum water level due to mis-operation of the sleeve valves. Floor slab at EL. 82.0 m is provided to reinforce the structure of the inlet shaft.

The Conguillo Inlet House is a one story reinforced concrete structure to house the access stairs and ventilation fans for the lower parts of the inlet facilities. Since it will not be usually occupied, the architectural furnishings and finishes will be kept to a basic minimum. Building facilities shall be composed of electric lighting and ventilation system.

(4) Discharge Control Valves

Two steel pipes with a diameter of 1,400 mm are embedded at EL. 67.2 m and one steel pipe with a diameter of 800 mm is embedded at EL. 65.5 m in the constructed inlet structure with a butterfly valve at each pipe. Steel pipe of 800 mm in diameter is installed to supplement the discharge of the two larger pipes and for the purpose of clearing the sedimentation accumulated in front of the steel pipes. These three pipes are extended to lead water into valve pits where the discharge through the two larger pipes will be controlled by a sleeve valves.

The cone sleeve valves are installed for purposes of energy dissipation and flow control. Four butterfly valves of 1400 mm in diameter are intalled as guard valves for main valves (cone sleeve valves).

(5) Hydraulic Design

The maximum operational water level in valve pit is EL. 69.00 m at the maximum discharge of 18.0 m^3/sec. This water level was obtained from the result of non-uniform flow calculation in the diversion tunnel under the condition that water level at tunnel outlet is EL. 63.5 m(Target water level).

(6) Structural Design

The structural analysis for the inlet tunnel and the inlet shaft is carried out using computer program, SAP 90 (Authorized computer program in Ecuador), and in accordance with the Ecuadorian Building Code. The inlet structures are analyzed as frame structure under the following design conditions.

The design conditions to be used for the structural analysis are as follows;

- Design loads

Case 1 : After construction
Dead weight of lining concrete + Bedrock pressure + Water pressure

Case 2 : During construction
Dead weight of lining concrete + Bedrock pressure

+ Backfill grout pressure + Water pressure

- Design values

Design values of bedrock

Unit weight	1.8 tf/m^3
Elasticity modulus	20,000 kgf/cm^2
Cohesion	5.0 kgf/cm^2
Internal angle of friction	40.0 degree

Design values of concrete

Unit weight	2.4 tf/m^3
Elasticity modulus of concrete	235,000 kgf/cm^2
Elasticity modulus of reinforcing bar	2,100,000 kgf/cm^2
Ultimate tensile strength of reinforcing bar	4,200 kgf/cm^2

The design of the Conguillo inlet structure is shown on Drawing Nos.1-DT-002 to 1-DT-006.

4.2.2 Daule-Peripa ~ La Esperanza Diversion Tunnel

(1) General

At the basic design stage, the rout of the diversion tunnel was selected so as to be shortest length between the inlet and outlet and a curve was provided in the rout to obtain the sufficient covering depth from the ground surface. From the result of further study, additional curve at 550 m upstream from the tunnel outlet is provided to obtain the sufficient covering depth from the riverbed of the Mulato river as shown on Drawing.

A water conveyance tunnel may be designed either as a pressuse flow tunnel or a non-pressure flow tunnel. For the proposed water transbasin project, a non-pressure, free flow tunnel is selected in view of the following factors.

- Geological conditions consisting of soft sandstone or mudstone with the compressive strength of about 60 kg/cm^2 will require strong and costly tunnel lining in case of a pressure flow tunnel.

- A pressure tunnel is subject to water hammering and an alternate pressure and non-pressure tunnel is subject to air hammering, both of which require a careful operation and a sophisticated apparatus, resulting in high operating and maintenance cost.

Thus, the diversion tunnel is designed as a non-pressure tunnel of 8.3 km long having a diameter of 3.7 m in standard horseshoe section and its slope is 1:1,500. The mean flow velocity in the tunnel is 1.84 m/sec at the maximum discharge (18.0 m^3/sec).

On the other hand, a tunnel design is closely related with a tunnel construction methods. There are several tunnel excavation method as well as tunnel lining or supporting methods as follows.

A. Tunnel excavation methods

A-1 : Blasting
A-2 : Tunnel boring machine (TBM)
A-3 : Excavator with load headers
A-4 : Shield tunneling
A-5 : TBM-Shield tunneling

B. Tunnel lining or supporting methods

B-1 : NATM
B-2 : Reinforced concrete lining
B-3 : Plain concrete lining
B-4 : Prefabricated concrete panels or segments

Blasting (A-1) is a conventional and most common tunnel excavation method, applicable both for hard and soft rocks and for any shape of tunnel section. TBM (A-2) is developed for tunnel excavation through hard rocks, applicable generally for a circular tunnel section. Excavator with load headers (A-3) is suitable for soft rocks and applicable for any shape of tunnel section. Shield tunneling (A-4) is developed for tunnel excavation through soils, applicable generally for a circular tunnel section. TBM-Shield tunneling (A-5) has recently be developed for tunnel excavation through soft rocks, applicable generally for a circular tunnel section. For the proposed transbasin project, the three methods, A-1, A-3 and A-5, will be conceivable.

NATM (B-1) is a common method as a primary supporting system with shotcreting and rock bolting, suitable for soft rocks. Reinforced concrete lining (B-2) is a conventional method applicable for both soft and hard rocks. Plain concrete lining (B-3) is also a conventional method applicable for soft rocks as a secondary lining and for hard rocks. Prefabricated concrete panels (B-4) are erected with a special machinery usually associated with the shield tunneling (A-4) or TBM-shield tunneling (A-5). B-4 is generally applied as a primary supporting, combined with A-4 or A-5.

It is decided to design the diversion tunnel as a combination of A-3, B-1 and B-3, based on the following considerations.

- Tunnel excavation with load headers (A-3) is the most effective for soft rocks and can minimize over-excavation as compared with blasting (A-1), adaptable for a horse-shoe section which is hydraulically ideal for non-pressure tunnels.

- NATM (B-1) is flexible to follow varied geological conditions during construction and considered to be a suitable method for soft rocks and as a primary supporting. If NATM is used as a final tunnel lining through soft rocks, it may cause an excessive maintenance cost during operation.

- A secondary support by plain concrete lining (B-3) is necessary to secure a smooth flow of water and to be a practically maintenance free diversion tunnel.

An alternative design of the proposed one may be a combination of A-5 and B-4 or A-5, B-4 and B-3, which, however, was rejected based on the following considerations.

- Only specialized and experienced contractors can apply this fully mechanized method of TBM-Shield tunneling (A-5) with prefabricated concrete panel lining (B-4) , which is not suitable for an international competitive bidding. This alternative design may be considered when a specialized contractor offers to apply it during tender and contact negotiation period.

- This method presents more difficulties when rock conditions are variable and when working sites are subject to excessive leakage water.

- Quality control of prefabricated concrete panels to be manufactured at the construction site will be difficult, resulting in poor quality of lining. The lining method (B-4) is acceptable only as a primary supporting system.

- Even if a secondary lining with plain concrete (B-3) is not taken into account, construction cost will be slightly higher in this alternative design than that of the proposed design, though a construction period may be reduced to a certain extent.

As mentioned in Section 3.5.1, the bedrock surrounding the tunnel is composed of sub-horizontally bedding mudstones and sandstones which occur alternately. From the results of the geological investigation, it turned out that unconfined compressive strength and elastic modulus of the bedrock were considerably low. The bedrock of this sort cause deformation into the tunnel cave due to lack of the strength of the bedrock after the tunnel cave has been made. The bedrock surface of the periphery of the tunnel cave is properly and timely supported by combination of shotcrete and systematic rock bolt pattern based on the results of the convergence measurements and obsevation of the exposed rock conditions just after excavation, so that NATM (New Austrian Tunneling Method) is adopted. Drain holes are provided in the crown part of the tunnel to avoid stability loss and collapse by saturating with ground water in the periphery of the tunnel cave. The tunnel typical cross sections are determined based on the results of the tunnel structural analysis by FEM.

Three work adits will be provided at Conguillo, El Guasmo and Membrillo to facilitate and expedite the tunnel constuction works.

The design of the Daule-Peripa ~ La Esperanza diversion tunnel is shown on Drawing Nos.1-DT-001 and 1-DT-007.

(2) Hydraulic Design

At the basic design stage, alignment, inside diameter, gradient and outlet invert level of the tunnel were decided according to the results of the following comparison study.

Flow capacity of the tunnel has been decided to be 18 m^3/s according to the interinstitutional agreement between CEDEGE and CRM. An open and free flow is proposed as far as possible to make the tunnel flow stable. A standard horse-shoe section is applied which is generally accepted as the most appropriate section for an open free flow tunnel.

A horizontal alignment of the tunnel should be straight as far as possible to minimize the tunnel length. Since the tunnel flow is planned by gravity, a steeper gradient is more economical because a smaller diameter tunnel can have the required flow capacity.

The proposed tunnel outlet site is near Membrillo village where the riverbed is at EL. 62 m. The following alternatives have been studied from the technical and economic viewpoints.

Alternative	Tunnel Diameter	Tunnel Length	Tunnel Gradient	Outlet Invert Level
A	3.7 m	8.3 km	1/1,500	EL. 60. 5m
B	4.0 m	8.3 km	1/2,070	EL. 62.0 m
C	3.7 m	8.6 km	1/1,500	EL. 60.3 m
D	3.5 m	9.2 km	1/1,200	EL. 58.3 m

To compare the above four alternatives on an equal basis, water levels at the tunnel outlet are assumed to be the target water level to keep an open flow in the tunnel. If the target water level is set lower, pumping head will be higher at the Severino pumping station. Therefore, energy cost is included in the evaluation as follows.

Alternative	Water Depth (m) (1)	Target Water Level (EL. m) (2)	Average R.W.L. (EL. m) (3)	ΔH (m) (4)	Incremental Energy (MWh) (5)
A	3.0	63.5	58.7	0	0
B	3.2	65.2	60.0	-1.3	-2,120
C	3.0	63.3	58.5	0.2	330
D	2.8	61.1	57.0	1.7	2,770

Remarks:

(1) Water depth = 0.8 x Tunnel Diameter

(2) Tunnel water level at outlet = Outlet invert level + water depth = Target water level

(3) From reservoir operation study

(4) Alt. A is considered to be a base case. Difference in average reservoir water level of La Esperanza

(5) Average annual transbasin volume from La Esperanza to Poza Honda is 213 MCM, equivalent to 6.8 m^3/s on a constant basis. Then,

$P (kw) = \eta g\ QH = 13 \times 6.8 \times 1.0\ m = 88.4\ kw$

$88.4\ kW \times 8{,}760\ hrs./year = 774\ MWh/year/m$

$Incremental\ energy = 774\ (MWh/year/m) \times \Delta H$

Construction cost of the tunnel is estimated for the Alt. A to be US$22.6 million in the feasibility study. Total cost including the construction cost and energy cost is estimated for each Alternative as shown below.

(Million US$)

Alternative	Construction Cost (1)	Capitalized Energy Cost (Incremental) (2)	Total Cost (3)
A	22.6	0	22.6
B	25.7	-0.4	25.3
C	23.4	0.1	23.5
D	22.9	0.8	23.7

Remarks:

(1) Construction cost = $\left(\frac{D + 0.8}{3.7 + 0.8}\right)^2 \times \frac{L}{8.3} \times 22.6$

(2) Capitalized incremental energy cost
= Incremental energy x US$0.06/kWh x 10 (Capitalization Factor)

(3) Total cost = (1) + (2)

In conclusion, Alternative A was selected as the best one and its technical features are as follows.

Section	:	Standard horseshoe
Diameter	:	3.7 m
Flow	:	Open free flow
Length	:	8.3 km
Slope	:	1:1,500

Invert level

Inlet	:	66.0 m
Outlet	:	60.5 m

Target water level of La Esperanza: EL. 63.5 m
Plan and profile of the diversion tunnel is shown on Drawing 1-DT-001.

(3) Structural Design

The tunnel structural analysis was carried out for the following two parts. The main tunnel part was analized by Finite Element Method (FEM) based on the theory of viscoelasticity and the transition parts at the inlet and outlet of the tunnel were carried out by frame analysis.

(A) Tunnel Structural Analysis

Tunnel structural analysis was carried out by Finite Element Method to study the followings;

(i) Bending moment, shearing and axial force acting on shotcrete and rock bolt from the time of immediately after tunneling up to 12 months for determining necessary thickness of shotcrete, interval of rock bolts, etc., as a primary lining.

(ii) Timing of secondary lining, and

(iii) Safety of secondary lining.

(a) Procedure of Analysis

The analysis is composed of 2 steps. The first step is an analysis of bending moment, shearing and axial force to act on primary lining consisting of shotcrete and rock bolts. The second step is an analysis of the maximum stress, minimum stress, maximum shear stress, etc., to act on lining concrete. Based on this analysis, thickness of shotcrete and arrangement of rock bolt as a primary lining and thickness of concrete as a secondary lining are determined.

(b) Conditions of Analysis

Initial stress in the proposed tunneling route is estimated on the basis of overburden from ground surface to the tunneling elevation. The initial stress is classified into 3 cases i.e., Cases A-1, A-2 and A-3 as shown in Figure 4.1.1 and in Table 4.1.1.

Design values of foundation rock at the proposed route of Daule-Peripa ~ La Esperanza diversion tunnel are shown in Table 4.1.1, and design values of shotcrete, rock bolt and lining concrete are shown below.

(i) Primary Lining
- Shotcrete
  - Design compressive strength : 210 kgf/cm^2
  - Shear strength : 42 kgf/cm^2

- Unit weight : 2.40 tf/m^3
- Elastic modulus : 235,00 kgf/cm^2 (at age of 28 days)
- Thickness : 10 cm or 15 cm

- Rock bolt (SD35, D25)
  - Tensile strength : 17.6 t/m^2
  - Cross sectional area : 5.067 cm^2
  - Elastic modulus : 2,100,000 kgf/cm^2
  - Length : 2.0 m

(ii) Secondary Lining

- Lining concrete
  - Design compressive strength : 210 kgf/cm^2
  - Unit weight : 2.40 tf/m^3
  - Elastic modulus : 235,000 kgf/cm^2
  - Poisson's ratio : 0.20
  - Thickness : 30 cm

Typical cross section of the tunnel is shown in Figure 4.1.2.

(c) Structural Analysis

Tunnel structural analysis was carried out by FEM. Input data meshes were made for the analysis, as shown in Figure 4.1.5. The base rock is considered as a visco-elastic material.

(d) Results of Analysis

The results of tunnel structural analysis are described hereunder.

(i) Case A-1: Overburden 60 m (1,100 m long, 13% of total tunnel length)

- Primary lining

  Stress resultant in the shotcrete (thickness 10 cm) is less than 50% of the strength of the shotcrete at the elapsed time of 12 months after tunneling. Axial force which acts on the rock bolt is less than 50% of the tensile strength of the same (refer to Table 4.1.3).

  Increment of compressive stress and tensile force which acts on the shotcrete and rock bolt from immediately after tunneling to 12 months is shown in Figure 4.1.7.

- Secondary lining

  The maximum compressive stress, maximum tensile stress and maximum shear stress which act on the concrete are less than allowable strength of concrete (refer to Table 4.1.4).

(ii) Case A-2: Overburden 140 m (2,400 m long, 29% of total tunnel length)

- Primary lining

  Stress resultant in the shotcrete of 10 cm thick is less than 60% of the strength of the shotcrete at the elapsed time of 12 months after tunneling.

  Increment of compressive stress and tensile force which act on the shotcrete and rock bolt is shown in Figure 4.1.8.

- Secondary lining

  Various stresses in the concrete are less than the strength of concrete (refer to Table 4.1.4).

(iii) Case A-3: Overburden 250 m (4,800 m long, 58% of total tunnel length)

- Primary lining

  Compressive stress in the shotcrete exceeds its strength at the time of 4 to 5 months after tunneling. On the other hand, tensile force in the rock bolt is around 95% of its strength at the time of 12 months after tunneling (refer to Table 4.1.3).

  Increment of compressive stress and tensile force acting in the shotcrete and rock bolt is shown in Figure 4.1.9.

  The results of the analysis suggest that secondary lining has to be done within 3 months after tunneling.

  Since the tunnel length of the case A-3 is more than a half of the total, construction schedule for this tunnel should be prepared so that the concrete lining is started within 3 months after tunneling.

- Secondary lining

  The maximum compressive stress is 19.6 kgf/cm^2, maximum tensile stress is 0.5 kgf/cm^2 and maximum shear stress is 9.5 kgf/cm^2 as shown in Table 4.1.4. Out of those stresses, the maximum shear stress is over its allowable stress (8.5 kgf/cm^2), but it acts on a limited portion and average maximum shear stress is 8.4 kgf/cm^2. Thus, basically, the lining concrete can be designed as non-reinforced concrete.

Detailed data obtained by FEM is shown in the Design Calculation Report.

Tunnel type to be applied for Daule-Peripa ~ La Esperanza diversion tunnel is shown in Figure 4.1.13.

The required thickness of shotcrete and number of rock bolts are determined based on the results of the structural analysis by FEM. From the results of analysis mentioned above, typical cross section of Type II is applied to the main part of the Daule Peripa ~ La Esperanza diversion tunnel (refer to the table shown below). However, Types I, III and IV are added to the typical cross section to cope with unforeseen geological conditions to be encountered during the construction.

Therefore, the following four types are designed to be applied in the diversion tunnel.

	Type I	Type II	Type III	Type IV
Place		As shown on Drawings		
Distance applied (m)	0	8,296	0	0
Shotcrete thickness (cm)	10	10	15	10
Rock bolts	D25x5Nos.x2m (1.2m pitch)	D25x8Nos.x2m (1.2m pitch)	D25x8Nos.x2m (1.2m pitch)	D25x8Nos.x2m (1.2m pitch)
Concrete lining (cm)	30	30	30	30
Reinforcement	Nil	Nil	Nil	Nil
H-steel support	Nil	Nil	Nil	H-125, 1.2 m pitch max.

The tunnel typical cross sections are shown on Drwaing No.1-DT-007.

(B) Structural Analysis of Tunnel Inlet and Outlet Parts

The design conditions to be applied for the structural analysis of the tunnel transition parts at the inlet and outlet are as follows;

- Design loads
  - Case 1 : After construction
    Dead weight of lining concrete + Bedrock pressure + Water pressure
  - Case 2 : During construction
    Dead weight of lining concrete + Bedrock pressure + Backfill grout pressure + Water pressure

- Design values

Design values of bedrock	Inlet part	Outlet part
Unit weight	1.8 tf/m^3	1.7 tf/m^3
Elasticity modulus	20,000 kgf/cm^2	10,000 kgf/cm^2
Cohesion	5.0 kgf/cm^2	2.5 kgf/cm^2
Internal angle of friction	40.0 degree	35.0 degree

Design values of concrete	
Unit weight	2.4 tf/m^3
Elasticity modulus of concrete	235,000 kgf/cm^2
Elasticity modulus of reinforcing bar	2,100,000 kgf/cm^2
Ultimate strength of reinforcing bar	4,200 kgf/cm^2

Cross sections of the tunnel transition parts at the inlet and outlet are shown on Drwaing Nos.1-DT-006 and 1-DT-009.

4.2.3 Membrillo Outlet

Location of the tunnel outlet was decided so as to minimize the tunnel length and taking into account the topographic and geological conditions at the site. The riverbed elevation at the Membrillo outlet site is around EL. 62 m, which is higher than the tunnel outlet invert level by about 1.5 m. Excavation of the river channel for a length of about 60 m is necessary from the outlet to downstream to secure a smooth flow out from the tunnel to the river or to the reservoir.

Average reservoir water level of La Esperanza is calculated to be EL. 58.7 m with the target water level of EL. 63.5 m. This means that the La Esperanza water level draws down below the riverbed elevation of EL. 62 m almost every year and sedimentation will be washed down during the low level period by the own basin flow as well as the diverted flow of 18 m^3/s.

The design of the Membrillo outlet is shown on Drwaing Nos.1-DT-008 and 1-DT-009.

4.2.4 Work Adits

Three work adits are to be provided as follows to facilitate and expedite the tunnel construction works. Locations of the work adits are decided according to the construction plan and taking account of the rout of access roads.

Conguillo work adit	192 m downstream from the tunnel inlet
El Guasmo work adit	3,439 m downstream from the tunnel inlet
Membrillo work adit	110 m upstream from the tunnel outlet

The work adit will have a semi-circular section, circular in upper half and rectangular in lower half, with a height of 4 m and a width of 4 m to arrange double track of trolley for tunnel mucking and other purposes. The surrounding bedrock of the work adit will be supported by shotcrete, rock bolts and steel supports except the bottom surface and lining concrete will be placed for the horizontal part. After completion of the tunnel construction, connection parts with main tunnel will be plugged by concrete to secure a smooth flow in the tunnel and to enhance the stability of structure at the connection parts.

The Conguillo work adit is provided to proceed with the tunnel construction from the inlet side in parallel with the construction of the inlet structures including the valve chamber. The adit entrance will be set at EL. 90 m and the adit length is about 183 m.

The El Guasmo work adit is provided to expedite the tunnel construction of 8.3 km long at about 3.4 km downstream from the tunnel inlet. The adit entrance will be at EL. 130 m and the adit length will be 350 m.

The Membrillo work adit is needed for tunneling from the outlet side. The adit entrance will be set at EL. 70 m and the adit length is about 128 m.

These adits are entirely at the Contractor's option and detailed design of the adits will be carried out by the Contractor based on the construction method of the tunnel to be submitted by the Contractor.

The reference design of the work adits is shown on Drawing Nos.1-DT-018 to 1-DT-022.

4.3 La Esperanza ~ Poza Honda Transbasin

4.3.1 Severino Pumping Station

(1) General Description

Sedimentation in and around the pumping station on La Esperanza reservoir is a serious issue. A sediment level after 50 years is anticipated at about EL. 45 m. The minimum pumping operation level (MOL) is therefore set out at EL. 47.0 m, 2 m above EL. 45 m of the anticipated sediment level to prevent sediment from entering to pump suction.

La Esperanza dam is at present under construction and will be completed in 1996. The pumping station will be constructed after completion of the dam and impounding of the reservoir.

On the other hand, water demand in the downstream of La Esperanza dam such as irrigation water and municipal water is not expected to increase rapidly. The irrigation project is at a feasibility level and will be implemented after year 2000. It is judged, therefore, that only a limited water requirement will depend on La Esperanza reservoir and a reservoir water level will be kept at a low level for the construction of the Severiono pumping station.

Only a small scale coffering and dewatering will be required for the construction of the pumping station if a water level of La Esperanza reservoir is kept at EL. 45 m. The crest elevation of the coffering is then determined at EL. 51 m to cope with a flood with 25-year return period as estimated below.

Initial water level + water depth raised up by flood + freeboard
= EL. 45 m + 5.7 m + 0.3 m = EL. 51 m

In accordance with the result of the integrated reservoir operation study, the design maximum discharge is determined at 16 m^3/sec and basic condition for a design of the pumping station are shown hereunder :

Water level in pump suction pit	
Flood water level (FWL)	: EL. 69.00 m
High water level (HWL)	: EL. 66.00 m
Design water level	: EL. 58.50 m
Minimum operation water level (MOL)	: EL. 47.00 m
Design water level in the head tank	
at design discharge	: EL. 114.02 m
over discharge	: EL. 114.06 m
Design actual head	: EL. 55.52 m
Intake structure sill level	: EL. 42.00 m
Elevation of pump center	: EL. 46.00 m

The pump house is a reinforced concrete structure and designed to house six pumping units, each having a rate of 3.2 m^3/sec driven by a motor of 2,400 kW output. The ground level around the pump house will be formed by excavation and backfilling of the existing steep slope and its elevation is set at EL. 70.0 m which is 1.0 m higher than the design flood water level of La Esperanza reservoir. Shotcrete slope protection with a thickness of 10 cm is applied to the excavation slope above EL. 70.0 m where rock/weathered rocks are encountered and sod facing is adopted to the slope where soils are encountered.

The pump house has a total length of 67.5 m and a total width of 29 m. The height from the foundation rock to the top of the superstructure is 43.60 m including 30.10 m in height of the substructure . The pump house extends upward from rock foundation at EL. 40.0 m to the top of roof.

Open space is provided behind the pump house by excavation and backfilling upto EL. 70.0 m to provide an adequate pumping station yard. Main transformer yard of Severino Substation is sited in the open space close to the pump house at EL. 70.0 m. The switchgear yard of the substation is constructed on the hill near the pump house at EL. 102.0 m.

Drain ditches and catch basins are provided on berm of EL. 92.5 m and surrounding the pump house and at the foot of cutting slope and the outside perimeter of the pump house at EL. 70.0 m to drain rainwater in and around the pumping station.

The trashracks with a raking device is provided in front of the inlet of the pump house to keep out debris which might clog or damage the pumping equipment. A trash boom is also provided in front of the inlet channel.

General layout of the pumping station is shown in Drawing No.2-PS-001.

(2) Inlet Channel

Inlet channel is required to introduce the reservoir water into the pump inlet and to secure a space for coffering during construction of the pump house.

The bottom elevation of the inlet channel should be sufficiently lower than the minimum operation level of EL. 47.0 m to lead the design pumping discharge smoothly to the suction pit of the pump house. The bottom is set at EL. 45.0 m at the inlet front and then slopes down to the sill of suction pit at EL. 41.6 m. The inclined portion is covered with a reinforced concrete slab with a thickness of 50 cm.

The side slope of the channel is determined to be 1 : 0.5 with a berm of 2.5 m wide at intervals of 7.5 m high considering that most of the channel alignment is covered by a rock/weathered rock which would allow the excavation with rather steep side slope. Slope protection will be made by shotcrete with a thickness of 10 cm.

A part of the original rock at the space for the inlet channel between the reservoir and the pumping station will be left and used as a coffering during construction of the pumping station. The coffering has a cut slope of 1 : 0.5 on the pump house side and a crest elevation at EL. 51.0 m to cope with a flood with 25-year return period in the reservoir. In final stage of the construction, the coffering will be removed in the dry season when the reservoir water level is kept below EL. 45.0 m.

Consequently, the inlet channel is designed as summarized below;

Section	:	Trapezoidal section, side slope of 1 : 0.5 with shotcrete slope protection
Bottom width	:	60.0 m to 56.6 m
Bottom Elevation	:	EL. 45.0 m to 41.6 m
Length	:	13.5 m (bottom slab portion)

(3) **Pump House, Substructure**

(a) **Type and number of unit of pump**

Considering the maximum actual head of 67.0 m and the design discharge of 3.2 m^3/sec as determined hereunder, two (2) alternative types, i.e., (i) horizontal shaft double suction pump and (ii) vertical shaft single suction pump, are conceivable. Out of the two types, a vertical shaft single suction pump is selected as a suitable type for the pumping station, from economic and constructional points of view, taking into account a cost of civil structures to resist high water pressure and uplift as well as pumping equipment cost.

The number of pump unit was decided on the basis that the design discharge could be dealt with on-duty pump units excluding a stand-by unit. One (1) unit of stand-by pump is installed to ensure a stable operation against a trouble or long term repair of one of on-duty pump units.

The number of on-duty pump unit is decided through comparison of pump installation costs of four (4) options as shown below:

Option	Pump capacity per unit (m3/sec)	Number of unit	Inlet diameter of pump (mm)
1	5.33	3 (4)	1,400
2	4.00	4 (5)	1,200
3	3.20	5 (6)	1,100
4	2.67	6 (7)	1,000

Note : Numeral in parentheses means installed pump unit number including one for reserve.

Comparative study was made taking into consideration (i) pump equipment cost and (ii) construction cost of civil works for the pumping station.

As a result, the most economical case of Option 3, 5 units of 3.2 m^3/sec on-duty and 1 unit for stand-by, is selected as the least cost one.

Unit : US $ 1,000

Option	Pump & motor cost	Civil works	Total Cost
1	5,212	9,797	15,009
2	4,620	10,365	14,985
3	4,200	10,688	14,888
4	4,116	11,002	15,118

(b) Pump House Arrangement

The pumps are arrayed at 8.0 m spacing. The center lines of pumps and their suction pipes are set at EL. 46.0 m and 43.2 m, respectively, in consideration of MOL 47.000 m. Valve rooms are provided at EL. 45.0 m neighboring the pump rooms. The space above EL. 50.0 m is used for motor room where motors and overhead crane are provided.

Neighboring to the motor room, a platform is located at EL. 70.1 m to provide an entrance space for equipment on northeast side of the pump house. An erection bay is provided at EL. 55.0 m. Four floors are provided transversely to the pumping flow at EL. 50.0 m, EL. 55.0 m, EL. 60.0 m and EL. 65.0 m.

The arrangement of the major rooms is determined as follows;

EL. 45.0 m	: Valve room
EL. 46.0 m	: Pump room
EL. 50.0 m	: Motor floor, liquid rheostat room
EL. 55.0 m	: High tension switchgear room, repair shop, erection bay
EL. 60.0 m	: Low tension switchgear room
EL. 65.0 m	: Cubicle galley, store room
EL. 70.1 m	: Platform
EL. 70.2 m	: Control room, offices, entrance hall
EL. 75.1 m	: Elevator machine room

On the ceiling of the motor room, an overhead traveling crane is equipped. The crane has a function of transporting the equipment from the erection bay to a specific place to be installed after assembling at the erection bay on the construction stage, and for repair and maintenance throughout pumping operation. Main hoist has a capacity of 32 ton and an auxiliary hoist with a capacity of 8 ton is attached. Pumping equipment will be carried in from the platform to the erection bay by another overhead crane having the same capacity to be installed in the superstructure at EL. 78.1 m.

(c) Structural System and Design

Reinforced concrete is adopted for the main structure system of the substructure of the pump house due to its simplicity and stability. In structural design of respective members of the substructure, the following assumptions are applied.

- All structural member parallel to the flow direction are designed as rigid frame structure in two dimensions,

- all member provided at right angle to the flow direction are designed as fixed beams, and

- walls and slabs are designed as two way slabs, fixed beams and simple beams according to their supporting conditions.

The design criteria applied to the structural design conform to " Ecuadorian Building Code, Requirements for Design of Reinforced Concrete, Fifth Edition" established by Ecuadorian Standards Institute (INEN). The following seven cases are made for structural analysis.

Case-1 : Normal Condition

Pumping station is completed and is under operation without earthquake effect and temperature change.

Hydrostatic pressure by the reservoir water, groundwater pressure in backfill, earth pressure by backfill and machinery weights are considered as the external forces.

Case-2 and Case-3 : Temperature change

Pumping station is completed and is under operation without earthquake effect.

Loads due to temperature changes, sudden 10°C increase (Case-2) and decrease (Case-3) are considered in addition to the forces of Case-1.

Case-4 : After Completion-1 (just after completion)

Pump house is completed but before removal of the coffering.

Earth pressure by backfill and machinery weights are considered as the external forces.

Case-5 : After Completion-2 (before operation)

Just after completion of pumping station being under the condition of lower groundwater level in backfill.

Hydrostatic pressure by the reservoir water at HWL 66.0 m, earth pressure by backfill and machinery weights are considered as the external forces.

Case-6 and Case-7: Seismic Condition

Earthquake force is assumed to act on the pump house to flow direction (Case-6) and toward the reservoir (Case-7) in addition to the forces of Case-1.

The structure is divided into two blocks by an expansion joint, that is, transformer yard side block and erection bay side block. Stability is analyzed to assure safety against overturning, sliding, floating and bearing capacity of foundation. The following three cases are considered in the stability analysis.

Case-I : After completion of construction

Pump house is completed and just after removal of the coffering.

The external forces acting on the substructure include dead load, hydrostatic pressure by the reservoir water at MOL 47.0 m, earth pressure by backfill, surcharge load and uplift due to the reservoir water.

Case-II : Normal Condition

Pumping station is completed and is under operation without earthquake effect.

The external forces acting on the substructure include dead load, hydrostatic pressure by the reservoir water at HWL 66.0 m, earth pressure by backfill, groundwater pressure, surcharge load and uplift.

Case-III : Seismic Condition

Pumping station is completed and is under operation with earthquake effect.

In addition to the external forces in Case-II, earthquake load is considered.

As discussed above, the pump house is divided into two blocks, which are designed to be constructed on weathered/rock foundation. Each block is nearly symmetrical structure, therefore, the stability analysis was carried out for the transformer yard block.

The details of the stability and structural analysis are discussed in the "Design Calculation Report".

(4) Architectural design

(a) Architectural finishings

Since the main purpose of the pumping station building is to provide the spaces required for the operation and maintenance of the machine and equipment as well as to provide shelter from the weather for these equipment, the main design criteria for architectural finishings are of matching finishings to the requirements of the room. However, it is also necessary to consider operational personnel and their amenity as well as to afford a pleasant impression to visitors. This will also be effective in raising the morale of the operational personnel. The finish materials shall be selected considering local availability, cost and durability.

The roof finish is provided with concrete covering for the protection of the water proofing layer.

Concrete block cavity walls are provided in the substructure of the pump station to avoid humidity due to seepage from underground walls.

(b) Superstructure structural design

The superstructure is one story high with a penthouse for the elevator machine room. It is divided into two blocks along line 4 by an expansion joint by which they are calculated as separate structures. The structural frame work was modeled three dimensionally and the computations were made by a computer using the SAPCON 90 software. The full calculation and the results are shown in the "Design Calculation Report".

(c) Building facilities

The building facilities for the pumping station comprises an air-conditioning system, ventilation system, domestic water supply system, drainage and sewerage system and a fire fighting system.

i) Domestic water supply system

The water supply system for the pumping station comprises the water supply for drinking, sanitary use and fire protection system.

The water is obtained from pump cooling pipe in the valve room at EL. 45.0 m. Raw water before treatment is stored in a raw water storage tank at the same level. The water treatment system comprising water filtering tank, treated water storage tank, water supply pump, pressure tank, and sterilization units are installed on EL. 50.0 m floor.

The water for drinking and sanitary facilities use will be filtered by a sand filtering method, stored in the treated water tank and distributed to each requirement by the water supply pumps via the pressure tank. Sterilization solution of hydroclorous acid soda will be automatically pumped into the water supply pipe.

The water supply for the fire protection system will be made through a separate system with a fire pump. The water will be supplied from a raw water storage tank at EL. 45.0 m floor.

ii) Drainage and sewerage system

Drainage and sewerage system of the pumping station is provided for waste water, roof rain water, seepage water and sewage. The roof rain water will be collected and drained into the site drainage system. The sewage is collected into a septic tank and pumped out into the site drainage system after treatment. The waste water will be collected and drained into the septic tank. The seepage water of the pumping station is collected into the drain gutters provided along the inside perimeter of the pumping station underground wall and drained into the sump pit provided at EL. 41.0 m level.

iii) Air conditioning and ventilation system

Air conditioning and ventilation system of the pumping station is designed to provide the pumping station with a suitable working environment. The air conditioning is provided for the control room, office rooms and other administrative areas where operation and maintenance personnel are commonly stationed. Ventilation by supplying fresh air is made to the other areas occupied by machines and equipment where air conditioning is not provided.

-Air conditioning

Design conditions for determining the capacity of the air conditioning are as follows.

Ambient value		Design Conditions	
Temperature(°C)	Humidity (%)	Temperature(°C)	Humidity (%)
33	68	25	50~60

The air conditioners are of heat-pump type packaged air conditioners. The air conditioners are installed in the machine rooms at EL. 70.2 m. Cool air will be distributed to each of the required rooms through the supply duct system, while the return air will be collected and returned to the air conditioner through a separate return duct system. Fresh air will be supplied at a rate of 25 m^3/h per personnel.

-Ventilation

Ventilation will be provided for the motor bay, cubicle rooms and other spaces where required. Fresh air supply fans are provided to take in outside air through ducts and distributing fresh air to each area as required by the ducts.

Foul air will be exhausted through louvers provided on platform walls and roof ventilators. A separate ventilation system will be provided for the battery room. Also, individual exhaust fans are provided for the kitchen and toilets.

(d) Fire protection system

Fire protection system of the pumping station is composed of a fire hydrant system.

The fire hydrant system is provided to cover the entire floor area of the pumping station. The fire hydrants are installed on all floors at intervals of approximately 50 m. Each fire hydrant covers an area of 25 m in radius.

Hand held portable fire extinguishers of 6 kg capacity each shall be also provided throughout the building.

(e) Diesel generator house

Considering the noise, smell and air supply difficulties, the emergency diesel engine generator is housed in a separate structure in the pumping station yard.

Design drawings of the pumping station are shown in Drawing Nos.2-PS-002 to 2-PS-082.

4.3.2 Severino Penstock

Severino Penstock extends from the pumping station toward the south. The center line is set straight in parallel to the flow direction and is bent to Severino Open Channel route to connect with Severino Head Tank provided at the end of the penstock.

Two (2) lanes of penstock are provided in consideration of ensuring minimum operation against a risk of breakdown and inspection and/or repair under operation.

In accordance with the optimum configuration of the structures for La Esperanza ~ Poza Honda Transbasin such as the pumping station, the head tank, the open channel and the diversion tunnel and the results of the integrated reservoir operation, the design conditions of the Severino Penstock are determined as shown below:

Total design discharge	: 16.0 m^3/sec
Max. design discharge	: 9.6 m^3/sec each lane (3.2 m^3/sec x 3 pumping units)
Maximum actual head	: 67.0 m
Length of pipeline	: 173 m (through No.1 pump and No.1 penstock)
	: 170 m (through No.6 pump and No.2 penstock)

As discussed in Section 4.6.2, it is decided to adopt the above ground type for the penstock, and 2,000 mm in diameter of the penstock is selected as the most economical one with 9.6 m^3/sec per one lane.

The penstock is longitudinally aligned along cutting slope for the construction of the pump house and the original ground surface. Between the pump house and IP-2 (59.250 m from the pump center), the penstock pipes are installed along the steep cutting slope embedded in or encased by concrete. Between IP-2 and the head tank, the pipes are installed above ground along a trench excavated to a foundation rock, and are anchored with concrete blocks at vertical and horizontal bend points and supported by saddle blocks with ring girders at intervals of 14 m. Expansion joints are placed in every span between two anchor blocks to absorb expansion and/or shrinkage of the pipes.

Water hammer analysis was carried out for the longitudinal layout and the selected diameter of the penstock. As discussed in Section 4.6.2, a surge tank is required at a maximum negative pressure point on the penstock.

Flow measuring instrument is provided in the penstock to measure a pumping discharge for counting up and forming water charge and operation plan in the future. Three types of the instrument are conceivable such as (i) ultrasonic type flow meter, (ii) electromagnetic flow meter and (iii) differential pressure type flow meter (venturi tube).

The ultrasonic flow meter is selected taking into account advantageous view point, (i) lower initial investment cost, (ii) saving annual energy cost and (iii) maintenance free.

Slope protection is designed by shotcrete with a thickness of 10 cm and 5 cm for rock/weathered rock excavation slope and by sod facing for earth excavation slope.

Design drawings of the Severino Penstock are shown in Drawing Nos.2-PE-001 to 2-PE-008.

4.3.3 Severino Head Tank

According to numbers of penstock lane, the head tank is divided into two separate lanes by a partition wall in consideration of operation and maintenance of the transbasin system consisting of the pumps, the penstock, the open channel and the tunnel.

The function of Severino Head Tank is to regulate water vein discharging from the penstock and to interconnect smoothly to the open channel. Another function is to close off the open channel in the event on which it is necessary to dewater the penstock for its inspection and maintenance, including prevention of backwater from the open channel when discharge valves do not work due to some troubles.

In due consideration of these functions, the following two types of head tank are considered and a comparative study was made;

i) Gate/stoplog type head tank

This type of head tank is equipped with gates/stoplog at its downstream end and the gate/stoplog will be operated in the event the pump motors are tripped and discharge valves are not closed.

ii) Overflow weir type head tank

This type consists of pond and overflow weir at its downstream end. The weir is designed to have an enough height so that no backwater from the open channel will occur.

Of the two types above, gate/stoplog type would not be recommended since the automatic operation of the gates is difficult. Manual operation of the gate/stoplog is not recommended because it would allow the backflow of water from the Open Channel in the event the pump motor are suddenly tripped and discharge valves are not closed.

The overflow weir type head tank is composed of settling basin, overflow weir and transition channel to the Open Channel. The crest elevation of weir is set out to have an enough height so that no backflow of water from the Open Channel will occur. The operation and maintenance of the overflow type head tank would be easier as compared with the other, since it is of simple structure and does not require any electrical and mechanical equipment. Accordingly, it is decided to adopt the overflow weir type head tank.

The settling basin has a function to settle an energy of outflow from the penstock. It is difficult to calculate a phenomenon in the basin precisely as hydraulic calculation. Therefore, an existing hydraulic model test for a river outlet facility of dam is referred to for the design.

The residual energy at the end of the penstock was evaluated by Froude number and velocity head as estimated below.

$$F = v_0 / \sqrt{g \cdot D}$$
$$H_V = v_0^2 / 2g$$

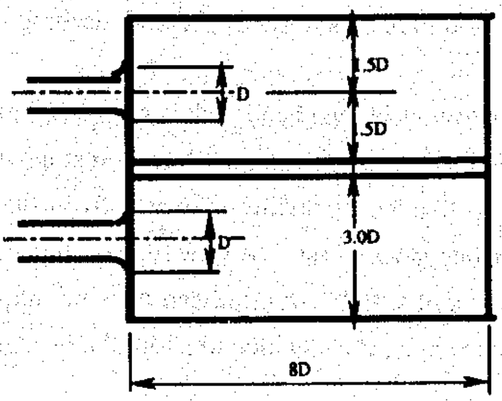
where,
- F : Froude number
- Hv : velocity head (m)
- g : acceleration of gravity (= 9.8 m/sec^2)
- D : diameter of penstock pipe at outlet (= 2.4 m)
- v_0 : velocity at outlet (= 4 Q / π D^2)
- Q : maximum pumping discharge (= 9.6 m^3/sec)

then, F = 0.44 and Hv = 0.23 m

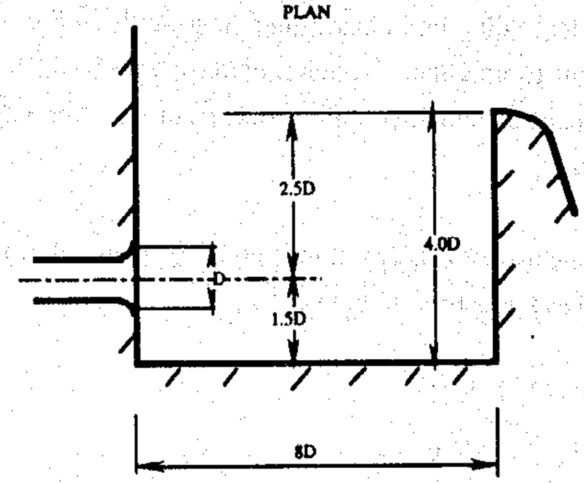
The Froude number is 0.44, less than 1 which means the flow condition is the subcritical flow and the velocity head is a small value. Considering the Froude number and the velocity head calculated, few residual energy will be encountered at the settling basin.

The existing hydraulic model test result evaluated a value of $Q/D^{2.5}$, which is calculated at 1.1 at the maximum pumping discharge. In the case a value of $Q/D^{2.5}$ is less than 6.5, the model test results indicated that it is not necessary to consider any special measure and structure for settling water energy.

In due consideration of the condition at the outlet and the results of the model test, the following dimension was recommended and adopted to the settling basin.



PLAN



PROFILE

Two sets of drain pipe and valve are provided for each settling basin to evacuate the basins during their cleaning and maintenance. The water is drained into side ditch provided in the penstock line through drain pipes.

Two sets of water level gauge are installed in each basin to supplement the flow meters attached to the penstock pipes described in subsection 4.3.2.

The function of the overflow weir is to close off the open channel in the event on which it is necessary to dewater the penstock for its inspection and maintenance, and to