社会開発調査部報告書

JAPAN INTERNATIONAL COOPERATION AGENCY

CENTRO DE REHABILITACION DE [illegible]
THE REPUBLIC OF [illegible]

THE DETAILED DESIGN STUDY
ON
THE WATER TRANSVASION SCHEME
FOR
[illegible]

FINAL REPORT
VOLUME VII

CONSTRUCTION PLAN
AND
SCHEDULE

MARCH 1995

NIPPON KOEI CO., LTD.
Tokyo, Japan

JAPAN INTERNATIONAL COOPERATION AGENCY

CENTRO DE REHABILITACION DE MANABI (CRM)
THE REPUBLIC OF ECUADOR

THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE - PORTOVIEJO RIVER BASINS

FINAL REPORT
VOLUME VIII

CONSTRUCTION PLAN AND SCHEDULE

MARCH 1995

NIPPON KOEI CO., LTD.
Tokyo, Japan

ESTIMATE OF PROJECT COST

Price Level	:	August 1994
Currency Exchange Rate	:	US$1 = S/. 2,250 = Yen 100

FINAL REPORT

LIST OF REPORTS

Volume	Title
I.	MAIN REPORT (SUMMARY)
II.	MAIN REPORT
III.	MAIN REPORT (ANNEX 1)
	1. DESIGN CRITERIA
	2. HYDROLOGICAL STUDY
	3. WATER TRANSBASIN PLAN
IV.	MAIN REPORT (ANNEX 2)
	4. GEOLOGY AND CONSTRUCTION MATERIALS
V.	MAIN REPORT (ANNEX 3)
	5. ENVIRONMENTAL STUDY
VI.	DESIGN CALCULATION REPORT
VII.	QUANTITY CALCULATION REPORT
VIII.	CONSTRUCTION PLAN AND SCHEDULE
IX.	COST ESTIMATE
X.	IMPLEMENTATION PROGRAM
XI.	DESIGN DRAWINGS

CONSTRUCTION PLAN AND SCHEDULE

Table of Contents

Page

List of Tables

List of Figures

ABBREVIATION

Ecuadorian Institutions

CEDEGE	:	Committee for Guayas River Basin Development
CETUR	:	Ecuadorian Corporation for Tourism
CLIRSEN	:	Integrated Center for Remote Sensing Survey
CONADE	:	National Development Council
CPC	:	Chamber of Shrimp Producer
CRM	:	Manabi Rehabilitation Center
DIGMER	:	Directorate General of Merchant Marine
DINAC	:	National Directorate of Valuation and Cadastre
DINAF	:	National Directorate of Forestry
DITURIS	:	Directorate of Tourism
EMAPAM	:	Municipal Enterprise of Potable Water and Sewerage of Manta
ESPOL	:	Polytechnic Littoral College
GOE	:	Government of Ecuador
IEOS	:	Ecuadorian Institute of Sanitary Works
IERAC	:	Ecuadorian Institute for Agrarian Reform
IGM	:	Geographic Military Institute
INAMHI	:	National Institute of Meteorology and Hydrology
INEC	:	National Institute of Statistics and Census
INECEL	:	Ecuadorian Institute for Electrification
INEFAN	:	Ecuadorian Institute of Forestry and Natural Areas
INEN	:	Ecuadorian Institute of Standards
INERHI	:	Ecuadorian Institute of Water Resources
INIAP	:	Institute of Agricultural Investigations
INOCAR	:	Military Oceanographic Institute
JRH	:	Jipijapa and Pajan Board of Water Resources
MAG	:	Ministry of Agriculture and Livestock
MICIP	:	Ministry of Industry, Commerce, Integration and Fishery
MOP	:	Ministry of Public Works and Communications
PFI	:	Institutional Reinforcement Planning Unit of CRM

PHIMA	:	Integrated Water Resources Development Plan of Manabi
PMRC	:	Management Program of Coastal Resources

International or Foreign Institutions

ACI	:	American Concrete Institute
ASCE	:	American Society of Civil Engineers
ASTM	:	American Society for Testing and Materials
CAF	:	Corporación Andina de Fomento
CEPIS	:	Panamerican Center for Sanitary Engineering and the Environment
CIDIAT	:	Interamerican Center for Integrated Development of Water and Land
FAO	:	Food and Agriculture Organization of the United Nations
IDB/BID	:	Interamerican Development Bank
IEC	:	International Electrotechnical Commission
JEC	:	Japanese Electrotechnical Committee
JICA	:	Japan International Cooperation Agency
JIS	:	Japanese Industrial Standards
OAS/OEA	:	Organization of American States
OECF	:	Overseas Economic Cooperation Fund of Japan
SCS	:	Soil Conservation Service of USDA
UNDP	:	United Nations Development Program
USA	:	United States of America
USAID	:	United States Agency for International Development
USDA	:	United States Department of Agriculture
WHO	:	World Health Organization of the United Nations

Technical Terms

A.C.	:	Alternating Current
ACSR	:	Aluminum Cable Steel Reinforced
BOD	:	Biochemical Oxygen Demand
COD	:	Chemical Oxygen Demand

D.C.	:	Direct Current
DO	:	Dissolved Oxygen
EC/CE	:	Electrical Conductivity
EIA	:	Environmental Impact Assessment
EMMP	:	Environmental Management and Monitoring Plan
FEM	:	Finite Element Method
F.M.	:	Finess Modulus
F/S	:	Feasibility Study
FWL	:	Flood Water Level
GPS	:	Global Positioning System
H	:	Horizontal
HWL	:	High Water Level
IEE	:	Initial Environmental Examination
IPM	:	Integrated Pest Management
LACAT	:	Program for Warm Tropical Lakes
LWL	:	Low Water Level
MOL	:	Minimum Operating Level
NATM	:	New Austrian Tunneling Method
PLC	:	Power Line Carrier
RWL	:	Reservoir Water Level
SPT	:	Standard Penetration Test
ST	:	Station
T-N	:	Total Nitrogen
T-P	:	Total Phosphorus
TRMS	:	Transbasin and Reservoir Management System
TSS	:	Total Suspended Solid
V	:	Vertical
ZEM	:	Special Zone for Management

Economic Terms and Others

CIF	:	Cost Insurance and Freight

EIRR	:	Economic Internal Rate of Return
FC	:	Foreign Currency
FIRR	:	Financial Internal Rate of Return
FOB	:	Free on Board
GDP	:	Gross Domestic Product
GRP	:	Gross Regional Product
IVA	:	Sales Tax or Value Added Tax
LC	:	Local Currency
NGO/ONG	:	Non Governmental Organization

ABBREVIATION OF MEASURES

Length

mm	=	millimetre
cm	=	centimetre
m	=	metre
km	=	kilometre
masl	=	metre above sea level
EL.	=	elevation

Area

ha	=	hectare
m^2	=	square metre
km^2	=	square kilometre

Volume

l, lit	=	litre
Kl, Klit	=	kilolitre
l/s	=	litre per second
m^3	=	cubic metre
m^3/s, cms	=	cubic metre per second
m^3/min	=	cubic metre per minute
m^3/hr	=	cubic metre per hour
MCM, mcm	=	million cubic metre
m^3/d, cmd	=	cubic metre per day

Weight

mg	=	milligram
mg/l	=	milligram per litre
meq/l	=	milli-equivalent per litre
g	=	gram
kg	=	kilogram
t, ton	=	ton
t/y	=	ton per year
MT	=	metric ton

Time

sec	=	second
min	=	minute
hr, HR	=	hour
d	=	day
yr	=	year

Money

S/.	=	Ecuadorian Sucres
¥	=	Japanese Yen
US$	=	U. S. Dollars

Energy

Kcal	=	Kilocalorie
KW, Kw	=	kilowatt
MW, Mw	=	megawatt
KWh, Kwh	=	kilowatt-hour
GWh, Gwh	=	gigawatt-hour
V	=	volt
KV	=	kilovolt
KVA	=	kilovolt ampere
MVA	=	megavolt ampere
Hz	=	Hertz

Others

%	=	percent
°	=	degree
'	=	minute
"	=	second
°C	=	degree Celsius
MD, md	=	man-day
mil.	=	million
NO. Nos	=	number
pers.	=	person
Umho	=	micromho
ppt	=	parts per thousand
ppm	=	parts per million
ppb	=	parts per billion
l/h/d	=	litre per person per day
g/c/d	=	gram per capita per day
LS	=	lump sum
MPN	=	most probable numbers
O&M	=	Operation and Maintenance
p.a.	=	per annum
rpm	=	revolutions per minutes

CONSTRUCTION PLAN AND SCHEDULE

1. GENERAL

The Water Transbasin Project for Chone-Portoviejo River Basin is located in the Province of Manabi. The Project is planned to supply the habitual and irrigation water to the Chone-Portoviejo river basin area including the several towns such as Portoviejo, Santa Ana, Rocafuerte, etc.

This report presents the proposed plan and construction schedule necessary to implement the construction works. The objectives of this report is to provide a guide for the execution of the construction works and for the construction cost estimate.

The construction plan is summarized on the basic assumptions made in the preparation of the construction schedule. The construction plan gives an outline of possible procedures, construction methods, types of construction equipment and plant which is conventional, mechanized and prevailing. Furthermore, the construction plan for major permanent structures required for the project is studied in accordance with the final plans, designs and specifications.

The construction method and equipment described herein are developed by assuming that the major construction works are performed by international contractors. The contractors will be selected on an international competitive tender who should be fully capable of employing modern construction method taking into consideration of local conditions, managing proper and sufficient equipment to complete the construction works of this scale. In the execution of actual construction works, the construction plan and construction equipment should be prepared by the selected contractors based on their own idea.

2. EXECUTION OF THE PROJECT

For the selection of the contractors and suppliers of the works, in the most fair-mind business transaction, international open competitive tenders are applied for the project.

The Project will be implemented by the Government of the Republic of Ecuador, the Manabi Rehabilitation Center (CRM) and supervised by the CRM with consulting engineers of international standing. The construction works of the project will be carried out by selected contractors through international competitive tenders in accordance with the standard international guidelines and the Ecuador guidelines, respectively. The execution of the works will be made based on the following basic implementation plan.

(1) Executing Body

The Water Transbasin Project will be implemented by the CRM, as the executing agency. The CRM will conduct the management and supervision of the Project. The selected international consulting engineer for construction supervision is planned to be employed to assist the CRM in implementing the Project.

(2) Financial Source

As for the financial prospect, the foreign currency portion of the construction cost will be financed by the Overseas Economic Cooperation Fund (OECF) which is foreseen to be available before the commencement of tendering. On the other hand, the local currency portion will be covered by the Government of the Republic of Ecuador.

(3) Executing System (Contract Package)

The construction works will be divided into three packages executed by international competitive tenders.

a. Package 1: Civil Works for Daule-Peripa ~ La Esperanza Transbasin

b. Package 2: Civil Works for La Esperanza ~ Poza Honda Transbasin and Poza Honda ~ Mancha Grande Transbasin.

c. Package 3: Electrical and Mechanical Works for Daule-Peripa~La Esperanza, La Esperanza ~ Poza Honda and Poza Honda ~ Mancha Grande Transbasins.

The Package 3 includes the following three sections:

- Section-1 : Severino Pumping Station
- Section-2 : Conguillo Inlet
- Section-3 : Poza Honda Inlet

d. Engineering Services

As for the engineering services, a consulting engineer will be required for the execution of the project and will be selected by a direct order and/or international competitive tenders.

3. OUTLINE OF THE PROJECT

The principal features of the major structures for the construction works are summarized below.

Table 3.1
Principal Features of the Water Transbasin Project

1. Location	Chone-Portoviejo River Basin, around the Daule-Peripa Dam, La Esperanza Dam and Poza Honda Dam.
2. Daule-Peripa ~ La Esperanza Transbasin	
2.1 Conguillo Inlet	: Daule-Peripa Reservoir (Conguillo River Course)
-Reservoir	
*Flood Water Level	: El.88.0m
*Normal High Water Level	: El.85.0m
*Low Water Level	: El.60.0m
-Bottom Level of Open Aproach Channel	: El.66.0m
-Inlet Sill Level	: El.66.0m
-Low Diversion Water Level	: El.76.6m ($18m^3/s$)
-Lowest Diversion Water Level	: El.66.6m($0m^3/s$)
-Valve Chamber	: Oval Shape
*Length	: 20.0m
*Width	: 16.0m
*Height	: 25.1m
*Roof Level	: El.90.2m
*Steel Pipe	: 1,400mm dia, 2 nos.at El.67.20m : 800mm dia, 1 no.at El.65.50m
*Discharge Control Valve	: Cone Sleeve Valve (1,400mm dia, 2nos.)
2.2 Daule-Peripa ~ La Esperanza Diversion Tunnel	
-Flow	: Open Free Flow
-Capacity	: $18m^3/s$ at 80% Water Depth
-Length	: 8,296m
-Diameter	: 3.70m, Standard Horseshoe
-Inlet Invert Level	: El.66.03m
-Outlet Invert Level	: El.60.50m
-Slope	: 1/1,500
-Section	: Shotcrete (10~15cm), Rock Bolt 1.2m Pitch : Concrete Lining (30cm), without Reinforcing Bar.
2.3 Membrillo Outlet	: La Esperanza Reservoir
-Reservoir	
*Flood Water Level	: El.67.7m
*Normal High Water Level	: El.66.0m
*Low Water Level	: El.37.0m
-Outlet Channel	: 80m long at El.60.50m

Table 3.1 (Cont'd)
Principal Features of the Water Transbasin Project

2.4 Conguillo Work Adit	
-Length	: Inclined Portion; 96.4 m
	: Horizontal Portion; 86.9 m
-Section	: Semi circular and rectangular section, 4.0m wide and 4.0m high
2.5 Access Road	
-Conguillo Access Road	: 22.6 km, Permanent, Paved
-El Guasmo Access Road	: 1.4 km, Temporary, Paved
-Membrillo Outlet Access Road	: 0.4 km, Temporary, Paved
3. La Esperanza ~ Poza HondaTransbasin	
3.1 La Esperanza Reservoir	
-Flood Water Level at Pumping Station	: 69.0m
-Normal High Water Level	: 66.0m
-Low Water Level	: 37.0m
3.2 Severino Pumping Station	
-Weighted Average Water Level	: El.58.5m
-Minimum Operation Water Level	: El.47.0m
-Pumps	
*Type	: Vertical Shaft, Single Suction Volute Type
*Number of Units	: 6 units., 5 units on duty and 1 unit for stand-by.
*Installed Capacity	: 16.0 m^3/s for each unit
-Maximum Actual Head	: 67.3m
-Minimum Actual Head	: 48.3m
-Design Actual Head	: 55.52m
-Intake Structure Sill Level	: El.42.1m
-Elevation of Pump Center	: El.46.0m
-Electric Motors	
*Type	: Vertical Shaft, Three Phases, Wound-Rotor Induction type.
*Output of Motor	: 2,400kW, Voltage 4.16kV, Frequency 60Hz.
-Pumping House	
*Substructure	
Length	: 29.0m
Width	: 67.5m
Height	: 30.1m
*Superstructure	
Length	: 22.5m
Width	: 65.0m
Height	: 13.5m
3.3 Severino Penstock	
-Length	
*No.1	: 193m
*No.2	: 190m

Table 3.1 (Cont'd)
Principal Features of the Water Transbasin Project

-No. of Lanes	: 2 nos.
*Inside Diameter	: 2,000mm
*Material	: Steel made

3.4 Head Tank

-Length	: 56.7m
-Width	: 19.160m
-Crest Elevation of Weir	: El.113.30m
-Maximum Water Level	: El.114.02m
-Maximum Overflow Depth	: 0.72m

3.5 Severino Open Channel

-Maximum Discharge	: 16.0m^3/s
-Length	: 6,395m (including of Siphon Length)
-Type	: Trapezoidal, Concrete Lining
-Bottom Width	: 1.60m
-Side Slope	: 1/1.2
-Height	: Type A, 3.0m including Freeboard : Type B, 2.8m including Freeboard
-Bottom Slope	: 1/3,000
-Water Level at Beginning Point	: El. 113.256m

3.6 Siphon

-Capacity : 16m^3/s

Siphon No.	Length	Max.head	Remarks
1	72m	9m	Concrete
2	233m	37m	Concrete
3	326m	48m	Concrete
4	76m	6m	Concrete
5	174m	18m	Concrete

3.7 Inspection Road

-Length	: 7,593 km in total
-Width	: 3.0m

3.8 Caña Dulce Inlet

-Inlet Culvert	: 78m long, Bottom El.107.363

3.9 La Esperanza-Poza Honda Diversion Tunnel

-Flow	: Open Free Flow
-Capacity	: 16.0m^3/s
-Length	: 11,417m
-Diameter	: 3.5, Standard Horseshoe
-Inlet Invert Level	: El.107.3m
-Outlet Invert Level	: El. 99.7m
-Slope	: 1/1,500

3.10 Los Cuyuyes Outlet : El.99.7m

Table 3.1 (Cont'd)
Principal Features of the Water Transbasin Project

3.11 Severino Substation	
-Space	
*138kV Switchgear Yard	: 1,800m^2 (30m x 60m)
*Main Transformer Yard	: 720m^2 (16m x 45m)
-Transformer	: 10MVA, 2 units
3.12 Transmission Line	: Length 32.6km (from Daule-Peripa Power Station to Severino Substation).
-Circuit	: Single Circuit
-Voltage	: 138kV
3.13 Access Road	
-Severino Access Road	: 9.3 km, Permanent, Paved
-Caña Dulce Inlet Access Road	: 2.7 km, Temporary, Paved
3.14 Base Camp	: 2.0 ha near Severino Pumping Station
-Electrical Facility	: 150 kVA
-Water Supply	: 0.3 m^3/min
3.15 Daule-Peripa Substation	
-Space	:11,635m^2 (121.2m x 96m)
4. Poza Honda-Mancha Grande Transbasin	
4.1 Poza Honda Inlet	: Poza Honda Reservoir
-Reservoir	
*Flood Water Level	: El.110.30m
*Normal High Water Level	: El.106.50m
*Low Water Level	: El.88.30m
-Inlet Sill Level	: El.91.4m
-Low Diversion Water Level	: El.94.00(4 m^3/s)
-Lowest Diversion Water Level	: El.91.40m(0m^3/s)
-Valve Chamber	
*Length	: 20.0m
*Width	: 16.0m
*Height	: 22.45m
*Roof Level	: 112.5m
*Steel Pipe	: 900mm dia, 2 nos. at El.90.80m
*Discharge Control Valve	: Cone Sleeve Valve (900mm dia., 2 nos.)
4.2 Poza Honda-Mancha Grande Diversion Tunnel	
-Flow	: Open Free Flow
-Capacity	: 4.0m^3/s
-Length	: 4,095m
Diameter	: 2.50m, Standard Horseshoe
-Inlet Invert	: 90.05m
-Outlet Invert	: 89.00m
-Slope	: 1/3,900

Table 3.1 (Cont'd)
Principal Features of the Water Transbasin Project

	-Section	
	*Shotcrete	: 10-15cm
	*Concrete Lining	: 30cm
4.3	Mancha Grande Outlet	: Mancha Grande River
	-Outlet Channel	: 200m long at El.89.00m
4.4	Access Road	
	-Los Cuyuyes Access Road	: 14.8km, Permanent and Temporary, Paved
	-La Seca Access Road	: 3.8km, Permanent and Temporary, Paved
	-Poza Honda Inlet Access Road	: 0.7km, Permanent, Paved

4. CONSTRUCTION SCHEDULE

4.1 Pre-construction Program

The Pre-construction activities comprise detailed design, preparation of tender documents, financial arrangement, prequalification of contractors, tendering, evaluation and award. The pre-construction program is essential to determine the time of commencement for the construction works.

The detailed design and preparation of tender documents are expected to be completed by the end of March 1995. The detailed design covers the preparation of design drawings, technical specifications and tender documents on the basis of accurate topographic surveys, geological investigation and boring, and necessary tests which provided in the detailed survey.

The financial arrangement of foreign loan is expected to be ten months period after the submission of implementation program. The arrangement of foreign loan will be completed before starting the selection of consultant. While the financial arrangement of national budget is also expected as the same of foreign loan arrangement.

The selection of consultant for the construction supervision will be required for three months as a direct contract before the commencement of tendering.

The tendering time which comprises of advertisement of tender and prequalification, tender evaluation, negotiation and contract awarding for respective contract packages are expected as shown in Fig. 4.1. Implementation Schedule for the Water Transbasin Project.

4.2 Construction Period and Target Date

The construction period required for the proposed implementation program of the Project is planned to be 4.5 years including three contract packages. The construction works are scheduled to be commenced at the beginning of June 1997 and be completed by the end of November in 2001.

The following target dates of the major works are required to ensure the good sequence of the Project construction.

(1) Package 1

.	Award of contract	: June 1, 1997
.	Diversion tunnel completed	: June 30, 2001
.	Lowering La Esperanza reservoir	: July-August, 2001
.	Outlet channel completed	: August 31, 2001
.	Dredging of inlet	: December 31, 2000
.	Intake shaft and tunnel completed	: February 28, 2001
.	Conguillo work adit	: October 31, 1998
.	El Guasmo work adit	: November 30, 1998
.	Membrillo work adit	: August 31, 1998
.	Access road started	: September 1, 1997

(2) Package 2

a.	Award of contract	: June 1, 1997
b.	Substructure concrete of pumping station completed.	: November 30, 1999
c.	Substructure concrete of pumping station completed.	: April 30, 2000
d.	Backfill behind pumping station completed.	: June 30, 2000
e.	Overhead crane installation completed	: June 30, 2000
f.	Superstructure and building works completed.	: June 30, 2000
g.	Encasement concrete around penstock below EL.70.0 m, completed.	: September 30, 1999
h.	Encasement concrete around penstock above EL.70.0 m, completed.	: November 30, 2000
i.	Severino open channel completed	: August 31, 2001
j.	Lowering La Esperanza reservoir	: July-August, 2001
k.	Inlet channel of pumping station, completed.	: August 31, 2001
l.	La Esperanza-Poza Honda diversion tunnel completed.	: August 31, 2001
m.	Poza Honda-Mancha Grande diversion tunnel started.	: January 1, 1998
n.	Lowering Poza Honda reservoir	: July-August, 2001
o.	Inlet and outlet channel of Poza Honda reservoir completed.	: August 31, 2001
p.	La Seca work adit completed	: Mid-August, 1998
q.	Los Cuyuyes work adit completed	: February 28, 1998
r.	Poza Honda work adit	: March 31, 1998
s.	Access road started	: August 1, 1997

(3) Package 3

a.	Award of contract	: June 1, 1998
b.	Embedded pipes for substructure pumping station, completed.	: February 28, 1999
c.	Penstock below EL.70.0 m within backfill behind pumping station completed.	: September 30, 1999
d.	Overhead crane completed	: June 30, 2000
e.	Valves, pipes, pumps completed	: January 31, 2001

d.	Overhead crane completed	:	June 30, 2000
e.	Valves, pipes, pumps completed	:	January 31, 2001
f.	Motors and auxiliary equipment completed.	:	February 28, 2001
g.	Penstock above EL.70.0 m, open area, completed.	:	January 31, 2001
h.	Switchgear and transformer completed	:	July 31, 2001
i.	Transmission line completed	:	July 31, 2001
j.	Substation equipment completed	:	July 31, 2001
k.	Conguillo inlet mechanical work completion.	:	June 30, 2001
l.	Poza Honda inlet mechanical work completion.	:	June 30, 2001
m.	Wet test completion	:	November 30, 2001

4.3 Construction Schedule

The construction schedule of the Project is shown in Fig. 4.2 by bar chart and the detailed schedule is shown on Annex II. The land acquisition and compensation for the Project will be settled by the CRM prior to the commencement of each contract package. The work schedule for the major items are summarized by year as follows:

(1) Package 1

1997
(a) Award of contract for Package 1
(b) Mobilization and construction of site facilities
(c) Conguillo access road earthwork

1998
(a) Work adit construction (Conguillo, El Guasmo and Membrillo)
(b) Conguillo access road earthwork
(c) Access road construction (El Guasmo and Membrillo outlet)
(d) Diversion tunnel (excavation and concrete lining)

1999
(a) Diversion tunnel construction
(b) Conguillo access road construction

2000
(a) Inlet excavation work
(b) Dredging of inlet channel portion
(c) Intake shaft and inlet tunnel work
(d) Diversion tunnel construction
(e) Conguillo access road construction

2001

(a) Outlet channel construction (La Esperanza reservoir lowering)
(b) Diversion tunnel construction
(c) Demobilization

(2) Package 2

1997

(a) Award of contract for Package 2
(b) Mobilization and construction of site facilities
(c) Los Cuyuyes and Poza Honda work adits excavation
(d) Access road construction (Severino, Caña Dulce, La Seca, Los Cuyuyes and Poza Honda inlet)

1998

(a) Excavation work of Severino pumping station and open channel
(b) La Esperanza - Poza Honda tunnel construction
(c) Poza Honda - Mancha Grande tunnel construction
(d) Work adit construction (La Seca, Los Cuyuyes and Poza Honda)
(e) Access road construction (Severino, Caña Dulce inlet, La Seca and Los Cuyuyes)

1999

(a) Pumping station concrete work
(b) A part of penstock encasement concrete work
(c) Penstock civil works
(d) Severino open channel construction
(e) Tunnel construction for La Esperanza - Poza Honda and Poza Honda - Mancha Grande.
(f) Los Cuyuyes access road construction

2000

(a) Backfilling behind pumping station building
(b) Superstructure concrete work and building works
(c) Concrete works of penstock line
(d) Severino head tank construction
(e) Open channel construction (channel concrete and syphon)
(f) Diversion tunnels construction
(g) Poza Honda intake shaft and tunnel construction

2001

(a) Removal of coffer dike and inlet channel construction (La Esperanza reservoir lowering).
(b) Building works
(c) Open channel concrete work and syphon construction
(d) Diversion tunnels construction
(e) Poza Honda inlet construction
(f) Demobilization

(3) Package 3

1998
(a) Award of contract for Package 3
(b) Design, manufacturing and delivery

1999
(a) Preparatory works
(b) Embedded pipes and penstock installation in the substructure concrete
(c) Transmission line construction

2000
(a) Installation of overhead cranes, valves, pipes, pumps and motors, gates and crane, trashracks, surge tank and penstock.
(b) Transmission line construction

2001
(a) Installation of motors, switchgears and transformers
(b) Transmission line construction
(c) Substation construction
(d) Mechanical works for Conguillo and Poza Honda inlets
(e) Dry and wet tests.

Fig. 4.1 IMPREMENTATION SCHEDULE

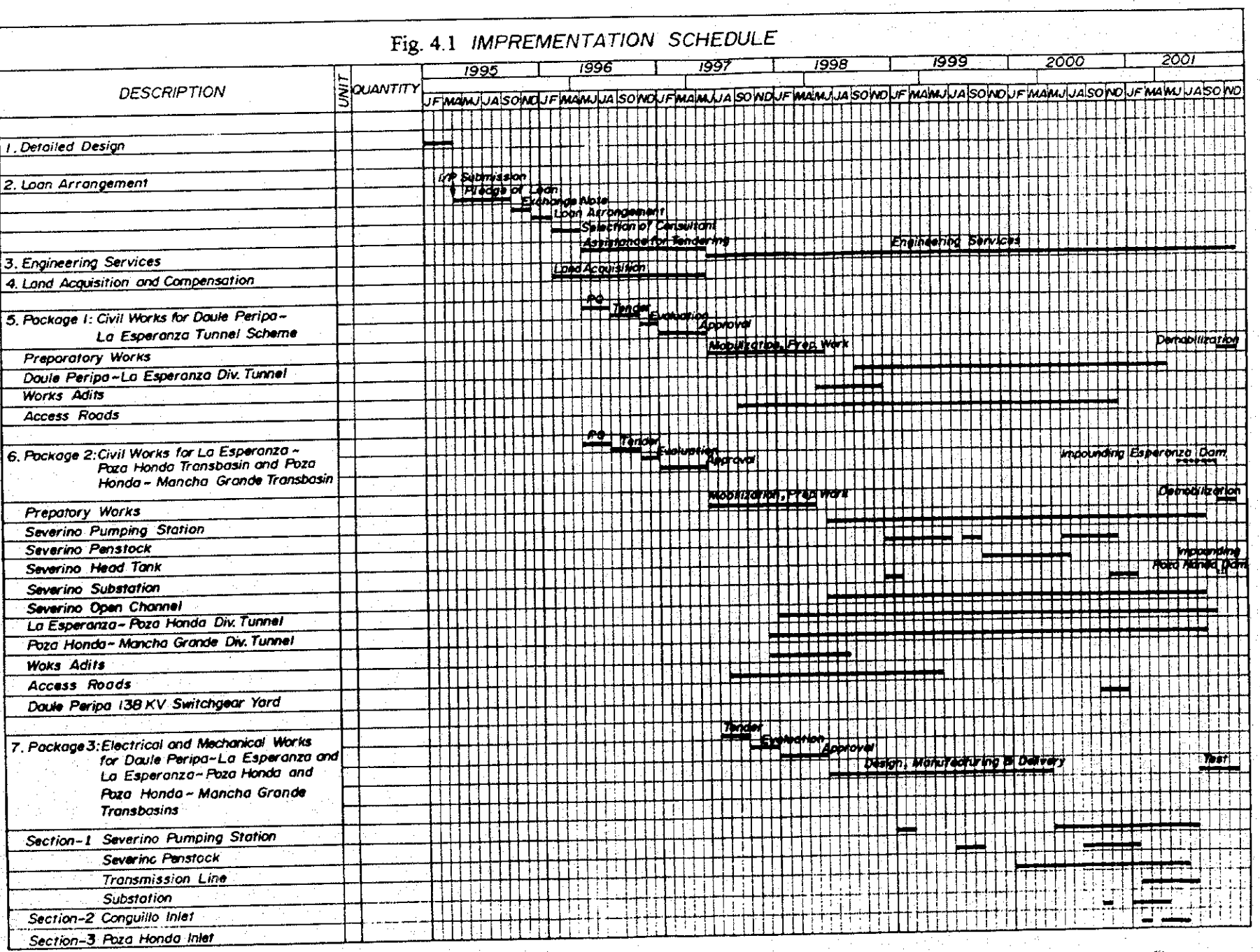
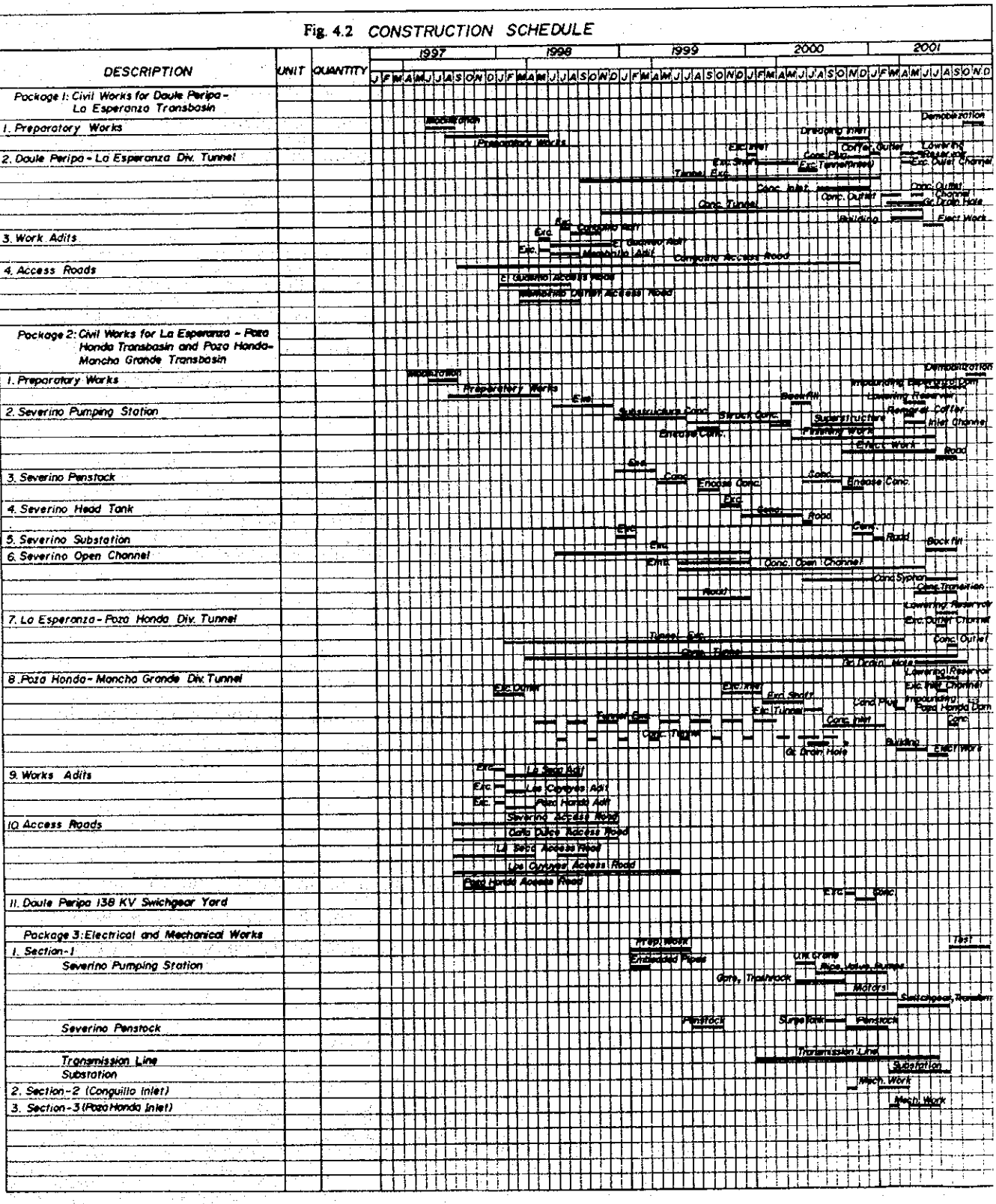


Fig. 4.2 CONSTRUCTION SCHEDULE



5. CONSTRUCTION METHOD

5.1 General

This chapter deals with an outline of the proposed construction method for the major works of permanent structures described in the drawings and specifications. It also describes preparatory works and construction facilities to be utilized for the implementation of the Water Transbasin Project.

The construction method and sequence is planned on the basis of the mode of construction and the target schedule of construction. In addition to the above, the construction conditions, site geological conditions and topographical conditions are taken into consideration and the conventional mechanical construction methods are applied for earthworks and concrete works in principle. However, the tunneling works will be required to carried out by the NATM.

Furthermore, the types and number of construction equipment and plant are studied in this chapter. As for the required number of major construction equipment, its calculation is attached in Annex VIII and IX together with the workable hour and the required progress rate for individual work.

5.2 Basic Conditions

In studying the construction method and sequence of the civil works for Package 1 and Package 2, the basic conditions, data and assumptions are considered as follows:

5.2.1 Construction Time Target

The tendering including prequalification for both packages is scheduled to be commenced from May 1996. The commencement date of both packages is scheduled to be June 1997 and be completed by November 2001. The construction period is to be fifty four months (4.5 years).

5.2.2 Workable Day and Hour for the Construction Works

The climate of the project area is characterized by a general rainy season lasting from January to April and/or May, and a dry period from June to December.

Average annual rainfall in the project area ranges from about 1,200 mm to 1,600 mm. Especially, the rainfall during dry season is not recorded or a quite small daily rainfall.

(1) Workable Day

The workable day for construction works is estimated on the basis of the rainfall data and monthly rainy days, which are recorded at two rainfall station in the project area; Dos Bocas and Poza Honda. The monthly rainy days at Dos Bocas is shown in Table 5.1. The monthly rainy day at Poza Honda and the detailed rainy days at each rainfall station are shown in Annex IV.

Table 5.1
Monthly Rainy Day

Month	(1) Less than 3 mm	(2) 3-5 mm	(3) 5-10 mm	(4) 10-30 mm	(5) 30-50 mm	(6) More than 50 mm
January	0.9	0.3	1.6	5.4	1.9	0.8
February	0.4	0.3	2.4	6.0	3.0	2.0
March	1.7	0.5	2.0	4.0	2.0	1.4
April	0.9	0.6	1.4	4.6	2.3	1.0
May	0.5	0	1.1	1.6	0.9	0
June	0.1	0.4	0.9	0.4	0.1	0
July	0.7	0	0.1	0.1	0	0
August	0.4	0.1	0.3	0.3	0	0
September	0.1	0	0.3	0	0	0
October	0.8	0	0.1	0.1	0	0.1
November	0.1	0	0	0.1	0	0
December	0.7	0.8	1.0	2.5	0.6	0

The earthworks will be suspended in case of daily rainfall of 3 mm over. The concrete work will be suspended in case of rainfall of 10 mm over. The suspended day due to rainfall for the earthwork is assumed as follows:

Table 5.2
Suspended Day due to Rainfall

Description	Less than 3 mm	3-5 mm	5-10 mm	10-30 mm	30-50 mm	More than 50 mm
Excavation	0	0	0.5	1.0	1.5	1.5
Embankment						
Earthfill	0	0.5	1.0	1.5	2.0	2.0
Random (weathered rock and soft rock).	0	0	0.5	1.0	1.5	1.5

The non-workable days are planned to be estimated four (4) days of Sunday per month and respective holidays.

The non-workable days are planned to be estimated four (4) days of Sunday per month and respective holidays.

Based on the above conditions, the workable day for each work item is estimated as follows. Detailed analysis is shown in Annex IV.

- Excavation — 20 days per month
- Embankment
  - Earthfill — 18 days per month
  - Random fill — 20 days per month
  - Rock (incl. tunnel) — 20 days per month
- Concrete — 21 days per month
- Tunnel work — 23 days per month

Random fill includes the excavated weathered rock, stockpiled weathered rock, and tunnel rock (soft rock). Earthfill will be made by common soil, top soil and unsuitable material.

Table 5.3
Workable Day

Month	Excavation	Embankment			Concrete
		Earth	Random	Rock	
January	15.8	10.7	15.8	16.6	17.9
February	6.3	0	6.3	7.5	10.0
March	15.9	11.0	15.9	16.9	18.6
April	15.8	10.8	15.8	16.5	18.1
May	21.5	19.7	21.5	22.1	22.5
June	24.0	23.1	24.0	24.5	24.5
July	25.9	25.8	25.9	25.9	25.9
August	25.6	25.2	25.6	25.7	25.7
September	24.9	24.7	24.9	25.0	25.0
October	23.7	23.6	23.7	23.8	23.8
November	23.9	23.9	23.9	23.9	23.9
December	19.1	16.7	19.1	19.6	19.9
Total	242.2	214.5	242.2	247.8	255.8

(2) Working Hour

Daily working hour is estimated as follows:

- Earthwork : The actual operation hour is assumed to be 6.5 hours out of 8 working hour per shift in principle. As for the pumping station, 2-shifts work is planned.

- Concrete work : 6.5 operation hours out of 8-working hour per shift.

- Underground work : The actual operation hour is assumed to be 18 hours per day out of 20-working hour per two shifts in principle.

5.2.3 Coefficient of Earth Volume Conversion

The coefficient of earth volume conversion is assumed as follows, with the consideration of geological conditions.

Table 5.4
Coefficient of Earth Volume Conversion

Class of Earth	Bank Measure	Loose Measure	Compacted Measure
a. Excavation			
Common	1.00	1.20	0.90
Sand and gravel	1.00	1.15	0.95
Weathered rock	1.00	1.30	1.10
Rock (soft rock)	1.00	1.40	1.20
b. Embankment and Fill Earthfill	1.00	1.20	0.90
	(1.11)	(1.33)	(1.00)
Sand and gravel	1.00	1.15	0.95
	(1.05)	(1.21)	(1.00)
Random material	1.00	1.30	1.10
	(0.91)	(1.18)	(1.00)
Rock Embankment	1.00	1.40	1.20
	(0.83)	(1.17)	(1.00)

Note: Figure in the parenthesis is the rate based on compacted volume.

Common : Cilty clay with some gravels, 0.5 - 0.9 km/sec

Weathered rock : Heavily weathered rock, 0.5 - 1.0 km/sec
Weathered, soft and loose, 1.5 - 1.6 km/sec.
(Weathered sandy mudstone)

Rock (Soft rock) : (Sandy mudstone)
Slightly loose mudstone, 1.8 - 1.9 km/sec.
Alternated with fine sand stone and mudstone, 2.1 - 2.2 km/sec.
Soft rock, massive and crackless, 2.4 - 2.5 km/sec.

5.2.4 Hourly Production Rate of the Major Equipment

The hourly Production rate of the major construction equipment is estimated as shown in Annex X with a formula used for such calculation and the coefficient of earth volume conversion. Furthermore, the hauling distance of material in average is assumed as follows:

Table 5.5
Hauling Distance

Description	Hauling Distance (m)
1. Excavation, embankment	
Conguillo inlet	2,000
Membrillo outlet	2,000
Inlet shaft/tunnel (2nd haul)	2,000
Tunnel excavation (2nd haul)	
Conguillo work adit (L1 = 2,700 m)	2,000
El Guasmo work adit (L2 = 2,800 m)	1,000
Membrillo work adit (L3 = 2,800 m)	2,000
Access road (Package 1)	
Embankment within 500 m	500
Embankment/Excavation	1,000
-do-	2,000
-do-	3,000
-do-	5,000
Severino pumping station	3,000
-do- (Backfill)	1,000
Severino penstock	2,000
Severino head tank	2,000
-do- (Backfill)	1,000
Severino open channel	1,000
-do- (Embankment)	1,000
-do- (Backfill)	1,000
Tunnel excavation (2nd haul)	
Caña Dulce portal	2,000
La Seca work adit	2,000
Los Cuyuyes work adit	2,000
Poza Honda work adit	2,000
Mancha Grande outlet	500
Caña Dulce inlet	2,000
Los Cuyuyes outlet	2,000
Poza Honda inlet	2,000
Mancha Grande outlet	500
Access road (Package 2)	
Embankment within 500 m	500
Embankment/Excavation	1,000
-do-	2,000
-do-	3,000

Table 5.5 (Cont'd)
Hauling Distance

Description	Hauling Distance (m)
2. Concrete	
Conguillo inlet and work adit	500
El Guasmo work adit	6,000
Membrillo work adit	500
Severino pumping station	2,000
Severino penstock	1,000
Severino head tank	1,000
Severino open channel	3,000
Caña Dulce inlet	4,000
La Seca work adit	4,000
Los Cuyuyes outlet and work adit	3,000
Poza Honda inlet and work adit	9,500
Mancha Grande outlet and work adit	500

5.3 Work Quantity

The work quantity required for the civil works is calculated from the detailed design drawings. The major work quantity of individual work is summarized in Table 5.6.

Table 5.6
Major Work Quantity

Description	Unit	Quantity
1. Package 1		
(1) Daule-Peripa~La Esperanza Diversion tunnel		
Excavation, open cut	m^3	33,600
Excavation, tunnel	m^3	163,650
Concrete, structure	m^3	4,102
Concrete lining	m^3	50,650
Steel support	ton	240
Rock bolt	m	118,390
Drain hole	m	6,310
Shotcrete, tunnel	m^3	10,120
(2) Conguillo work adit		
Excavation, open cut	m^3	14,440
Excavation, tunnel	m^3	3,560
Concrete	m^3	550
Steel support	ton	11
Rock bolt	m	2,630
Shotcrete, tunnel	m^3	225

Table 5.6 (Cont'd)
Major Work Quantity

Description	Unit	Quantity
(3) El Guasmo work adit		
Excavation, open cut	m^3	11,420
Excavation, tunnel	m^3	6,560
Concrete	m^3	556
Steel support	ton	31
Rock bolt	m	5,050
Shotcrete, tunnel	m^3	440
(4) Membrillo work adit		
Excavation, open cut	m^3	6,810
Excavation, tunnel	m^3	2,550
Concrete	m^3	549
Steel support	ton	8
Rock bolt	m	1,750
Shotcrete, tunnel	m^3	153
(5) Conguillo access road		
Excavation	m^3	805,200
Embankment	m^3	725,300
Subbase	m^3	20,470
Concrete	m^3	6,150
(6) El Guasmo access road		
Excavation	m^3	500
Embankment	m^3	42,500
Subbase	m^3	943
Concrete	m^3	610
(7) Membrillo access road		
Excavation	m^3	2,340
Embankment	m^3	7,200
Subbase	m^3	212
Concrete	m^3	686
2. Package 2		
(1) Severino pumping station		
Excavation, open cut	m^3	328,140
Fill and backfill	m^3	28,640
Concrete	m^3	31,129
(2) Severino penstock		
Excavation, open cut	m^3	12,780
Concrete	m^3	2,025

Table 5.6 (Cont'd)
Major Work Quantity

Description		Unit	Quantity
(3)	Severino head tank		
	Excavation, open cut	m^3	16,590
	Fill and backfill	m^3	5,130
	Concrete	m^3	3,760
(4)	Severino substation		
	Excavation, open cut	m^3	10,896
	Fill and backfill	m^3	1,170
	Concrete	m^3	658
(5)	Severino open channel		
	Excavation, open cut	m^3	299,960
	Embankment	m^3	209,900
	Fill and backfill	m^3	9,790
	Concrete lining, open channel	m^3	9,390
	Concrete, Structure	m^3	11,145
	Subbase	m^3	3,420
(6)	La Esperanza - Poza Honda Diversion tunnel		
	Excavation, open cut	m^3	24,960
	Excavation, tunnel	m^3	198,360
	Concrete, structure	m^3	859
	Concrete lining	m^3	65,880
	Steel support	ton	117
	Rock bolt	m	161,740
	Drain hole	m	8,680
	Shotcrete, tunnel	m^3	16,480
(7)	Poza Honda-Mancha Grande Diversion tunnel		
	Excavation, open cut	m^3	110,600
	Excavation, tunnel	m^3	51,190
	Concrete, structure	m^3	3,718
	Concrete lining	m^3	17,220
	Steel support	ton	83
	Rock bolt	m	38,510
	Drain hole	m	3,110
	Shotcrete, tunnel	m^3	5,400
(8)	La Seca work adit		
	Excavation, open cut	m^3	4,962
	Excavation, tunnel	m^3	9,590
	Concrete	m^3	577
	Steel support	ton	51
	Rock bolt	m	7,530
	Shotcrete, tunnel	m^3	651

Table 5.6 (Cont'd)
Major Work Quantity

Description	Unit	Quantity
(9) Los Cuyuyes work adit		
Excavation, open cut	m^3	5,140
Excavation, tunnel	m^3	2,680
Concrete	m^3	544
Steel support	ton	11
Rock bolt	m	1,870
Shotcrete, tunnel	m^3	168
(10) Poza Honda work adit		
Excavation, open cut	m^3	5,806
Excavation, tunnel	m^3	3,340
Concrete	m^3	570
Steel support	ton	10
Rock bolt	m	2,430
Shotcrete, tunnel	m^3	209
(11) Severino access road		
Excavation	m^3	6,900
Embankment	m^3	298,300
Subbase	m^3	8,290
Concrete	m^3	1,750
(12) Caña Dulce Inlet access road		
Excavation	m^3	10,400
Embankment	m^3	58,700
Subbase	m^3	1,610
Concrete	m^3	724
(13) La Seca access road		
Excavation	m^3	2,500
Embankment	m^3	43,660
Subbase	m^3	2,320
Concrete	m^3	750
(14) Los Cuyuyes access road		
Excavation	m^3	21,000
Embankment	m^3	236,800
Subbase	m^3	12,870
Concrete	m^3	3,954
(15) Poza Honda Inlet access road		
Excavation	m^3	4,740
Embankment	m^3	24,800
Subbase	m^3	600
Concrete	m^3	171

5.4 Preparatory Works and Construction Facilities

5.4.1 Construction Layout

The basic planning of the preparatory works and construction facilities required for the construction works are described in this chapter. They are access roads, temporary buildings, power supply system, water supply system, telecommunication system, CRM offices and camps, etc.

As for the civil works of Package1 and 2, the mobilization is scheduled to be required for three months after the commencement of work. The CRM base camps is scheduled to be constructed within six months after the commencement of work and the temporary buildings will be prepared by the end of December 1997. The permanent access roads will be used as a temporary road for each work adit and the various work sites.

The construction layout of the construction facilities and plant are presented in Annex I.

The land acquisition areas for base camp, temporary yard, construction site, transmission line, etc. are listed in Annex III.

5.4.2 Access Road

The road between Guayaquil and Portoviejo is about 200 km and the entire length is an asphalt pavement road. The access to the project site from Portoviejo is available for passing the existing pavement road for Rocafuerte-Tosagua, San Plácido-Pichincha and Santa Ana-Poza Honda. However, the permanent access roads are required to connect the particular work sites from the existing roads.

Almost construction equipment and plant, imported material and goods, hydromechanical and electrical equipments and so on will be delivered from the Guayaquil port. The Manta port located 35 km apart from Portoviejo will also be available for general cargo transportation.

(1) Permanent Access Roads

The permanent access roads will be constructed at early stage of the construction as shown in Fig. 4.2, Construction Schedule. Before the completion of permanent access roads, the same routes will be used as temporary access roads and hauling roads. The access roads are planned as follows:

- Package 1

Conguillo access road	22.6 km
El Guasmo access road	1.6 km
Membrillo outlet access road	0.4 km
Total	24.6 km

- Package 2

Severino access road	9.3 km
Caña Dulce inlet access road	2.7 km
La Seca access road	3.8 km
Los Cuyuyes access road	14.8 km
Poza Honda inlet access road	0.7 km
Total	31.3 km

(2) Temporary Access Roads

The temporary access roads for the construction services is planned to be distributed from the permanent access roads to the spoil areas and construction facilities. The construction of temporary access road will be done by dozing and leveling with 21 ton bulldozer with ripper. The road surface is protected by the excavated weathered rock and soft rock and sufficiently compacted. During the construction period, the access road will be maintained by 3.7 m motor grader and 6 kl water sprinkler truck. Temporary access roads are as shown in Table 5.7.

Table 5.7
Temporary Access Road

Description	Length (m)
1. Package 1	
Conguillo inlet to spoil area	500
El Guasmo work adit to spoil area	500
Membrillo outlet to spoil area	500
Total	1,500
2. Package 2	
Along the open channel	7,000
For spoil area located along open channel	2,000
Mancha Grande outlet to spoil area	500
Other	2,000
Total	11,500

5.4.3 CRM Base Camp and Temporary Buildings

(1) Base Camp

The CRM base camp is planned to be located 800 m apart from the pumping station along the Severino access road. The CRM base camp comprises of main office, branch offices and housing for campground. The CRM base camp will be constructed at early stage of the construction to supervise and manage the project. The permanent resident quarters will be used for the operational and maintenance staff after the commissioning of pumping station. The base camp facilities are summarized in Table 5.8.

Table 5.8
Offices and Housing for the Supervision

Description	Number	Floor Area (m^2)
1. Package 1		
- Branch office at Membrillo outlet	1	100
- Branch office at Conguillo inlet	1	50
2. Package 2		
- Main office at Severino		
Office space for CRM	1	250
Office space for supervision	1	150
- Branch office at Poza Honda inlet	1	100
- Branch office at Mancha Grande outlet	1	50
- Housing for campground		
Housing for CRM engineers ($8 \times 120\ m^2$)	8	960
Housing for supervision engineers ($8 \times 120\ m^2$)	8	960
Housing (20 bed rooms)	1	260
- Medical Center (Clinic)	1	120
- Kindergarten/elementary school	1	100
- Social hall	1	100
- Club house	1	120
- Guard house	1	20
- Church	1	100
- Stores	1	150
- Recreation facilities		
Swimming pool, 7.5 m x 15 m	1	
Tennis court	2	
Valley ball court	1	
Football pitch	1	
3. Base camp area (Land area)		
- Package 1		750
- Package 2		20,000

(2) Temporary Buildings

The contractor's temporary buildings and quarters required for each package are planned to be located near the pumping station, at Membrillo outlet, at Conguillo inlet, at Poza Honda inlet and at Mancha Grande outlet as shown in Table 5.9.

Table 5.9
Temporary Buildings for the Contractor

Description	Number	Floor Area (m^2)
1. Package 1		
- Main office at Membrillo outlet	1	220
- Branch office at Conguillo		1/
- Contractor's quarter at Membrillo	1	250
- Labor quarter		
Conguillo inlet	1	400
El Guasmo work adit	1	320
Membrillo outlet	1	320
- Concrete plant (at Membrillo)	1	100
- Concrete plant (at El Guasmo)	1	100
- Laboratory	1	100
- Cement warehouse	2	200
- Site warehouse	3	300
- Repair shop, tunnel	3	150
- Repair shop, motor pool	1	200
- Winch house	3	90
- Diesel generator house	3	150
- Battery charge house	3	60
- Explosive magazine	1	30
- Rest house	3	90
2. Package 2		
- Main office at pumping station	1	220
- Branch office at Poza Honda inlet	1	100
- Branch office at Mancha Grande outlet	1	50
- Contractor's quarter at pumping station	1	430
- Labor quarter		
At pumping station	1	1,160
At Caña Dulce inlet	1	280
At La Seca work adit	1	320
At Los Cuyuyes work adit	1	320
At Poza Honda work adit	1	280
At Mancha Grande outlet	1	240
- Concrete plant at pumping station	1	100
- Concrete plant at Los Cuyuyes	1	100
- Concrete plant at Mancha Grande outlet	1	100

Table 5.9 (Cont'd)
Temporary Buildings for the Contractor

Description	Number	Floor Area (m^2)
- Laboratory	2	200
- Cement warehouse	3	500
- Site warehouse	6	700
- Repair shop, tunnel	5	250
- Repair shop, motor pool	2	400
- Formwork, reinforcing bar	1	200
- Diesel generator house	5	250
- Battery charge house	5	90
- Winch house	3	90
- Explosive magazin	1	30
- Rest house	6	350
3. Contractor's temporary land area		
- Package 1		
Membrillo outlet		6,800
El Guasmo		2,500
Conguillo inlet		3,300
- Package 2		
Main office area (pumping station)		11,600
Caña Dulce inlet		2,200
La Seca work adit		4,200
Los Cuyuyes work adit		2,500
Poza Honda work adit		2,700
Mancha Grande outlet		2,600
- Package 3		
Main office area (pumping station)		5,000
Conguillo Honda inlet		1,000
Poza Honda inlet		1,000

Remarks: 1/, The existing office at Conguillo will be used for the construction purpose.

5.4.4 Power Supply System

The electric power supply for the construction and camp use is planned to be done by diesel generator provided by each package contractor. The power supply system for the main base camp is planned to be 13.8 kV distribution line extended from the proposed transmission line connected to the Severino pumping station.

The diesel generator sets will be provided at each work adit and the Severino pumping station site. The distribution line covered on all project area is not considered, since the electric demand sites are isolated each other. The total installation capacity of electric power for civil construction work is summarized in Table 5.10.

Table 5.10
Electric Power Requirement

Description	Installation Capacity (kW)	Peck Demand (kW) (Factor x 0.60)
1. Package 1		
Membrillo site		
Main camp	45	27
Concrete plant	100	60
Tunnel work	800	480
El Guasmo site		
Camp	15	9
Tunnel work	800	480
Conguillo site		
Camp	25	15
Concrete plant	100	60
Tunnel work	800	480
CRM branch office (included in the above capacity)		
2. Package 2		
Severino site		
Main camp	70	42
Concrete plant	100	60
Work shop	30	18
Caña Dulce inlet		
Camp	15	9
Tunnel work	550	330
La Seca site		
Camp	15	9
Tunnel work	800	480
Los Cuyuyes site		
Camp	15	9
Tunnel work	800	480
Concrete plant	100	60
Poza Honda inlet site		
Camp	15	9
Tunnel work	700	420
Mancha Grande site		
Camp	15	9
Tunnel work	500	300
Concrete plant	100	60
3. CRM Base camp	200	120

The diesel generator sets for each packages are planned to be located considering the site conditions and each capacity due to demand factor are as follows:

- Base camp for CRM and Supervision — 150 kVA x 1

- Package 1

Conguillo camp and work adit	300 kVA x 2,	100 kVA x 1
El Guasmo camp and work adit	300 kVA x 2,	50 kVA x 1
Membrillo camp area and work adit	300 kVA x 2,	150 kVA x 1

- Package 2

Pumping station site (incl. main camp)	150 kVA x 1,	30 kVA x 3
Caña Dulce inlet	300 kVA x 1,	150 kVA x 1
La Seca camp and work adit	300 kVA x 2,	50 kVA x 1
Los Cuyuyes camp and work adit	300 kVA x 2,	100 kVA x 1
Poza Honda camp and work adit	300 kVA x 2,	
Mancha Grande outlet site	300 kVA x 2,	100 kVA x 1

- Package 3

Pumping station site (incl.camp)	75 kVA x 1
Election site, Severino site	175 kVA x 1
Conguillo inlet (office, erection)	50 kVA x 2
Poza Honda inlet (office, erection)	50 kVA x 2

5.4.5 Water Supply System

The water supply system for the construction use and domestic use at base camp is planned at each project package. The water sources, the location and the work adit portals are taken into consideration for providing water supply facilities. The water sources and locations are as follows:

- Package 1
  - Conguillo inlet and work adit : Conguillo river
  - El Guasmo work adit : Tributaries (El Guasmo river)
  - Membrillo outlet and work adit, base camp. : Membrillo river

- Package 2
  - Severino pumping station, penstock, open channel, Caña Dulce inlet, base camp. : Severino river
  - La Seca work adit and Los Cuyuyes work adit. : Pata de Pájaro river
  - Poza Honda inlet and work adit : Poza Honda reservoir
  - Mancha Grande outlet : Mancha Grande river

The water requirement for the construction work and base camp are shown in Table 5.11.

Table 5.11
Water Requirement for Construction Use and Base Camp

Description	Water Requirement (m^3/min)
1. Package 1	
Membrillo site (Office, camp, tunnel, concrete plant and CRM branch office)	0.44
El Guasmo site (Camp and tunnel)	0.22
Conguillo site (Camp, tunnel, concrete plant and CRM branch office)	0.34
2. Package 2	
Severino site (Main office, camp and concrete plant)	0.42
Caña Dulce inlet (Camp and tunnel)	0.22
La Seca site (Camp and tunnel)	0.22
Los Cuyuyes site (Camp, tunnel and concrete plant)	0.32
Poza Honda inlet (Camp and tunnel)	0.22
Mancha Grande outlet (Camp, tunnel and concrete plant)	0.32
3. Base camp for CRM and Supervision	0.30

5.4.6 Telecommunication System

The telecommunication systems consisting of radio communication system and wireless telephone system (micro wave) will be installed for construction use and operation and maintenance. These facilities will be provided by package 2 contract.

The wireless radio communication system is planned to be VHF radio equipment and will be established for communications among the CRM's main office and the branch offices. While, the wireless telephone system will be installed between Calceta transmission station and CRM's main office at Severino. Both systems are as follows:

Radio communication system:

Main office - Portoviejo (3 stations, 1-antenna)
Main office - Mancha Grande, Poza Honda, Membrillo and Conguillo (4 stations, 1-antenna)

Telephone communication system:

Transmission station at Calceta (20 lines)
Main office - Antenna and receiving station (20 lines)
Telephone Station

The contractor may use the above telephone system as an emergency purpose. The radio communication system will be installed by each package contractor. The wired telephone facilities will be required within each tunnel work site including all work adit and open construction sites.

As for the CRM's main camp and the pumping station, the wired telephone facilities will be installed to connect the telephone system. After the completion of the construction, the telephone system will be used for the operation and maintenance. The private automatic branch exchange is planned to be provided at the main base camp.

5.4.7 Concrete Plant

The concrete batcher plants will be installed at following location, taking into account the construction conditions, transportation length and concrete placing volume. The concrete plants are scheduled to be provided before starting the work adit construction.

- Package 1
  - Conguillo concrete plant : For Conguillo inlet, tunnel of 0 to 2,700 m, tunnel of 2,700 to 5,500 m.
  - Membrillo concrete plant : For Membrillo outlet, tunnel of 5,500 m to 8,170 m.
- Package 2
  - Severino concrete plant : For pumping station, penstock, head tank, open channel, Caña Dulce inlet, tunnel of 0 to 4,200 m.
  - Los Cuyuyes concrete plant : For tunnel of 4,200 to 7,500 m, tunnel of 7,500 to 11,417 m, Los Cuyuyes outlet, Poza Honda inlet, tunnel of 0 to 2,200 m (Poza Honda-Mancha Grande).

- Mancha Grande concrete plant: For Mancha Grande outlet, tunnel of 2,200 to 4,095 m.

The total concrete volume for the civil works is estimated at 218,685 m^3, of which are 63,853 m^3 for Package 1 and 154,832 m^3 for Package 2 as shown in Table 5.12.

Table 5.12
Concrete Volume for Each Work Site

Description	Concrete Volume (m^3)
1. Package 1	
Daule-Peripa ~ La Esperanza diversion tunnel	54,752
Conguillo work adit	550
El Guasmo work adit	556
Membrillo work adit	549
Conguillo access road	6,150
El Guasmo access road	610
Membrillo outlet access road	686
2. Package 2	
Severino pumping station	31,129
Severino penstock	2,025
Severino head tank	3,760
Severino substation	658
Severino open channel	20,535
La Esperanza - Poza Honda diversion tunnel	66,739
Poza Honda - Mancha Grande diversion tunnel	20,938
La Seca work adit	577
Los Cuyuyes work adit	544
Poza Honda work adit	570
Severino access road	1,758
Caña Dulce inlet access road	724
La Seca access road	750
Los Cuyuyes access road	3,954
Poza Honda inlet access road	171

(1) Concrete Plant

According to the construction schedule and the concrete placing volume, the daily concrete requirement and required plant capacity are as follows:

(a) Conguillo concrete plant

Daily concrete placement	:	73 m^3/span x 2 places = 146 m^3/day
Daily working hours	:	4 hrs/span x 2 time/day = 8 hrs
Hourly concrete requirement	:	18.3 m^3/hr
Required plant capacity	:	1.0 m^3 x 60 min/2 min x 0.8 = 24 m^3/hr
Concrete plant	:	Automatic type with one 1.0 m^3 mixer

(b) Membrillo concrete plant

Daily concrete placement	:	73 m^3/span•day
Daily working hours	:	4 hrs/span
Hourly concrete requirement	:	18.3 m^3/hr
Required plant capacity	:	1.0 m^3 x 60 min/2 min x 0.8 = 24 m^3/hr
Concrete plant	:	Automatic type with one 1.0 m^3 mixer

(c) Severino concrete plant

Daily concrete placement	:	170 m^3/day plus 67 m^3/span
Daily working hours	:	8 hrs and 4 hrs (tunnel)
Hourly concrete requirement	:	34.2 m^3/hr
Required plant capacity	:	0.75 m^3 x 2 x 60 min/2 min x 0.8 =36 m^3/hrs
Concrete plant	:	Automatic type with two 0.75m^3 mixer

(d) Los Cuyuyes concrete plant

Daily concrete placement	:	117 m^3/day at peak
Daily working hours	:	4 hrs/span (2-tunnel)
Hourly concrete requirement	:	29.3 m^3/hr
Required plant capacity	:	0.75 m^3 x 2 x 60 min/2 min x 0.8 = 36 m^3/hr
Concrete plant	:	Automatic type with two 0.75m^3 mixer

(e) Mancha Grande concrete plant

Daily concrete placement	:	50 m^3/span
Daily working hours	:	4 hrs/span
Hourly concrete requirement	:	12.5 m^3/hr
Required plant capacity	:	0.75 m^3 x 60 min/2 min x 0.8=18 m^3/hrs
Concrete plant	:	Automatic type with one 0.7 m^3 mixer

(1) Cement Storage

The project site is located to be far from the cement company located at Guayaquil. The cement silo fabricated with steel will be provided just close to each concrete plant. The capacity of cement silo is planned to be 7 days for Package 1 and 5 days for Package 2, and the cement warehouse capacity will be required to be at fifty percent of the cement silo.

	Cement Silo (ton)	Warehouse (ton)
- Conguillo concrete plant	300	150
- Membrillo concrete plant	150	75
- Severino concrete plant	250	125
- Los Cuyuyes concrete plant	200	100
- Mancha Grande concrete plant	100	50

5.4.8 Aggregate Plant

Available quarry sites are not situated within the project area. The private quarry companies are developing the quarry near Montecristi. All concrete aggregate required for the La Esperanza Dam project (under construction) is also supplied from the quarry companies. In this construction plan, the concrete aggregate, crushed stone subbase, boulders, cobbles and so on are the purchased quarried materials.

Sand material sources are to be located near San Jacinto and San Clemente for sea sand. While, the river sand will be obtained from the Quevedo river about 200 km apart from the project sites. The quarry companies also produce the sand material to supply the La Esperanza Dam Project. However, the quarried sand will be required to add the washed sea sand and/or river sand, taking into account the specified gradation and the improvement of workability of concrete.

The location of concrete aggregate sources are as shown in Annex V.

5.5 Construction Method, Package 1

5.5.1 General

The civil works for Daule-Peripa ~ La Esperanza Transbasin (Package 1) comprise diversion tunnel including inlet, intake shaft and outlet, three work adits and three access roads.

The package 1 construction is scheduled to be commenced in the beginning of June 1997 and completed by the end of November 2001. The construction period of package 1 is planned to be fifty four months (4.5 years).

The proposed construction method is prepared in consideration with the construction schedule, conventional and available construction equipment. As for the tunnel works, the NATM is applied in principle.

5.5.2 Inlet Structure

The inlet facilities lead the water of Daule-Peripa reservoir to the diversion tunnel through hydromechanical equipment. The Conguillo inlet tunnel of 12.0 m long was constructed from July 1989 to January 1990 and the inlet portion is under water of about 20 m deep in the Daule-Peripa reservoir.

The inlet structure is scheduled to be constructed for twelve months from January 2000. The deposited sand in front of inlet channel will be dredged for three months during dry season of 2000.

The inlet structure is made of concrete having 20 m x 16 m section and 25.1 m high in underground. The valve chamber is 10.4 m deep from the bottom of inlet structure. The new construction of inlet tunnel is to be 15.0 m to connect the previous tunnel bulkhead.

The open excavation at EL.90.20 m is scheduled in January 2000. The excavation volume is estimated at 24,900 m^3. The Conguillo access road will be constructed to connect the inlet structure. The common and weathered rock will be carried out by 21 ton bulldozer and 32 ton bulldozer with ripper.

After the open excavation above EL.90.20 m, the inlet shaft will be sinked downward. The rock excavation will be made by 7 m^3 crawler drill and 2.9 m^3/min sinke drill. The broken rock will be gathered by 0.4 m^3 tractor shovel and 0.3 m^3 backhoe and loaded into a deposit bucket. The deposit bucket will be pulled up by 30 ton truck crane and discharged into 11 ton dump truck bessel. The sinking height is to be 1.0 m and the excavated surface will be supported by rock bolts, shotcrete and H-300 steel rib.

Succeeding to the shaft excavation, the inlet tunnel of 15.0 m will be driven by blasting method and the broken rock will be loaded by 0.4 m^3 tractor shovel into deposit bucket handled with 30 ton truck crane. The concrete bulkhead will be demolished carefully after the confirmation of the interior water in the previous tunnel. The demolishing will be made by manpower with hand type concrete breaker and pick hammers.

The concrete work is scheduled to be made from August to December 2000. The concrete will be transported by 3.0 m^3 agitator truck from the Conguillo concrete plant. The concrete will be discharged into 1.0 m^3 concrete bucket and handled to the concrete hopper by 30 ton truck crane and distributed into the placing spot through chutes from the hopper. The concrete lining of inlet tunnel will be carried out by means of concrete placer applied for the diversion tunnel lining work.

Inlet mechanical work is scheduled to be carried out for three months from January 2001 after the completion of inlet structure concrete work. However, the inlet pipes is scheduled to be installed for one month from November 2000 and the plug concrete work will follow.

The dredging of inlet channel will be carried out by a 200 HP class dredger and the sand material will be delivered through 200 m dia.delivery pipes. The delivered sand will be dried and then loaded by 0.6 m^3 backhoe into 11 ton dump truck for hauling to the spoil bank.

Table 5.13
Construction Equipment of Inlet Structure

Description	Spec.	Required Number
1. Open excavation		
Bulldozer	21 ton	1
Bulldozer/ripper	32 ton	1
Tractor shovel	2.2 m^3	2
Dump truck	11 ton	6
Bulldozer	11 ton	1
2. Shaft excavation		
Crawler drill	7 m^3/min	2
Air compressor	10 m^3/min	2
Tractor shovel	0.4 m^3	1
Backhoe	0.3 m^3	1
Deposit bucket	3 m^3	1
Truck crane	30 ton	1
3. Concrete Work		
Concrete plant	1 m^3	1
Agitator truck	3 m^3	2
Concrete bucket	1 m^3	2
Truck crane	30 ton	1
Vibrator	50 mm	5
4. Dredging work		
Dredger	200 PS	1
Anchor boat	30 PS	1
Motor boat	30 PS	1
Pontoon	30 ton	1

5.5.3 Outlet Work

The outlet structures of tunnel portal are scheduled to be constructed from January 2001 after constructing temporary coffer dams. The remaining tunnel of 10 m long at the outlet will also be driven and concrete lined by the same method applied for the diversion tunnel work. However, the outlet channel construction will require the water lowering of La Esperanza dam reservoir. The lowering period is scheduled to be two months from March 2001. The impounding at MWL of reservoir of La Esperanza dam will require four months.

5.5.4 Diversion Tunnel

The horseshoe type concrete lined tunnel is planned for Daule-Peripa~La Esperanza Transbasin, and to be 3.7 m in diameter and 8,295 m long. The diversion tunnel is mainly aligned in massive and soft sandy mudstone with a compressive strength of about 100 kg/cm^2 and anticipated to encounter neither fault nor water problem. The tunnel construction will be a critical path of the Package 1 work. In order to shorten the construction period, three work adits are planned to be provided considering with the construction sequence.

Conguillo work adit is planned to be located near the inlet portion (168 m from upstream). El Guasmo work adit is located at middle point (3,000 m from upstream). Membrillo work adit is located just upstream of the outlet portal (8,170 m from upstream).

The diversion tunnel is divided mainly into two cross sections due to the supporting method. The gradient of tunnel slope is to be 1/1,500.

The construction period of diversion tunnel is scheduled to be thirty three months from September 1998 to May 2001. Before starting the tunnel work, the access roads and the work adits will be provided for each tunnel work section.

(1) Construction Sequence and Tunnel Work Section

The tunnel work sections are planned to be six driving sections by providing three work adits, to secure the construction schedule. The driving sections are shown in Fig. 5.1 and are as follows:

- Upstream portion from Conguillo work adit (excluding inlet structure) : Section I, 168 m
- Downstream portion from Conguillo work adit : Section II, 2,532 m
- Upstream portion from El Guasmo work adit : Section III, 300 m
- Downstream portion from El Guasmo work adit : Section IV, 2,500 m
- Upstream portion from Membrillo work adit : Section V, 2,670 m

- Downstream portion from Membrillo work adit : Section VI, 125 m

The concrete lining works are also planned to be made in above work sections in parallel work of the tunnel excavation. The time lag between the driving and the concrete lining is to be two months, taking into account the geological conditions and the tunneling method of NATM.

The tunnel excavation sequence are shown in Fig. 5.1, Tunnel Work Diagram for the Diversion Tunnel. After the completion of work adits construction, the tunnel excavation work will be commenced from September 1998. The construction period of each driving section is as follows:

Section I	:	1.6 months
Section II	:	23.9 months
Section III	:	2.8 months
Section IV	:	23.6 months
Section V	:	25.2 months
Section VI	:	1.2 months

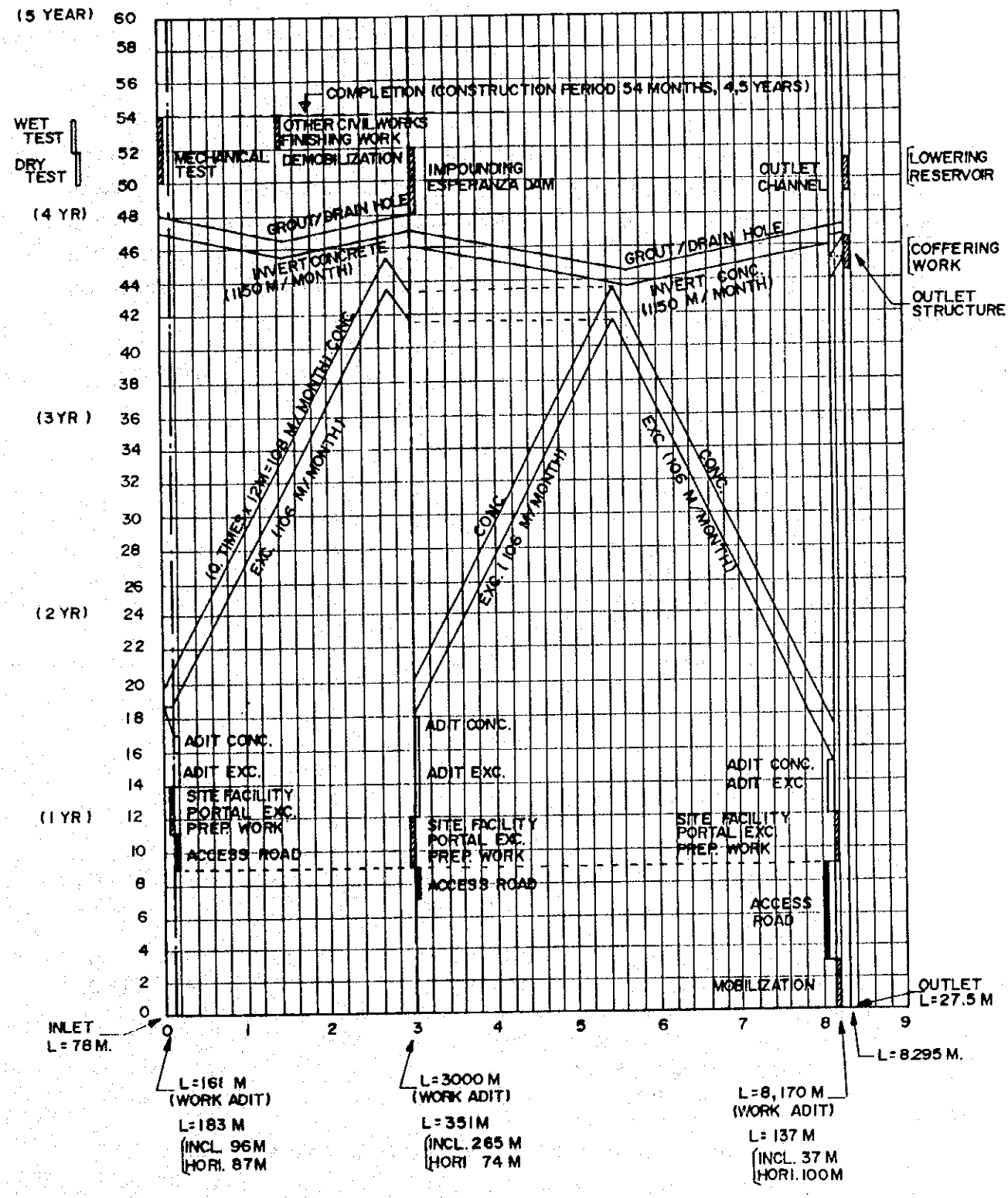
Before starting the diversion excavation, the following work adits construction period will be required:

Conguillo work adit	:	Access road, 2 months Site facilities, portal excavation, preparatory works, 3 months Adit excavation, 2 months Concrete lining (horizontal tunnel), 1 month
El Guasmo work adit	:	Access road, 2 months Site facilities, portal excavation, preparatory works, 3 months Adit excavation, 5 months Concrete lining, 1 month
Membrillo work adit	:	Mobilization, 3 months Access road, 6 months Site facilities, portal excavation, preparatory works, 3 months Adit excavation, 2 months Concrete lining, 1 month

(2) Work Adit Construction

The work adit is designed to be a vertical wall and arch roof type, 4.0 m wide x 4.0 m high. The supporting system is to be a rock bolting and shotcrete method applied for the

FIG. 5.1 TUNNEL WORK DIAGRAM FOR DAULE PERIPA - LA ESPERANZA TUNNEL



diversion tunnel supporting. The steel support section will be considered at 10 percent of each adit length. The length of inclined portion and horizontal portion is as follows:

	Inclined	Horizontal	Total Length
Conguillo work adit	96.4 m	86.9 m	183.3 m
El Guasmo	265.0 m	84.6 m	349.6 m
Membrillo work adit	37.6 m	99.8 m	137.4 m

The tunnel excavation is planned to be made by applying a full face attack method. The drilling rock will be carried out by 4 nos.leg drill with portable deck. The broken rock will be loaded by 0.4 m3 inclined type muck loader into 2 nos. of 4.5 m3 muck car, and then the muck cars will be pulled up outside of tunnel portal by using 150 kW winch. The broken rock will be loaded by 1.2 m3 tractor shovel into 8 ton dump truck. The tunnel driving rates of progress is as follows:

	Conguillo	El Guasmo	Membrillo
- Excavated area 15.747 m^2			
- Shooting rate, 1.2 m			
- Driving cycle per one shoot			
Setting up for drilling	15	15	15
Drilling	60	60	60
Loading & shooting explosives	25	25	25
Ventilating and removing dust	15	15	15
Setting up for mucking	20	20	20
Loading & hauling muck	50	70	50
Extending rail	10	10	10
Barring	20	20	20
Shotcreting	45	45	45
Rock butting	50	50	50
Erecting steel support	(50)	(50)	(50)
Loss time (others)	10	10	10
Total without H-steel	320 min (370 min)	340 min (390 min)	320 min (370 min)
with H-steel	5.33 hr (6.17 hr)	5.67 hr (6.5 hr)	5.33 hr (6.17 hr)
- Working hour, 18 hrs/day			
- Number of shooting per day	3.38 (2.92)	3.17 (2.77)	3.38 (2.92)
- Daily progress rate (m/day)	4.06 (3.50)	3.80 (3.32)	4.06 (3.50)
- Monthly progress rate (m.month)	93.38 (80.50)	87.40 (76.36)	93.38 (80.50)
- Average progress rate (m.month)	92.09	86.30	92.09
without H-steel, 90%			
with H-steel, 10%			

(Remarks: Figure in the parenthesis is the rate of H-steel section)

The required construction equipment for the work adit excavation is listed as follows:

Table 5.14
Construction Equipment for Work Adit

Description	Spec.	Required Number
1. Open excavation		
Bulldozer	21 ton	1
Bulldozer with ripper	32 ton	1
Tractor shovel	2.2 m^3	3
Dump truck	11 ton	7
Bulldozer	11 ton	2
2. Tunnel excavation		
Leg drill	2.7 m^3/min	12
Portable plat form		3
Pick hammer	7 kg	12
Muck loader	0.4 m^3	2
Muck car	4.5 m^3	4
Winch	150 kW	3
Vent fan	300 m^3/min	3
Vent fan	100 m^3/min	3
Air compressor	16 m^3/min	3
Tractor shovel	1.2 m^3	3
Dump truck	8 ton	3
3. Shotcrete and rock bolt		
Gunite spray machine	10 m^3/hr	3
Dust collector	150 m^3/hr	3
Leg drill	2.7 m^3/min	6
Stopper drill	2.7 m^3/min	6
Mortar mixer	50 lit	3
Mortar feeder	50 lit	3

(3) Diversion Tunnel Excavation

The typical cross section of diversion tunnel is planned to be four sections such as Type I, II, III and IV, according to the geological conditions and NATM tunnel supporting system.

Type I : Rock bolt 25 mm dia, 2.0 m long, 4 nos, 1.2 m pitch, shotcrete 10 cm
Type II : Rock bolt 25 mm dia, 2.0 m long, 8 nos, 1.2 m pitch, shotcrete 10 cm
Type III : Rock bolt 25 mm dia, 2.0 m long, 8 nos, 1.2 m pitch, shotcrete 15 cm
Type IV : Rock bolt 25 mm dia, 2.0 m long, 8 nos, 1.2 m pitch, shotcrete 10 cm, H-steel support 125 x 125.

A full save attack method is recommended to apply for driving the tunnel, while hauling of broken rock is by a rail haulage method. The tunnel excavation work will be mainly such two cross sections as type II (92%) and IV (8%). The average driving rate of progress is 106.54 m/month taking into account of decreasing excavation working hour due to the concrete lining work.

The driving rate of progress is as follows:

	II (7.686 m)	III (610 m)
- Excavated area (m^2)	18.62	18.65
- Driving rate (m)	1.20	1.20
- Driving cycle (min)		
Setting up	10	10
Excavation & mucking	55	55
Removal of machine	15	15
Shotcreting	45	45
Rock bolting	70	70
Erecting steel support	-	50
Changing bit	10	10
Maintaining equipment	10	10
Loss time (others)	15	15
Total	230 min (3.83 hr)	280 min (4.67 hr)
- Working hour, 18 hrs/day		
- Number of driving (nos/day)	4.70	3.85
- Daily progress rate (m/day)	5.64	4.62
(1.20 m per one cycle)		
- Monthly progress rate (m/month)	129.72	106.26
Average progress rate (m/month)	127.84 m	
II: 92%, IV: 8%		

Progress rate due to the affection of concrete lining

1st day : 127.84 m/month (only excavation work)

2nd day : 127.84 x 12 hr/18 hr = 85.23 m/month (6 hrs affected)

Planned progress: (127.84 + 85.23) x ½ =106.54 m/month

Three attacking faces will be provided concurrently to ensure the construction schedule. The tunnel excavation work will be carried out using an arm type mechanical tunneling machine with a cutting head, considering with the geological conditions and the following supporting system comprising of shotcreting and rock bolting. The broken rock will be gathered by gathering arm of tunneling machine, transported through velt conveyor of the machine, and loaded into 4.5 m^3 muck cars with 8 ton battery locomotive. At the bottom of inclined tunnel, every two muck cars will be pulled up outside by 150 kW winch. The broken rock carried to the open yard will be loaded by 1.2 m^3 tractor shovels into 8 ton dump trucks for hauling to the spoil area.

Just after finishing one cycle excavating operation of 1.2 m progress, the shotcrete of 100 mm thick with 100 x 100 mm wire mesh and rock bolts of 2.0 m long will be made. As for the lower compressive strength sections and fault zones, H-steel beam ribs and additional shotcreting will be required.

Table 5.15
Construction Equipment for Diversion Tunnel
Tunnel excavation

Description	Spec.	Required Number
1. Excavation		
Arm type tunnel machine	110 kW	3
Muck car	4.5 m^3	30
Battery locomotive	8 ton	6
Pick hammer	7 kg	12
Winch	150 kW	3
Vent fan	300 m^3/min	19
Vent fan	100 m^3/min	6
Air compressor	16 m^3/min	3
Tractor shovel	1.2 m^3	3
Dump truck	8 ton	3
2. Shotcrete and rock bolt		
Gunite spray machine	10 m^3/hr	3
Dust collector	150 m^3/hr	3
Leg drill	2.7 m^3/min	6
Stopper drill	2.7 m^3/min	6
Mortar mixer	50 lit	3
Mortar feeder	50 lit	3

(4) Concrete Lining

The concrete lining thickness is designed to be 300 mm except for the shotcrete supporting system. The concrete lining work is required to be performed in parallel with the tunnel excavation work. The concrete lining work will be made to keep the distance of about 200 m from the heading (2 months interval), considering with the NATM analysis.

During concrete lining work including concrete placing and primary concrete curing, the haulage of broken rock will be suspended. The suspended hour is estimated at 6 hours. The sliding centle preparation will be made during about 4 hours of tunnel excavation cycle. The concrete lining is planned to be carried out to follow the tunnel driving rate of 106 m/month.

An arch and then invert concrete lining method is planned through the whole tunnel length. The concrete lining work will be made by using 12.0 m long telescopic type steel form to shorten the installation time. Three concrete lining sections will be provided concurrently. The concrete lining work is scheduled to be carried out two months after the commecement of tunnel excavation, from November 1998 to March 2001. The invert concrete work is scheduled to be carried out about four months from Mid January 2001.

The concrete will be transported by 3.0 m^3 agitator truck from the concrete plant located at Conguillo and at Membrillo respectively. The concrete will be discharged into 6 m^3 concrete vesell car and then pulled down by 100 kW winch. At the bottom of inclined tunnel, the concrete will be again discharged into 6 m^3 concrete placer through a hopper. The concrete placer will be delivered to the placing spot by 6 ton battery locomotive and be placed behind steel from by means of compressed air from the concrete placer. The invert concrete will be transported and placed by 4.5 m^3 agitator car. The progress rate of invert concrete is planned to be 1,150 m/month.

One month after the invert concrete placement, the backfill grouting and drilling of drain holes will be followed in parallel with the invert concrete lining. The backfill grouting will be made by 11 kW low pressure grout pump and 200 x 2 lit grout mixer. The drain hole of 45 mm dia. and 1.5 m long will be drilled by 5.5 kW rotary boring machine.

Table 5.16
Construction Equipment for Diversion Tunnel
Concrete Lining

Description	Spec.	Required Number
Concrete plant, Conguillo	1 m^3	1
Concrete plant, Membrillo	1 m^3	1
Agitator truck	3 m^3	10
Concrete vessel car	6 m^3	3
Winch	100 kW	3
Concrete placer	6 m^3	6
Battery locomotive	6 ton	6
Agitator car	4.5 m^3	6
Telescopic steel form	12 m	3
Vibrator	55 mm	12
Form vibrator	0.5 kW	18
5/5 kW boring machine	5.5 kW	6

5.5.5 Access Roads

The package 1 work site is located far from the existing earthroad of Canuto-Buenaventura. The permanent access road is planned to be constructed from Buenaventura to Conguillo inlet. The length of Conguillo access road is to be 22.6 km. El Guasmo access road and Membrillo outlet access road is planned to connect the work adits branched from the Conguillo access road.

The accessible road will be first connected to the Conguillo inlet by the end of April 1998, before starting the preparatory works for the work adit construction. The Conguillo access road will be constructed for three years in parallel with the work adit and diversion tunnel construction. Other access roads construction for El Guasmo and Membrillo will be completed before the commencement of adit driving works.

The embankment material will be obtained from the excavate material in principle. The surplus spoiled material is planned to be disposed to the spoil area located along the access road alignment.

The excavated material comprises mainly common material including topsoil and weathered mudstone assumed to be 0.8 to 1.6 km/sec in seismic wave and 10-20 kg/cm^2 in qu. The excavation work will be carried out 21 ton bulldozer and 32 ton bulldozer with ripper, and loaded by 2.2 m^3 tractor shovel into 11 ton dump truck. As for the embankment, the weathered mudstone will be spread by 21 ton bulldozer and compacted using 20 ton tamping roller at 20 cm compacted thickness with 12 passes.

The subgrade preparation of cutting and embankment portion will be made with compaction of 10 ton vibrating roller and 20 ton tire roller. The subgrade is designed to be not less than CBR 20. The subbase material is planned to be graded crushed stone obtained from the existing quarry companies located near Montecristi. The subbase material will be spread by 11 ton bulldozer and 3.7 m motor grader, and compacted to CBR 60 with 10 ton vibrating roller.

The concrete works for drainage and minor structures will be carried out by using small capacity concrete mixer and man power placement. The box culvert located near Membrillo will be constructed with 3.0 m^3 agitator truck and 1.0 m^3 concrete bucket with 30 ton truck crane.

The required construction equipment for the permanent access road is listed as follows:

Table 5.17

Construction Equipment for Access Road

Description	Spec.	Required Number
1. Earthwork		
Bulldozer	21 ton	3
Bulldozer w/ripper	32 ton	8
Tractor shovel	2.2 m^3	17
Dump truck	11 ton	69
Bulldozer	11 ton	3
Tramping roller	20 ton	4
Motor grader	3.7 m	2
Water sprinkler	5.5 kl	3
2. Concrete work		
Agitator truck	3 m^3	1
Concrete bucket	1 m^3	1
Truck crane	30 ton	1
Portable mixer	0.2 m^3	3
Vibrator	55 mm	10

5.5.6 Construction Plant and Equipment

As the result of the study of construction method and the calculation of required number of equipment, the major construction plant and equipment to be used for the Package 2 construction is summarized in Table 5.18.

Table 5.18

Major Construction Equipment, Package 1

Description	Spec.	Required Number
Bulldozer with ripper	32 ton	9
Bulldozer	21 ton	3
Bulldozer	11 ton	6
Tractor shovel	2.2 m3	19
Tractor shovel	1.2 m^3	3
Backhoe	0.6 m^3	1
Backhoe	0.3 m^3	3
Dump truck	11 ton	71
Dump truck	8 ton	3
Crawler drill	7 m^3/min	2
Crawler drill	10 m^3/min	1
Air compressor	10 m^3/min	2
Air compressor	13.5 m^3/min	1

Table 5.18 (Cont'd)
Major Construction Equipment, Package 1

Description	Spec.		Required Number
Tamping roller	20	ton	4
Vibrating roller	10	ton	2
Vibrating roller	4	ton	1
Vibrating roller	1	ton	2
Concrete plant	1	m^3	2
Agitator truck	3	m^3	12
Concrete bucket	1.0	m^3	2
Concrete pump car	45	m^3/hr	1
Truck crane	30	ton	1
Truck crane	20	ton	1
Trailer	20	ton	1
Compactor	100	kg	5
Concrete vibrator	55	mm	12
Arm type tunneling machine	110	kW	3
Muck loader, inclined	0.4	m^3	2
Muck car	4.5	m^3	30
Battery locomotive	8	ton	6
Air compressor	16	m^3/min	3
Vent fan	300	m^3/min	19
Vent fan	100	m^3/min	6
Winch	150	kW	3
Winch	100	kW	3
Leg hammer	2.7	m^3/min	12
Jack hammer	2.4	m^3/min	6
Stopper drill	2.7	m^3/min	6
Shotcrete spray gun	10	m^3/hr	3
Concrete placer	6	m^3	6
Battery locomotive	6	ton	6
Agitator car	4.5	m^3	6
Concrete vibrator	55	mm	12
Sliding form, 3.7 m dia.	12	m	3
Boring machine	5.5	kW	6
Grout pump	11	kW	4
Grout mixer	200 x 2		4
Diesel generator	300	kVA	6
Diesel generator	150	kVA	1
Diesel generator	100	kVA	1
Diesel generator	50	kVA	1
Motor grader	3.7	m	2
Macadam roller	10	ton	1
Tire roller	20	ton	2
Water sprinkler	5.5	klit	3
Dredger	200	HP	1

5.6 Construction Method, Package 2

5.6.1 General

The civil works for La Esperanza-Poza Honda Transbasin and Poza Honda-Mancha Grande Transbasin (Package 2) comprise pumping station, penstock, head tank, open channel, La Esperanza~Poza Honda diversion tunnel, Poza Honda~Mancha Grande diversion tunnel, three work adits five access roads and Daule-Peripa 138 kV switchgear yard.

The package 2 construction is scheduled to be commenced in the beginning of June 1997 and completed by the end of November 2001. The construction period of package 2 is planned to be fifty four months (4.5 years).

The proposed construction method is prepared in consideration with the construction schedule, conventional and available construction equipment. As for the tunnel works, the NATM is applied in principle.

5.6.2 Severino Pumping Station

The pumping station is planned to be located at Severino, upstream of the La Esperanza reservoir. The La Esperanza dam impounding will be reached at the H.W.L. 66.00 m before starting the pumping station construction. The lowering of reservoir water level is required to be at EL.51.00 m as a temporary cofferdike provided in front of the inlet portion. The open construction is necessary for the pumping station construction.

The pumping station is designed as an on-ground type reinforced concrete structure of 67.5 m wide, 29.0 m long and 30.1 m high, in which accommodate six units of vertical shaft type single suction volute pump. Five units are on duty and one for stand-by. Each pumping capacity is 3.2 m^3/sec and the total discharge capacity is planned to be 16.0 m^3/sec.

The pumping station is scheduled to be constructed for about three years from June 1998 to August 2001. The first stage construction consists of open excavation, substructure concrete and embedded metal and pipe installation, The second stage construction consists of structural concrete for walls, piers and beams, encasement concrete of penstock, superstructure concrete and overhead crane installation. The architectural work will follow the structural concrete work and carried out in parallel with the superstructure work.

The inlet channel concrete work and the removal of cofferdike is scheduled to be made during two months from April to May 2001, by lowering again the La Esperanza dam reservoir level below EL.45.00 m. The impounding level to EL.58.50 m will be required for wet testing of pumps and the impounding-period is estimated at four months to supply the water from the Daule-Peripa.

Access road to the pumping station is newly planned to be about 9.3 km long from the existing road of carretera Manta-Quevedo route.

(1) Excavation Work

The excavation of pumping station is planned to be under water of the La Esperanza dam reservoir. The excavation work will be carried out in open dry conditions due to lower the reservoir water level. The excavation work will be carried out by 21 ton bulldozer and 32 ton bulldozer with ripper. The excavated materials are assumed to be mainly common material, heavily weathered mudstone and weathered mudstone. The soft rock will be excavated by a combined method of low bench blasting and ripping. The excavated material will be loaded by 2.2 m^3 tractor shovel into 11 ton dump truck and hauled to the spoil area located along the open channel route. The excavation work will be made by two shift per day.

The removal of cofferdike will be carried out using 32 ton bulldozer with ripper, 0.6 m^3 backhoe and by manpower finishing of pick hammer.

Table 5.19
Construction Equipment for Pumping Station
Excavation

Description	Spec.	Required Number
Bulldozer	21 ton	1
Bulldozer with ripper	32 ton	2
Tractor shovel	2.2 m^3	4
Dump truck	11 ton	16
Bulldozer	11 ton	1
Crawler drill	10 m^3/min	2
Air compressor	13.5 m^3/min	2

(2) Concrete Work

The concrete volume is estimated at 31,100 m^3 in total. The concrete placement is divided into two stages. The substructure below EL.50.00 m will be constructed for seven months from December 1998 to June 1999. The structural concrete and a part of superstructure at erection bay are scheduled to be constructed for ten months from July 1999 before starting the overhead installation.

The daily concrete placement is to be about 140 m^3 per day for the substructure block, 10 m wide, 13.5 m long and 1 m lift. The concrete plant will be installed near the head tank area or the beginning point of open channel. The concrete will be transported by

3.0 m^3 agitator truck from the concrete plant of 0.75 m^3 x 2, and placed by 1.0 m^3 concrete bucket with 30 ton truck crane and 45 m^3/hr concrete pump car. Two nos. of fixed type tower crane with 1 ton lifting load and 30 m working radius will be provided for handling formwork material, reinforcement bars and so on.

The penstock to be below EL.70.00 m will be first installed and the encacement concrete placement will be followed and finished by September 1999. And then the backfilling will be made up to EL.70.00 m to start the superstructure concrete work.

The required construction equipment is listed as follows:

Table 5.20
Construction Equipment for Pumping Station
Concrete Work

Description	Spec.		Required Number
Concrete plant	0.75	m^3 x 2	1
Agitator truck	3	m^3	4
Concrete pump car	45	m^3/hr	1
Truck crane	30	ton/hr	1
Concrete bucket	1	m^3	1
Concrete vibrator	55	mm	6
Tower crane	1	ton	2

(3) Architectural Work

At the last stage of structural concrete work, the platform block to be facilitated with overhead crane will also be finished by the end of April 2000. The roof concrete placement will be made by temporary supporting pipes. The building works for internal accommodation, finishing works, doors, windows, handrails, etc. will be commenced in May 2000. The installation works for plumbing, air conditioning utilities and water supply system and the electrical work will be carried out in parallel with the finishing works.

(4) Mechanical and Electrical Works

The mechanical and electrical works of Package 3 is scheduled to be commenced in June 1998. The embedded pipes of substructure concrete will be installed at the early stage of pumping station works, from January to February 1998. The penstock located below EL 70.00 m will also installed in advance from July to September 1998. These mechanical works will be carried out with 30 ton truck crane and 1 ton fixed tower crane.

After the installation of two overhead cranes, the main valves, pumps and motors will be installed from July 2000 to January 2001.

5.6.3 Severino Penstock

Two lanes of penstock line with 2.0 m dia. are planned to supply the water to open channel, consisting of 173 m long for No.1 and 170 m long for No.2. The penstock installation is divided two stages. The penstock under backfilling of EL 70.00 m will be installed for three months from July to September 1999. The remaing length to connect the head tank is scheduled to be installed from October 2000 to January 2001.

The open excavation work and concrete work are the some method applied for the pumping station. The saddle concrete slab will be placed before the installation of penstock. The steel pipe segment of 6 m long will be transported from the Guayaquil port to the stockyard. The steel pipe segments will be installed using inclined machine, dolly and 30 ton truck crane. And then the pipes will be set on in position and adjusted to the correct alignment for joining by welding. As for the flat portion, the saddle concrete and anchor bars will be first provided. The ring girder will be set to the anchor bolt.

5.6.4 Severino Head Tank

The head tank is planned to be 56.7 m long and 19.16 m wide. The head tank is divided into two channel between the penstock outlet and the crest. The maximum overflow depth is to be 0.72 m.

The head tank construction is scheduled to be carried out for eight months from October 1999 to May 2000. The headrace concrete work will be made in parallel work with the open channel concrete work. The concrete placement will be carried out 1.0 m^3 concrete bucket with 30 ton truck crane, 45 m^3/hr concrete pump car and manpower placement.

5.6.5 Severino Open Channel

The open channel is designed that the maximum discharge is to be 16.0 m^3/sec and trapezoidal section concrete lining structure. The total length of open channel is 6,395 m including syphon length of 881 m.

The open channel is scheduled to be constructed for about three years from June 1998 to August 2001.

(1) Earthwork

Before starting the excavation work, the temporary access road will be constructed on the right side of open channel alignment. The haulage road to the spoil area will be branched from the above access road. This temporary access road will be also used for the La Esperanza - Poza Honda diversion tunnel work.

The excavation work above planned inspection road surface will be carried out using 21 ton bulldozer and 32 ton bulldozer with ripper. The material will be loaded by 2.2 m^3 tractor shovel into 11 ton dump truck for hauling to the spoil area. As for the channel section, the excavation work will be made by 11 ton bulldozer, 0.6 m^3 backhoe and rock breaker with 0.6 m^3 backhoe. The final stage excavation adjacent to the channel slope will be made using pick hammer and manpower trimming and finishing.

The embankment section will be first filled entirely, and then the channel section will be excavated. The embankment work will be made only during dry season from June to December.

The required construction equipment is listed as follows:

Table 5.21
Construction Equipment for Open Channel
Earthwork

Description	Spec.	Required Number
1. Excavation		
Bulldozer	21 ton	1
Bulldozer with ripper	32 ton	1
Tractor shovel	2.2 m^3	3
Dump truck	11 ton	10
Bulldozer	11 ton	1
Backhoe	0.6 m^3	2
Breaker with backhoe		2
Pick hammer	7 kg	10
Air compressor	5 m^3/min	3
2. Embankment		
Bulldozer with ripper	32 ton	2
Tractor shovel	2.2 m^3	4
Dump truck	11 ton	7
Bulldozer	21 ton	1
Tamping roller	20 ton	1

(2) Concrete Work

The reinforced concrete lining is designed that thickness is 150 mm, the slope is 1:1.2 and the drainage layer of 100 mm is provided under the concrete lining. The construction joint is provided at 6 m interval.

The concrete placement is planned to be made by a conventional method using a portable metal form. The bottom slab concrete will be first placed, and then the slope concrete will be placed at two lifts. The metal forms will be installed and removed by 20 ton truck crane with manpower. The concrete will be transported by 3.0 m^3 agitator and handled by 0.5 m^3 concrete bucket and one wheel buggy with manpower.

Before concrete placement, the underdrain of 100 mm dia., perforated pipe with sand and gravel is planned at the bottom. The drainage layer of 100 mm thick on the bottom will be filled and compacted by manpower.

Syphon concrete work will be made by a conventional method using 45 m^3/hr concrete pump car and 1.0 m^3 bucket with 30 ton truck crane.

Table 5.22
Construction Equipment for Open Channel
Concrete Work

Description	Spec.		Required Number
Agitator truck	3	m^3	3
Concrete bucket	0.5	m^3	4
Truck crane	20	ton	2
Vibrator	45	mm	8
Concrete pump car	45	m^3/hr	1
Concrete bucket	1	m^3	1
Truck crane	30	ton	1
Vibrator	55	mm	4

5.6.6 La Esperanza-Poza Honda Diversion Tunnel

The horseshoe type concrete lined tunnel is planned for La Esperanza-Poza Honda Transbasin, and to be 3.5 m in diameter and 11,417 m long. The diversion tunnel is mainly aligned in massive and soft sandy mudstone with a compressive strength of about 100 kg/cm^2 and anticipated to encounter neither fault nor water problem. The tunnel construction will be a critical path of the Package 2 work. In order to shorten the construction period, two work adits are planned to be provided considering with the construction sequence.

La Seca work adit is planned to be located at middle point (7,500 m from upstream Caña Dulce inlet). Los Cuyuyes work adit is located near the outlet (11,244 m from upstream Caña Dulce inlet).

The diversion tunnel is divided mainly into three cross sections due to the supporting method. The gradient of tunnel slope is to be 1/1,500.

The construction period of diversion tunnel is scheduled to be forty five months from January 1998 to September 2001. Before starting the tunnel work, the access roads and the work adits will be provided for each tunnel work section.

(1) Construction Sequence and Tunnel Work Section

The tunnel work sections are planned to be four driving sections by providing two work adits, to secure the construction schedule. The driving sections are shown in Fig. 5.2, and are as follows

- Downstream portion from Caña Dulce inlet (excluding inlet structure) : Section I, 4,200 m
- Upstream portion from La Seca work adit : Section II, 3,300 m
- Upstream portion from Los Cuyuyes work adit : Section III, 3,744 m
- Downstream portion from Los Cuyuyes work adit : Section IV, 173 m

The concrete lining works are also planned to be made in above work sections in parallel work of the tunnel excavation. The time lag between the driving and the concrete lining is to be two months, taking into account the geological conditions and the tunneling method of NATM.

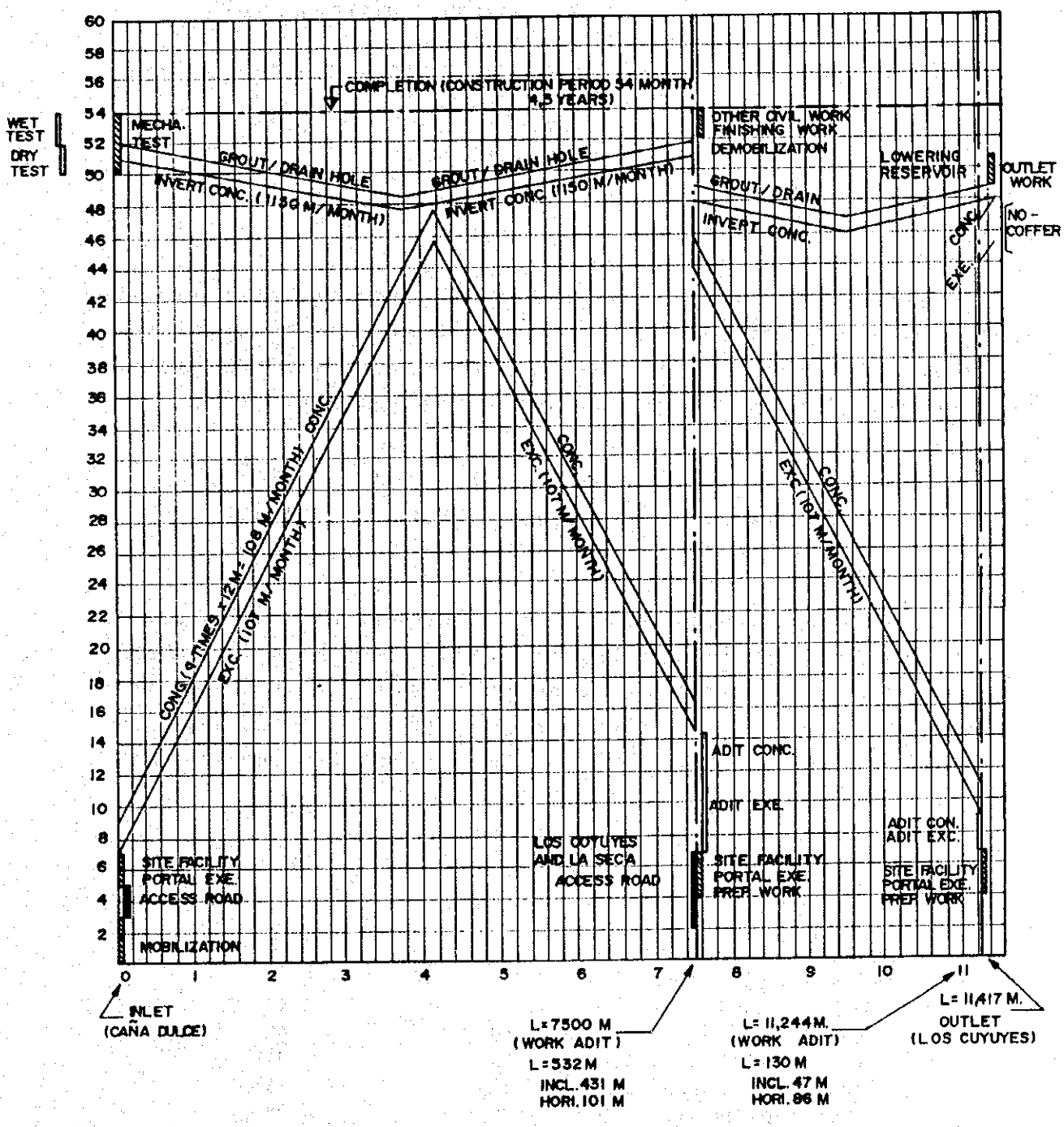
The tunnel excavation sequence are shown in Fig. 5.2, Tunnel Work Diagram for the Diversion Tunnel. After the completion of work adits construction, the tunnel excavation work will be commenced from January 1998. The construction period of each driving section is as follows:

Section I	:	39.2 months
Section II	:	30.8 months
Section III	:	35.0 months
Section IV	:	1.6 months

Before starting the diversion tunnel excavation, the following work adits construction period will be required:

FIG.5.2 TUNNEL WORK DIAGRAM FOR

LA ESPERANZA - POZA HONDA TUNNEL



La Seca work adit	:	Access road, 5 months Site facilities, portal excavation, preparatory works, 8 months (in parallel with access road). Adit excavation, 6 months Concrete lining (horizontal tunnel), 1 month
Los Cuyuyes work adit	:	Site facilities, portal excavation, preparatory works, 3 months. Adit excavation, 1 month Concrete lining, 1 month

(2) Work Adit Construction

The work adit is designed to be a vertical wall and arch roof type, 4.0 m wide x 4.0 m high. The supporting system is to be a rock bolting and shotcrete method applied for the diversion tunnel supporting. The steel support section will be considered at 10 percent of each adit length. The length of inclined portion and horizontal portion is as follows:

	Inclined	Horizontal	Total Length
La Seca work adit	430.9 m	101.4 m	532.3 m
Los Cuyuyes work adit	44.5 m	85.5 m	130.0 m

The tunnel excavation is planned to be made by applying a full face attack method. The drilling rock will be carried out by 4 nos. leg drill with portable deck. The broken rock will be loaded by 0.4 m^3 inclined type muck loader into 2 nos. of 4.5 m^3 muck car, and then muck cars will be pulled up outside of tunnel portal by using 150 kW winch. The broken rock will be loaded by 1.2 m^3 tractor shovel into 8 ton dump truck. The tunnel driving rates of progress is as follows:

	La Seca	Los Cuyuyes
- Excavated area 15.747 m^2		
- Shooting rate, 1.2 m		
- Driving cycle per one shoot		
Setting up for drilling	15	15
Drilling	60	60
Loading & shooting explosives	25	25
Ventilating and removing dust	15	15
Setting up for mucking	20	20
Loading & hauling muck	80	50
Extending rail	10	10
Barring	20	20
Shotcreting	45	45
Rock booting	50	50
Erecting steel support	(50)	(50)

	La Seca		Los Cuyuyes	
Loss time (others)	10		10	
Total without H-steel	350 min	(400 min)	320 min	(370 min)
with H-steel	5.83 hr	(6.67 hr)	5.33 hr	(6.17 hr)
- Working hour, 18 hrs/day				
- Number of shooting per day	3.09	(2.70)	3.38	(2.92)
- Daily progress rate (m/day)	3.71	(3.24)	4.06	(3.50)
- Monthly progress rate (m/month)	85.33	(74.52)	93.38	(80.50)
- Average progress rate (m/month)	84.25		92.09	
without H-steel, 90%				
with H-steel, 10%				

(Remarks: Figure in the parenthesis is the rate of H-steel section.)

The required construction equipment for the work adit excavation is listed as follows:

Table 5.23
Construction Equipment for Work Adit

Description	Spec.	Required Number
1. Open excavation		
Bulldozer	21 ton	1
Bulldozer with ripper	32 ton	1
Tractor shovel	2.2 m^3	2
Dump truck	11 ton	5
Bulldozer	11 ton	2
2. Tunnel Excavation		
Leg drill	2.7 m^3/min	8
Portable plat form		2
Pick hammer	7 kg	8
Muck loader	0.4 m^3	2
Muck car	4.5 m^3	4
Winch	150 kW	2
Vent fan	300 m^3/min	2
Vent fan	100 m^3/min	2
Air compressor	16 m^3/min	2
Tractor shovel	1.2 m^3	2
Dump truck	8 ton	2
3. Shotcrete and rock bolt		
Gunite spray machine	10 m^3/hr	2
Dust collector	150 m^3/min	2
Leg drill	2.7 m^3/min	4
Stopper drill	2.7 m^3/min	4
Mortar mixer	50 lit	2
Mortar feeder	50 lit	2

(3) Diversion Tunnel Excavation

The typical cross section of diversion tunnel is planned to be four sections such as Type I, II, III and IV, according to the geological conditions and NATM tunnel supporting system.

Type I	:	Rock bolt 25 mm dia, 2.0 m long, 4 nos, 1.2 m pitch, shotcrete 10 cm
Type II	:	Rock bolt 25 mm dia, 2.0 m long, 8 nos, 1.2 m pitch, shotcrete 10 cm
Type III	:	Rock bolt 25 mm dia, 2.0 m long, 8 nos, 1.2 m pitch, shotcrete 15 cm
Type IV	:	Rock bolt 25 mm dia, 2.0 m long, 8 nos, 1.2 m pitch, shotcrete 10 cm, H-steel support 125 x 125.

A full save attack method is recommended to apply for driving the tunnel, while hauling of broken rock is by a rail haulage method. The tunnel excavation work will be mainly such three cross sections as type II (41%), III (55%) and IV (55%). The average driving rate of progress is 106.97 m/month taking into account of decreasing excavation working hour due to the concrete lining work.

The driving rate of progress is as follows:

	II (4,647 m)	III (6,300 m)	IV (470 m)
- Excavated area (m^2)	17.00	17.62	17.08
- Driving rate (m)	1.20	1.20	1.20
- Driving cycle (min)			
Setting up	10	10	10
Excavation & mucking	50	50	50
Removal of machine	15	15	15
Shotcreting	45	55	45
Rock bolting	70	70	70
Erecting steel support	-	-	50
Changing bit	10	10	10
Maintaining equipment	10	10	10
Loss time (others)	15	15	15
Total	225 min(3.75 hr)	235 min(3.92 hr)	275 min(4.58 hr)
- Working hour, 18 hrs/day			
- Number of driving (nos/day)	4.80	4.59	3.93
- Daily progress rate (m/day) (1.20 m per one cycle)	5.76	5.51	4.72
- Monthly progress rate (m/month)	132.48	126.73	108.56

Average progress rate (m/month) 128.36 m
II: 41%, III: 55%, IV: 4%
Progress rate due to the affection of concrete lining
1st day : 128.36 m/month (only excavation work)
2nd day : 128.36 x 12 hr/18 hr = 85.57 m/month (6 hrs affected)
Planned progress: (128.36 + 85.57) x ½ =106.97 m/month

Three attacking faces will be provided concurrently to ensure the construction schedule. The tunnel excavation work will be carried out using an arm type mechanical tunneling machine with a cutting head, considering with the geological conditions and the following supporting system comprising of shotcreting and rock bolting. The broken rock will be gathered by gathering arm of tunneling machine, transported through velt conveyor of the machine, and loaded into 4.5 m^3 muck cars with 8 ton battery locomotive. At the bottom of inclined tunnel, every two muck cars will be pulled up outside by 150 kW winch. The broken rock carried to the open yard will be loaded by 1.2 m^3 tractor shovels into 8 ton dump trucks for hauling to the spoil area.

Just after finishing one cycle excavating operation of 1.2 m progress, the shotcrete of 100 mm thick with 100 x 100 mm wire mesh and rock bolts of 2.0 m long will be made. As for the lower compressive strength sections and fault zones, H-steel beam ribs and additional shotcreting will be required.

Table 5.24
Construction Equipment for Diversion Tunnel
Tunnel excavation

Description	Spec.		Required Number
1. Excavation			
Arm type tunnel machine	110	kW	3
Muck car	4.5	m^3	24
Battery locomotive	8	ton	6
Pick hammer	7	kg	12
Winch	150	kW	2
Vent fan	300	m^3/min	25
Vent fan	100	m^3/min	6
Air compressor	16	m^3/min	3
Tractor shovel	1.2	m^3	3
Dump truck	8	ton	3
2. Shotcrete and rock bolt			
Gunite spray machine	10	m^3/hr	3
Dust collector	150	m^3/min	3
Leg drill	2.7	m^3/min	6
Stopper drill	2.7	m^3/min	6
Mortar mixer	50	lit	3
Mortar feeder	50	lit	3

(4) Concrete Lining

The concrete lining thickness is designed to be 300 mm except for the shotcrete supporting system. The concrete lining work is required to be performed in parallel with the tunnel excavation work. The concrete lining work will be made to keep the distance of about 200 m from the heading about (2 months interval), considering with the NATM analysis.

During concrete lining work including concrete placing and primary concrete curing, the haulage of broken rock will be suspended. The suspended hour is estimated at 6 hours. The sliding centle preparation will be made during about 4 hours of tunnel excavation cycle. The concrete lining is planned to be carried out to follow the tunnel driving rate of 106 m/month.

An arch and then invert concrete lining method is planned through the whole tunnel length. The concrete lining work will be made by using 12.0 m long telescopic type steel form to shorten the installation time. Three concrete lining sections will be provided concurrently. The concrete lining work is scheduled to be carried out two months after the commecement of tunnel excavation, from March 1998 to May 2001. The invert concrete work is scheduled to be carried out about five months from April 2001.

The concrete will be transported by 3.0 m^3 agitator truck from the concrete plant located at Severino and at Los Cuyuyes respectively. The concrete will be discharged into 6 m^3 concrete vessel car and then pulled down by 100 kW winch. At the bottom of inclined tunnel, the concrete will be again discharged into 6 m^3 concrete placer through a hopper. The concrete placer will be delivered to the placing spot by 6 ton battery locomotive and be placed behind steel from by means of compressed air from the concrete placer. The invert concrete will be transported and placed by 4.5 m^3 agitator car. The progress rate of invert concrete is planned to be 1,150 m/month.

One month after the invert concrete placement, the backfill grouting and drilling of drain holes will be followed in parallel with the invert concrete lining. The backfill grouting will be made by 11 kW low pressure grout pump and 200 x 2 lit grout mixer. The drain hole of 45 mm dia. and 1.5 m long will be drilled by 5.5 kW rotary boring machine.

Table 5.25
Construction Equipment for Diversion Tunnel
Concrete Lining

Description	Spec.	Required Number
Concrete plant, Severino	0.75 x 2 m^3	1
Concrete plant, Los Cuyuyes	1.0 m^3	1
Agitator truck	3 m^3	12
Concrete vessel car	6 m^3	2
Winch	100 kW	2
Concrete placer	6 m^3	6
Battery locomotive	6 ton	6
Agitator car	4.5 m^3	6
Telescopic steel form	12 m	3
Vibrator	55 mm	12
Form vibrator	0.5 kW	18
Boring machine	5.5 kW	6

(5) Inlet and Outlet Works

Caña Dulce inlet structures between the open channel and the diversion tunnel is scheduled to be constructed during dry season of 2000. The outlet structure is scheduled to be made for two months from July to August 2001, after lowering Poza Honda reservoir. The impounding at EL 94.0 m of reservoir water level will require one month, before commencing the wet test of mechanical equipment.

The required construction equipment for the inlet and outlet works is listed as follows:

Table 5.26
Construction Equipment for Inlet and Outlet Works

Description	Spec.	Required Number
1. Open excavation		
Bulldozer	21 ton	1
Tractor shovel	2.2 m^3	1
Dump truck	11 ton	2
Bulldozer	11 ton	1
2. Concrete work		
Agitator truck	3 m^3	2
Concrete bucket	1 m^3	2
Truck crane	30 ton	1
Vibrator	50 mm	4

5.6.7 Poza Honda-Mancha Grande Diversion Tunnel

The horseshoe type concrete lined tunnel is planned for Poza Honda-Mancha Grande diversion tunnel, and to be 2.5 m in diameter and 4,095 m long. The diversion tunnel is aligned in massive and soft sandy mudstone. The tunnel construction will be made within the period of La Esperanza-Poza Honda diversion tunnel work.

Poza Honda work adit is planned to be located near the inlet portion (300 m from upstream inlet). The diversion tunnel is divided into three cross sections due to the supporting method. The gradient of tunnel slope is to be 1/1,500.

The construction period of diversion tunnel is scheduled to be thirty months from April 1998 to October 2000.

(1) Construction Sequence and Tunnel Work Section

The tunnel work sections are planned to be three driving sections by providing a work adit, to secure the construction schedule. The driving sections are shown in Fig. 5.3, and are as follows

- Upstream portion from Poza Honda work adit : Section I, 300 m
- Downstream portion from Poza Honda work adit : Section II, 1,900 m
- Upstream portion from Mancha Grande outlet : Section III, 1,895 m

The concrete lining works are also planned to be made in the same work sections. In a view point of the supporting system analysis, the concrete lining is also planned to be carried out within two months after driving the tunnel heading. The driving and concrete works will be not carried out concurrently, since the tunnel cross section is quite small. Both works are planned to be changed every 200 m tunnel progress.

The tunnel excavation sequence are shown in Fig. 5.3, Tunnel Work Diagram from the Diversion Tunnel. The construction period of each driving sections is as follows:

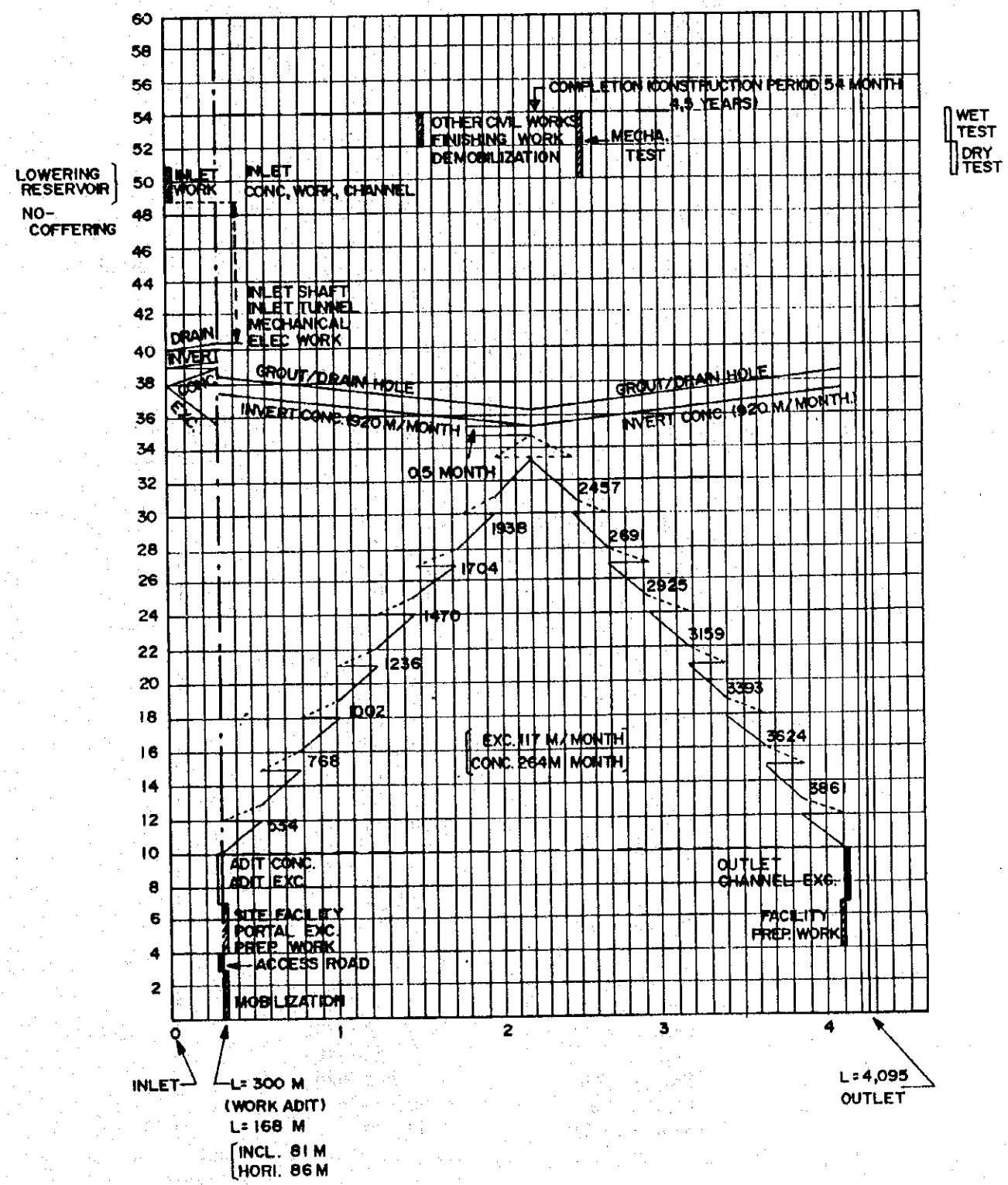
Section I	:	2.6 months	(to add 1.1 months for concrete lining)
Section II	:	16.2 months	(to add 7.2 months for concrete lining)
Section III	:	16.2 months	(to add 7.2 months for concrete lining)

(2) Work Adit Construction

The work adit is designed to be a vertical wall and arch roof type, 4.0 m wide x 4.0 m high. The total length is 167.9 m, of which 81.3 m is for inclined portion and 86.6 m for horizontal portion. The tunnel excavation work is the same method applied for the work adit construction of La Esperanza-Poza Honda diversion tunnel. Two nos. of 3.0 m^3 muck car and 100 kW winch are planned according to the diversion tunnel cross section and driving method. The tunnel driving rates of progress is as follows:

- Excavated area	15.747 m^2
- Shooting rate	1.2 m
- Driving cycle per one shoot	
Setting up for drilling	15
Drilling	60
Loading & shooting explosives	25
Ventilating and removing dust	15
Setting up for mucking	20
Loading & hauling muck	55
Extending rail	10
Barring	20
Shotcreting	45

FIG.5.3 TUNNEL WORK DIAGRAM FOR
POZA HONDA - MANCHA GRANDE TUNNEL



Rock botting	50	
Erecting steel support	(50)	
Loss time (others)	10	
Total without H-steel	325 min	(375 min)
with H-steel	5.42 hr	(6.25 hr)

- Working hour, 18 hrs/day
- Number of shooting per day 3.32 2.88
- Daily progress rate (m/day) 3.98 3.46
- Monthly progress rate (m/month) 91.54 79.58
- Average progress rate (m/month) 90.34
  without H-steel, 90%
  with H-steel, 10%

(Remarks: Figure in the parenthesis is the rate of H-steel section.)

The required construction equipment for the work adit excavation is listed as follows:

Table 5.27
Construction Equipment for Work Adit

Description	Spec.	Required Number
1. Open excavation		
Bulldozer/ripper	21 ton	1
Tractor shovel	2.2 m^3	1
Dump truck	11 ton	3
Bulldozer	11 ton	1
2. Tunnel excavation		
Log drill	2.7 m^3/min	4
Portable plat form		1
Pick hammer	7 kg	4
Muck loader	0.4 m^3	1
Muck car	3 m^3	2
Winch	100 kW	1
Vent fan	300 m^3/min	1
Vent fan	100 m^3/min	1
Air compressor	16 m^3/min	1
Tractor shovel	1.2 m^3	1
Dump truck	8 ton	1
3. Shotcrete and rock bolt		
Gunite spray machine	10 m^3/hr	1
Dust collector	150 m^3/min	1
Leg drill	2.7 m^3/min	2
Stopper drill	2.7 m^3/min	2
Mortar mixer	50 lit	1
Mortar feeder	50 lit	1

(3) Diversion Tunnel Excavation

The typical cross section of diversion tunnel is planned to be four sections such as Type I, II, III and IV.

Type I : Rock bolt 25 mm dia, 2.0 m long, 3 nos, 1.2 m pitch, shotcrete 10 cm
Type II : Rock bolt 25 mm dia, 2.0 m long, 5 nos, 1.2 m pitch, shotcrete 10 cm
Type III : Rock bolt 25 mm dia, 2.0 m long, 8 nos, 1.2 m pitch, shotcrete 15 cm
Type IV : Rock bolt 25 mm dia, 2.0 m long, 8 nos, 1.2 m pitch, shotcrete 10 cm, H-steel support 125 x 125.

The tunnel driving method is the same applied for the La Esperanza - Poza Honda diversion tunnel. The tunnel excavation sections are type II (12%), III (85%) and IV (3%). The average driving rate of progress is 116.86 m/month. The tunnel excavation and concrete lining are planned to be carried out at every 200 m long one after the other.

The driving rate of progress is as follows:

	II (479 m)	III (3,500 m)	IV (100 m)
- Excavated area (m^2)	10.24	10.67	10.29
- Driving rate (m)	1.20	1.20	1.20
- Driving cycle (min)			
Setting up	10	10	10
Excavating & mucking	35	40	35
Changing muck car	20	20	20
Removal of machine	15	15	15
Shotcreting	45	55	45
Rock bolting	70	70	70
Erecting steel support	-	-	50
Changing bit	10	10	10
Maintaining equipment	10	10	10
Loss time (others)	15	15	15
Total	235 min(3.83 hr)	245 min(4.08 hr)	280 min(4.67 hr)
- Working hour, 18 hrs/day			
- Number of driving (nos/day)	4.70	4.41	3.85
- Daily progress rate (m/day) (1.20 m per one cycle)	5.64	5.29	4.62
- Monthly progress rate (m/month)	129.72	121.67	106.26

Average progress rate (m/month) 122.17 m/month
II: 12%, III: 85%, IV: 3%

Progress rate due to one after the other (2 days per every 2 month)
122.17 m/month x 22 day/23 day = 116.86 m/month

Two attacking faces will be provided concurrently to secure the construction schedule. The tunnel excavation work will be carried out using an arm type mechanical tunneling machine with a cutting head , 3 m^3 muck cars with 6 ton battery locomotive. At the bottom of inclined tunnel, every two muck cars will be pulled up outside by 100 kW winch. Hauling to the spoil area will be done by 1.2 m^3 tractor shovel and 8 ton dump truck. The shotcreting and rock bolting will be follow every 1.2 m progress of driving.

Table 5.28
Construction Equipment for Diversion Tunnel
Tunnel excavation

Description	Spec.	Required Number
1. Excavation		
Arm type tunnel machine	110 kW	2
Muck car	3 m^3	16
Battery locomotive	6 ton	4
Pick hammer	7 kg	6
Winch	100 kW	1
Vent fan	300 m^3/min	9
Vent fan	100 m^3/min	4
Air compressor	16 m^3/min	2
Tractor shovel	1.2 m^3	1
Dump truck	8 ton	1
2. Shotcrete and rock bolt		
Gunite spray machine	10 m^3/hr	2
Dust collector	150 m^3/min	2
Leg drill	2.7 m^3/min	4
Stopper drill	2.7 m^3/min	4
Mortar mixer	50 lit	2
Mortar feeder	50 lit	2

(4) Concrete Lining

The concrete lining thickness is designed to be 300 mm except for the shotcrete supporting system. The concrete lining is planned to be carried out at every 200 m long driving section. The driving equipment will be removed behind the planned lining section, when the tunnel progress rate reaches at 200 m. And then, the telescopic forms and lining equipment will be mobilized into tunnel. One after the other method for the tunnel driving and lining will require temporary shunting places and shunting lines.

An arch and then invert concrete lining method is planned and 12 m long telescopic type steel form will be applied. The concrete will be transported by 3.0 m^3 agitator truck

from the concrete plant located at Los Cuyuyes and Mancha Grande. As for the inclined work adit, the concrete bucket car will be pulled down by 100 kW winch. The concrete will be discharged into 4.5 m^3 placer with 6 ton battery locomotive at the bottom of work adit. The concrete lining progress rate is planned to be 264 m per month based on 12.0 m long concrete lining span as shown below.

- Sliding form length — 12.0 m
- Concrete lining cycle
  - Formwork preparation — 4 hrs
  - Concrete placement — 4 hrs
  - Curing — 16 hrs
  - Total — 24 hrs (one day)
- Workable day 22 days
  (one day is used for removal/ movable operation, monthly workable day is 23 days).
- Number of placing per day (One day cycle) — 12.0 m
- Monthly progress rate — 264.0 m

Invert concrete placement, backfill grouting and drain hole drilling will be carried out by the same method applied for the La Esperanza-Poza Honda diversion tunnel.

The required construction equipment is listed as follows:

Table 5.29
Construction Equipment for Diversion Tunnel
Concrete Lining

Description	Spec.	Required Number
Concrete plant, Conguillo	1.0 m^3	1
Concrete plant, Membrillo	1.0 m^3	1
Agitator truck	3 m^3	9
Concrete vessel car	6 m^3	1
Winch	100 kW	1
Concrete placer	4.5 m^3	4
Battery locomotive	6 ton	4
Agitator car	4.5 m^3	4
Telescopic steel form	12 m	2
Vibrator	55 mm	8
Form vibrator	0.5 kW	12
Boring machine	5.5 kW	6

(5) Inlet and Outlet Works

The inlet facilities are designed to be similar with the Conguillo inlet facilities. The inlet tunnel portion is to be 46.0 m long and the inlet shaft is 20 m x 16 m x 22.45 m deep. The shaft excavation will be carried out by a sinking method applied for the Conguillo shaft. The tunnel driving will be made by blasting method and the excavated material will be loaded by 0.4 m^3 tractor shovel into deposit bucket.

The inlet facilities are scheduled to be constructed from October 1999 and completed by July 2000. While, the outlet excavation will be completed by the end of March 1998, before starting the tunnel excavation work. The inlet channel and a part of inlet tunnel are scheduled to be made for two months of July and August 2001, after lowering the Poza Honda reservoir. The impounding period of Poza Honda reservoir is to be one month of October 2001, after the completion of the inlet channel construction.

Table 5.30
Construction Equipment of Inlet and Outlet Structure

Description	Spec.	Required Number
1. Open excavation		
Bulldozer	21 ton	1
Bulldozer/ripper	32 ton	1
Tractor shovel	2.2 m^3	4
Dump truck	11 ton	8
Bulldozer	11 ton	1
2. Shaft excavation		
Crawler drill	7 m^3/min	2
Air compressor	10 m^3/min	2
Tractor shovel	0.4 m^3	1
Backhoe	0.3 m^3	1
Deposit bucket	3 m^3	1
Truck crane	30 ton	1
3. Concrete work		
Concrete plant	1 m^3	1
Agitator truck	3 m^3	4
Concrete bucket	1 m^3	2
Truck crane	30 ton	1
Vibrator	50 mm	5

5.6.8 Access Road

The construction work sites are located separately each other. The permanent access road will be required to access to the various work sites from the existing asphalt pavement road, Carretera Manta-Quevedo and Santa Ana-Poza Honda. The access road construction will be divided into two groupes: one for Severino and Caña Dulce access roads, another for La Seca and Los Cuyuyes and Poza Honda inlet access roads.

The temporary road located on the same alignment of the permanent access roads will be required for starting the work adit construction as shown in Appendix II, Construction Schedule.

The embankment material will be obtained from the excavated material in principle. The surplus spoiled material is planned to be disposed to the spoil area located along the access road alignment.

The excavated material comprises mainly common material including topsoil and weathered mudstone assumed to be 0.8 to 1.6 km/sec in seismic wave and 10-20 kg/cm^2 in qu. The excavation work will be carried out 21 ton bulldozer and 32 ton bulldozer with ripper, and loaded by 2.2 m^3 tractor shovel into 11 ton dump truck. As for the embankment, the weathered mudstone will be spread by 21 ton bulldozer and compacted using 20 ton tamping roller at 20 cm compacted thickness with 12 passes.

The subgrade preparation of cutting and embankment portion will be made with compaction of 10 ton vibrating roller and 20 ton tire roller. The subgrade is designed to be not less than CBR 20. The subbase material is planned to be graded crushed stone obtained from the existing quarry companies located near Montecristi. The subbase material will be spread by 11 ton bulldozer and 3.7 m motor grader, and compacted to CBR 60 with 10 ton vibrating roller.

The concrete works for drainage and minor structures will be carried out by using small capacity concrete mixer and man placement. The box culvert will be constructed with 3.0 m^3 agitator truck and 1.0 m^3 concrete bucket with 30 ton truck crane.

The required construction equipment for the permanent access road is listed as follows: