No.

PUBLIC WORKS DEPARTMENT
THE GOVERNMENT OF GOA
THE REPUBLIC OF INDIA

STUDY ON AUGMENTATION OF WATER SUPPLY AND SANITATION FOR THE GOA STATE IN THE REPUBLIC OF INDIA

Volume V
Appendix for Feasibility Study

November 2006

JAPAN INTERNATIONAL COOPERATION AGENCY

NIHON SUIDO CONSULTANTS CO., LTD.
and
NJS CONSULTANTS CO., LTD.

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PREFACE

In response to a request made by the Government of Republic of India, the Government of Japan decided to conduct the Study on Augmentation of Water Supply and Sanitation for the Goa State in the Republic of India and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to India a study team headed by Mr. Takemasa MAMIYA of Nihon Suido Consultants Co., Ltd. between March 2005 and October 2006. The study team was composed of members from Nihon Suido Consultants Co., Ltd. and NJS Consultants Co., Ltd. JICA also established an Advisory Committee headed by Mr. Yoshiki OMURA, Senior Advisor, Institute for International Cooperation JICA, which, from time to time during the course of the study, provided specialist advice on technical aspects of the study.

The team held discussions with the officials concerned of the Government of the Republic of India and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared present report.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of India and Government of Goa for their close cooperation extended to the team.

November, 2006

Ariyuki MATSUMOTO
Vice-President
Japan International Cooperation Agency

November, 2006

Mr. Ariyuki MATSUMOTO
Vice-President
Japan International Cooperation Agency

Letter of Transmittal

Dear Sir,

We are pleased to submit to you this Final Report on the Study on Augmentation of Water Supply and Sanitation for the Goa State in the Republic of India. This report incorporates the views and suggestions of the authorities concerned of the Government of Japan, including your Agency. It also includes the comments made on the Draft Final Report by Public Works Department of the Government of Goa and Ministry of Urban Development of the Government of the Republic of India and other government agencies concerned of the Republic of India.

The Final Report comprises a total of six volumes as listed below.

Volume I	: Executive Summary
Volume II	: Main Report: Master Plan
Volume III	: Main Report: Feasibility Study
Volume IV	: Annex for Master Plan
Volume V	: Annex for Feasibility Study
Volume VI	: Drawings

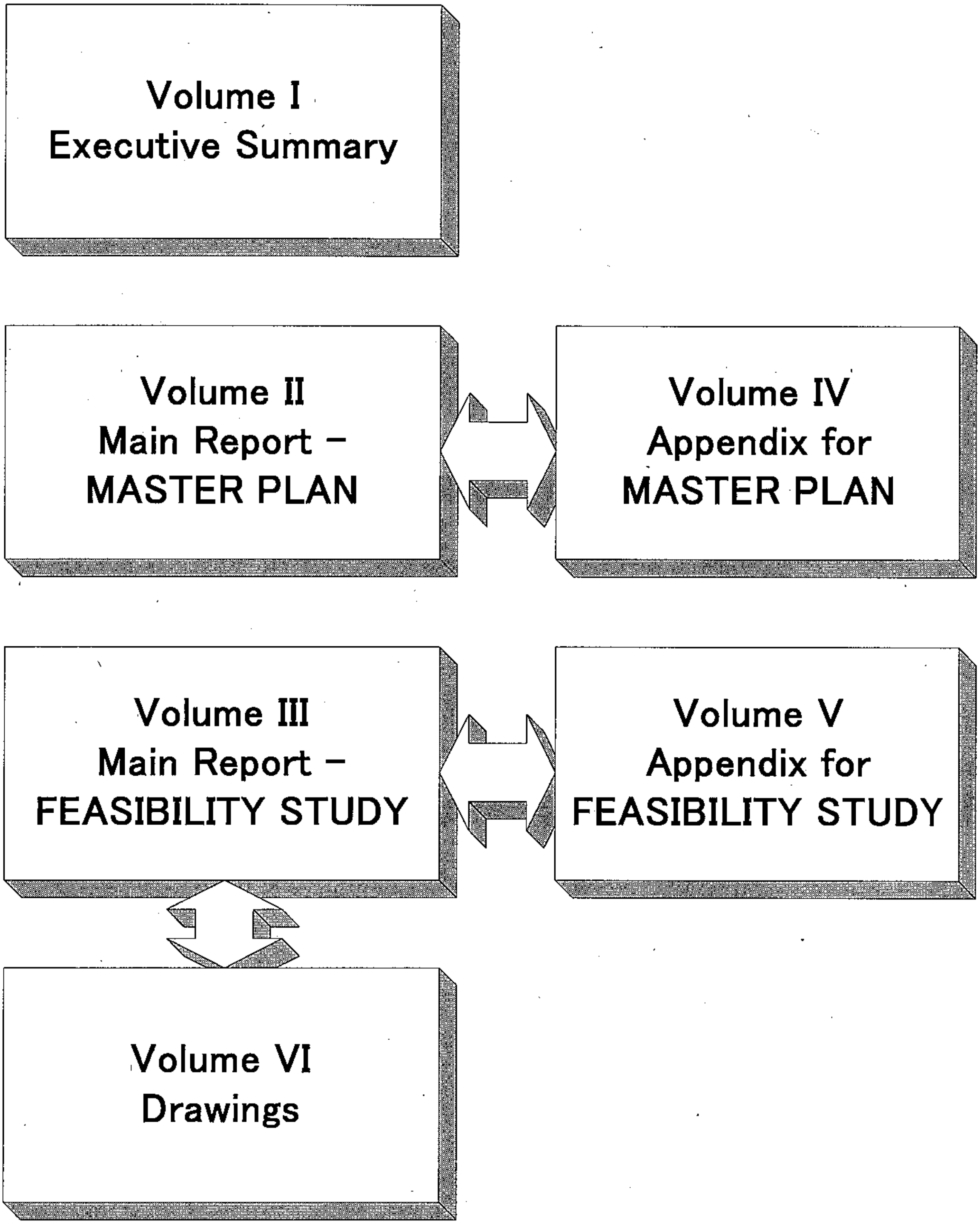
This report contains the Study Team's findings, conclusions and recommendations derived from the three phases of the Study. The main objective of the Phase I was to conducted a reconnaissance survey. That of Phase II was to formulate a long term master plan and to identify priority projects, whilst that of the Phase III was to examine the feasibility of the priority projects which had previously been identified in Master Plan during the course of the Phase II.

We wish to take this opportunity to express our sincere gratitude to your Agency, the Ministry of Foreign Affairs and the Ministry of Health, Labour and Welfare of the Government of Japan for their valuable advice and suggestions. We would also like to express our deep appreciation to the relevant officers of Public Works Department of the Government of Goa and Ministry of Urban Development of the Government of the Republic of India for their close cooperation and assistance extended to us throughout our Study.

Very truly yours,

Takemasa Mamiya, Team Leader
Study on Augmentation of Water Supply
And Sanitation for Goa State in the
Republic of India

Structure of Report



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MAIN REPORT – FEASIBILITY STUDY

ABBREVIATIONS

ACP	Asbestos Cement Pipe
ADB	Asian Development Bank
ATP	Affordability to Pay
BOD	Biochemical Oxigen Demand
CE	Chief Engineer
CI	Cast Iron
CMMS	Computerised Maintenance Management System
COD	Chemical Oxygen Demand
CPWD	Central Public Works Department
CRZ	Coastal Regulation Zone
CSM	Customer Service Management
D	Diameter
DI	Ductile Cast Iron
DSR	Debt-service Ratio
DST&E	Department of Science, Technology and Environment
EE	Executive Engineer
EIA	Environmental Impact Assessment
FS, F/S	Feasibility Study
GDP	Gross Domestic Product
GI	Galvanised Iron
GIS	Geographical Information System
GLR	Ground Level Reservoir
GOG	Government of Goa
GOI	Government of India
GOJ	Government of Japan
GRDP	Gross Regional Domestic Product
GSDP	Gross State Domestic Product
GVA	Gross Value Added
HDPE	High-density Polyethylene
IEE	Initial Environmental Examination
IS	Information Systems
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency
KPI	Key Performance Indicator
lpcd	Per Capita Water Demand (liter per capita day)
M&E	Machinery and Electricity
MBR	Master Balancing Reservoir
MIS	Management Information System
MLD	Million Liter per Day
MNF	Minimum Night Flow
MOF	Ministry of Finance
MOUD	Ministry of Urban Development
MP, M/P	Master Plan

ABBREVIATIONS

MS	Mild Steel
NPV	Net Present Value
NRPP	NRW Reduction Pilot Project
NRW	Non Revenue Water
NTU	Nephelometric Turbidity Unit
ODA	Official Development Assistance
OECD	Organization for Economic Cooperation and Development
OHR	Over Head Reservoir
PHE	Public Health Engineering
PSC	Prestressed Concrete
PSP	Public Stand Post
PVC	Polyvinyl Chloride
PWD	Public Works Department
RCC	Regional Control Centre
RL	Reduced Level (Height above specified datum level)
SC	Steering Committee
SCM	Supply Chain Management
SE	Superintending Engineer
SS	Suspended Solids
STP	Sewage Treatment Plant
TOR	Terms of Reference
UFW	Unaccounted-for Water
WSS	Water Supply Scheme
WTP	Water Treatment Plant
WTP	Willingness To Pay

APPENDIX F3

This appendix is reference to and supporting data of

Volume 3 Main Report – Feasibility Study

Chapter 3 Water Supply System

Appendix F31

Components of Expansion and Rehabilitation Works in Salaulim WTP

Contents for Appendix F31

F31.1 Components of Expansion Works in Salaulim WTP

Name of Facility / Equipment		Component of Expansion Work
Intake & Raw Water Transmission Facilities		
Intake Facilities	Intake Structure	RC Structure – 2 Basins Intake Pumping Well : ^{W}8.60 m × ^{L}5.50 m × ^{D}29.00 m Pump House : ^{W}18.00m × ^{L}12.95 m (233.1 m^2) Pump House Floor : RC & Grating
	Intake Pump	Vertical Turbine Selfwater Lubricated Pump : 25.5 m^3/min × 4 Units（1 - Standby）
		Check Valve : D450mm × 4 Units Butterfly Valve : D450 mm Electric Motor-drive × 4 Units
	Inlet Valves & Interconnecting Valves	Inlet Butterfly Valve with Manual Operating Stand : 1st (L.W.L.) - D2,000 mm × 2 Units, 2nd (M.W.L.) - D2,000 mm × 2 Units, 3rd (Opening) - ^{W}2,000 mm × ^{D}1,500 mm × 2 Units Interconnecting Butterfly Valve with Manual Operating Stand : D1,800 mm x 1 Unit
	Crane Equipment	10 ton Electric Motor-drive Chain Hoist Crane × 1 Unit
Raw Water Transmission Facilities	Raw Water Transmission Main	MSP : D1,400 mm for 200 MLD MSP : D800 mm of Flow Meter & Flow Control Line for 100 MLD
	Flow Meter & Flow Control Valve Facility	Raw Water Flow Meter Chamber & Flow Control Valve Chamber
		Flow Control Valve : D800 mm Tooth-shaped Disk Type Butterfly Valve (Horizontal Type) × 2 Units（Electric Motor-drive Type × 1 Unit, Manual Type × 1 Unit）
Water Treatment Facilities		
Receiving Well & Connecting Pipe	Receiving Well	RC Structure – 1 Basin, Detention Time = 1.0 min. for 200 MLD Dimension : ^{W}5.60 m × ^{L}5.60 m × ^{D}5.50 m × $^{E.D}$5.00 m
	Connecting Pipe ①	MSP : D1,800 mm for 200 MLD, MSP : D1,350 mm for 100 MLD
	Connecting Pipe ②	MSP : D1,200 mm of By-Pass Pipe for 200 MLD
Bio-Contact Filtration Facilities (Future Construction) & Connecting Pipe	Bio-Contact Filtration Basin	Filtration Type : Automatic Backwash with Air Scouring Type RC Structure - 10 Basins (10 Basins/System) Filtered Area = 52.2 m^2/Basin Dimension : ^{W}4.50 m × ^{L}11.60 m Filtration Rate : 210.7 m/d
		Back Wash Rate = 0.50 m^3/min/m^2 Air Scouring Rate = 1.00 m^3/min/m^2
		Filter Media : Effective Size = 6.0 mm Depth of Media = 1.50 m
		Under drain System : Strainer with Air Distribution Type
	Operating Valves for Filtration	Inlet Valve : D600 mm Electric Motor-drive Type Butterfly Valve × 10 Units (1 Unit/Basin)
		Filtered (Back Wash) Valve : D600 mm Electric Motor-drive Type Butterfly Valve × 10 Units (1 Unit/Basin)
		Air Scouring Valve : D300 mm Electric Motor-drive Type Butterfly Valve × 10 Units (1 Unit/Basin)
		Wash Drain Valve : D800 mm Electric Motor-drive Type Butterfly Valve × 10 Units (1 Unit/Basin)
	Air Scouring Equipment	Air Blower : 26.1 m^3/min × 3 Units (1-Stand-by)
		Flow Meter : D250mm Orifice-type × 1 Unit
	Flow Measurement Devices	Overflow Weir : ^{B}10.00 m × 1 Unit for 100 MLD
	Connecting Pipe ③	MSP : D1,800 mm for 200 MLD, MSP : D1,350 mm for 100 MLD
Mixing Chamber & Distribution Chamber	Mixing Chamber	Mixing Type : Gravitational Force Mixing by Weir Type RC Structure - 1 Basin, Detention Time = 1.0 min. Dimension : ^{W}4.00 m × ^{L}4.00 m × ^{D}5.50 m × $^{E.D}$5.00 m
	Distribution Chamber	Distribution Method : By Weir Type RC Structure - 1 Basin, Dimension : $^{Dia.}$3.50 m ×^{D}7.70 m × $^{E.D}$7.00 m
	Collecting Chamber	RC Structure - 1 Basin Dimension : $^{Dia.}$6.50 m ×^{D}2.20 m × $^{E.D}$1.30 m
Flocculation & Sedimentation Facilities (Clariflocculator)	Flocculation Basin	Flocculation Type : Paddle Wheel on Vertical Shaft Type RC Structure - 4 Basins, Detention Time = 20.0 min. Dimension : $^{Dia.}$10.40 m × ^{D}5.00 m × $^{E.D}$4.50 m
	Sedimentation Basin	Sedimentation Type : Radial-upflow Type – Clariflocculator RC Structure, 4 Basins, Detention Time = 2.01 hr Dimension : ^{Dia}31.40 m × ^{D}4.00 m ×$^{E.D}$3.50 m
	Connecting Pipe ④	MSP : D900 mm for 50 MLD, MSP : D1,350 mm for 100 MLD

Name of Facility / Equipment		Component of Expansion Work
Filtration Facilities	Rapid Sand Filtration Basin	Filtration Type : Automatic Backwash with Air Scouring Type RC Structure - 20 Basins (10 Basins/System) Filtered Area = 40.50 m^2/Basin Dimension : ^{W}4.50 m × ^{L}9.00 m Filtration Rate : 135.8 m/d
		Back Wash Rate = 0.65 m^3/min/m^2 Air Scouring Rate = 1.00 m^3/min/m^2
		Sand : Effective Size = 0.7 mm、 Depth of Sand = 0.70 m
		Under drain System : Strainer with Air Distribution Type
	Operating Valves for Filtration	Inlet Valve : D400 mm Electric Motor-drive Type Butterfly Valve × 20 Units (1 Unit/Basin)
		Filtered (Back Wash) Valve : D600 mm Electric Motor-drive Type Butterfly Valve × 20 Units (1 Unit/Basin)
		Air Scouring Valve : D250 mm Electric Motor-drive Type Butterfly Valve × 20 Units (1 Unit/Basin)
		Wash Drain Valve : D800 mm Electric Motor-drive Type Butterfly Valve × 10 Units (1 Unit/Basin)
	Air Scouring Equipment	Air Blower : 20.3 m^3/min × 3 Units (1-Stand-by)
		Flow Meter : D250mm Orifice-type × 1 Unit
	Flow Measurement Devices	Overflow Weir : ^{B} 10.00 m × 2 Units for 100 MLD
	Connecting Pipe ⑤	MSP : D1,800 mm for 200 MLD,　MSP : D1,350 mm for 100 MLD,　MSP : D900 mm for 50 MLD
Transmission Facility	Clear Water Reservoir	RC Structure、Effective Capacity = 4,800 m^3, Detention Time = 1.15 hr. Dimension : Reservoir - ^{W}2.0 m × ^{L}30.0 m × ^{D}4.85 m × $^{E.D}$4.0 m × 2 Basins Pumping Well - ^{W}30.0 m × ^{L}5.0 m × ^{D}6.85 m × $^{E.D}$4.0 m × 1 Basin
		Inlet Valve : D1,350 mm Butterfly Valve with Manual Operating Stand x 2 Units
		Connecting Valve : D1,350 mm Butterfly Valve with Manual Operating Stand x 3 Units
		Over-flow Pipe : D1,000mm
		Ventilation Device : 1 Lot
	Transmission Pump Building	RC Structure, Building Area = 400 m^2 Dimension : ^{W}40.0 m × ^{L}10.0 m
	Transmission Pumping Equipment	Distribution Pump : Horizontal Double Suction Volute Pump D400mm x D250 mm × 23.2 m^3/min × 4 Units (1 - Standby)
		Foot Valve : D400 mm × 4 Units Suction Valve : D400 mm Butterfly Valve (Manual Operate) × 4 Units
		Check Valve : D250 mm Unti-water-hummer Type Check Valve × 4 Units Delivery Valve : D250 mm Electric Motor-drive Type Butterfly Valve (Horizontal Type) × 4 Units
	Crane Equipment	10 ton Electric Motor-drive Chain Hoist Crane × 1 Unit
	Flow Meter & Flow Control Valve Facility	Transmission Flow Meter Chamber & Flow Control Valve Chamber
		Flow Control Valve : D1,200 mm Tooth-shaped Disk Type Electric Motor-drive Type Butterfly Valve (Horizontal Type) × 1 Unit
	Transmission Pipe	DIP : D1,400 mm
Chemical Feeding Facilities	Chemical Feeding Room	Located in the 2nd Floor of the Administration Building except the Chlorine Gas Feeding Equipment Crane Equipment : 1 ton Electric Motor-drive Chain Hoist Crane (Traversing, Traveling, Hoisting) × 1 Unit
	Aluminum Sulfate Feeding Equipment	Solution Tank : RC Structure - 4 Tanks
		Mixer : D500 mm Vertical Suspended Type × 4 Units
		Feeding Machine : 2 Units
	Lime Feeding Equipment	Solution Tank : RC Structure - 3 Tanks
		Mixer : D500 mm Vertical Suspended Type × 3 Units
		Feeding Machine : 2 Units
	Chlorine Storage & Chlorine Feeding Equipment Room	Chlorine Storage & Chlorine Feeding Room : 1 Lot Crane Equipment : 5 ton Electric Motor-drive Chain Hoist Crane × 1 Unit
		Liquid Chlorine System : Load Cell & Platform, Evaporator, Vacuum Regulating Check & Shut-Off Unit Chlorine Feeder (Injector, Rotormeter) : 5 Units (3 Units for Pre-Cl, 2 Units for Post-Cl)
		Neutralization Equipment : Intake & Suction Duct, Ejector – Venturi Scrubber, Separation Tank & Caustic Soda Solution Storage, Paoked Tower

Name of Facility / Equipment		Component of Expansion Work
		Safty Measures : Proveided Eye Wash, Shower, and Gas Masks of Canister Type
Electrical Facilities	Power Receiving & Transformer Equipment	Power Receiving Equipment Power Transformer
		Electric Power Generator
	Power Supply Equipment	Power Receiving Panel、Power Supply Panel & Auxiliary Power Supply Panel for Intake Pump (Located in Intake Pump House)
		Power Supply Panel for Filter's Operation Equipment (Locate in Transmission Pump Building)
		Power Receiving Panel、Power Supply Panel、Auxiliary Power Supply Panel & Local Panel for Transmission Pump
		Power Supply Panel for Chemical Feeding Facilities (Located in Transmission Pump Building)
	Control Panel	Control Panel for Raw Water Flow Rate & Transmission Flow Rate
		Control Panel for Filter's Operation (Located in Filter's Operation Gallery)
		Control Panel for Chemical Feeding Facilities (Located in Chemical Feeding Room)
	Air Conditioning Facilities	Installation of Air Conditioning Facilities (Located in Electrical Room of Transmission Pump Building and Administration Building)
	Lightning Protection Equipment	Lightning Rod Equipment (Located in Raw Water Intake House、Filtration Gallery、Administration Building、Transmission Building）
	Inter-communication System inside the Treatment Plant	Intercommunication Equipment (Located in Raw Water Intake House、Filter's Operation Gallery、Transmission Pump Building、Administration Building, Chlorine Storage & Feeding Room）
Instrumentation Facilities	Instrumentation Equipment	Central Supervising Panel & Instrumentation Panel (Located in Operation Room of Administration Building)
		Raw Water Level Meter : Ultrasonic Type - Water Level for Raw Water Intake Pumping Well
		Raw Water Flow Meter : Ultrasonic Type
		Total Filtered Flow Meter : Suppressed Rectangular Weir – Float Type
		Clear Water Reservoir Level Meter : Ultrasonic Type
		Transmission Line Piesometer : Electronic Type
		Transmission Flow Meter : Ultrasonic Type
		Chemical Solution Tank Level Meter : Electrode Type
Administration Building		RC Structure、Floor Area = 200 m^2 × 2 F (Dimension : ^{W}20.00 m × ^{L}10.00 m × 2 F)、Management office, Laboratory, Control Room & Chemical Feeding Facilities
Laboratory		Located in Administration Building
		Water Quality Analysis Equipment & Reagent
Landscaping and Others		Site Preparation, Embankment, Cutting Land, Roads, Lighting, Gate & Fence, others

F31.2 Components of Rehabilitation and Improvement Works in Salaulim WTP

Name of Facility / Equipment		**Component of Existing**	**Component of Rehabilitation Work**	
Intake Facilities	Civil & Archtechtural Structures	• Open Channel : 1-Channel Width 3.0 m × Height 29.0 m ×Length 210 m • Box Culvert : RC Structure Width 2.0 m × Height 2.0 m ×Length 195 m • Pump Well (Wet Well) : RC Structure, Area = 200 m^2, Width 9.4 m × Height 28.7 m ×Length 11.4 m • Pump House & Control Room : RC Structure, Area = ??? m^2	Reuse	—
	Raw Water Pump & Motor	• Vertical Turbine Selfwater Lubricated Pump : 19.685 m^3/min × 94.559 m × 410 kW × 8 Units (2-Standby) • One System : 4 Pumps (1-Standby)	Replace	• The Same Specifications of the Existing
		• D??? mm Check Valve × 8 Units • D??? mm Gate Valve with Motor-Drive × 8 Units	Replace	• The Same Specifications of the Existing
	Inlet Gate	• □1.60 m × 1.25 m × 3 Units × 2 Stage	Reuse	—
	Crane Equipment	• 10 Ton Semi-Electric Operated Travelling Crane × 1 Unit	Reuse	—
	Level Meter	• Not Provided	Improve	• Float Type
	Electrical Equipment	• Incommers Panel : 3 Units, • Motor Control Panel : 8 Units • Bus Coupler : 3 Units • L.T. Panel : 1 Unit • Capacitors : 8 Units	Replace	• The Same Specifications of the Existing
Power Substation	Transformer	• Outdoor Type : 33 kV / 3.3 kV – 2,000 kVA × 3 Units • Outdoor Type : 33 kV / 440 V – 250 kVA × 1 Unit • Outdoor Type : 33 kV / 440 V – 160 kVA × 1 Uni	Replace	• The Same Specifications of the Existing
	Electrical Equipment	• Outdoor Vaccuum Circuit Breaker : 3 Units • Current Transformer : 6 Units • Potencial Transformer : 6 Units • Lighting Arrester : 5 Units • Battery Charger : • Oil Filtration Plant : 1 Unit	Replace	• The Same Specifications of the Existing
Raw Water Transmission Facilities (Rising Main)	Raw Water Transmission Main	• MS Pipe with Gunniting : D1,000 mm × 450 m × 1 Line • MS Pipe with Gunniting : D1,000 mm × 550 m × 1 Line	Reuse	—
	By-Pass Pipe & Valve	• Not Provided	Improve	• By-Pass pipe : D1,000 mm • By-Pass Valve : D1,000 mm × 2 Units
	Zero Valve	• D1,000 mm × 2 Units (1 Unit / System)	Replace	• The Same Specifications of the Existing
	Aie Chamber	• 2 Units (1 Unit / System)	Remove	—
	FloW Meter	• Electromagnetic Type: 2 Units (1 Unit / System)	Replace	• Ultrasonic Type : 2 Units (1 Unit / System)
	Flow Control Valve	• Not Provided	Improve	• D1,000 mm × Butterfly Valve with Motor-Drive Type × 2 Units (1 Unit / System))
Aerator & Mixing Facilities	Aerator	• RC Structure • 2 Basins (1 Basin / System)、Diameter = 5.5 m	Reuse	—
	Parshal Flume	• RC Structure、2 Basins (1 Basin / System)、	Reuse	—
	Flow Meter	• Flow Meter : 2 Units (1 Basin / System) – Not Working	Replace	• The Same Specifications of the Existing
	Mixing Chamber	• RC Structure、4 Basins (2 Basins / System)、 • Inlet Gate : Steel Fabricate - 4 Units (2 Units / System)	Reuse	—
	Flash Mixer	• Vertical Suspended Type : 4 Units (2 Units / System)	Replace	• The Same Specifications of the Existing
	By-Pass Channel	• RC Structure、2 Units (1 Unit / System)、	Reuse	—
	By-Pass Gate	• MS Fabricate、2 Units (1 Unit / System)、	Replace	• The Same Specifications of the Existing
Flocculation & Sedimentation	Clariflocculator	• RC Structure、4 Basins (2 Basins / System)、 - Overall Diameter = 40.0 m	Reuse	—

Name of Facility / Equipment		Component of Existing	Component of Rehabilitation Work	
Facilities		• Flocculation Zone : Vertical Flocculator Type、 - Diameter = 17.6 m - Detention Time = 28.8 min. • Sedimentation Zone : Inclined Up-Flow Type ➢ Diameter = 17.6 m ～ 40.0 m • Detention Time = 2.0 hrs.		
	Inlet Pipe	• D1,000 mm HP × 4 Lines (2 Lines / System)	Reuse	—
	Desludging Equipment	• Desludgeing Pipe : D300 mm × 4 Lines (2 Lines / System)	Reuse	—
	Flocculator	• MS Fabricate、 • Peripheral Type : 1.5 kW × 750 rpm × 4 Units / Basin	Replace	• The Same Specifications of the Existing
	Drive Arrangement of Bridge	• MS Fabricate • 1.5 kW × 750 rpm × 4 Units	Replace	• The Same Specifications of the Existing
	Outlet Channel	• RC Structure、2 Units (1 Unit / System)	Reuse	—
	By-Pass Gate	• MS Fabricate、4 Units (2 Units / System)	Replace	• The Same Specifications of the Existing
Filtration Facilities	Rapid Sand Filtration basin	• RC Structure、12 Basins (2 Cells / Unit) • Filtration Type : Rapid Sand Filtration – Air Scouring Wash & Backwash Water System、 • Filtered Area = 63.78 m^2/Basin (Dimension : Width 6.70 m × Length 9.52 m), 2 Cells / Basin • Filtration Rate = 213.2 m/d	Reuse	—
	Washing Rate	• Backwash Rate = 0.50 $m^3/min/m^2$ (per 1 Cell) • Air Scouring Rate = 0.85 $m^3/min/m^2$ (per 1 Cell)		—
	Under Drain System	• Under Drain System : D100 mm × CIP Laterals Type - Grit : Size 2.5 mm ～ 6.0 mm × Depth 175 mm - Gravel : Size 6 mm ～ 12 mm × Depth 100 mm - Gravel : Size 12 mm ～ 38 mm × Depth 100 mm - Pebble : Size 38 mm ～ 50 mm × Depth 150 mm	Replace	• The Same Specifications of the Existing
	Filter Sand	• Effective Size of Sand = 0.70 mm、 • Depth of Sand ＝0.835 m	Replace	• The Same Specifications of the Existing
	Wash Water Troughs	• Width 0.38 m × Depth 0.38 m × Length 3.35 m × 8 Units / Basin	Reuse	—
	Operating Valves & Piping	• Inlet Gate : D600 mm Sluice Gate with Air-Pneumatic Operating Stand × 12 Units (1 Unit / Basin)	Replace	• The Same Specifications of the Existing
		• Filtered Water Valve : D300 mm Sluice Valve with Air-Pneumatic Operating Stand × 24 Units (2 Units / Basin)	Replace	• The Same Specifications of the Existing
	Operating Valves & Piping	• Wash Water Drain Gate : D400 mm Sluice Gate with Air-Pneumatic Operating Stand × 12 Units (1 Unit / Basin)	Replace	• The Same Specifications of the Existing
		• Back Wash Valve : D300 mm Sluice Valve with Air-Pneumatic Operating Stand × 24 Units (2 Units / Basin)	Replace	• The Same Specifications of the Existing
		• Air Scouring Wash Valve : D150 mm Sluice Valve with Air-Pneumatic Operating Stand × 24 Units (2 Units / Basin)	Replace	• The Same Specifications of the Existing
		• Control Valve Set : D400 mm Control Valve with Controller Float (D760 mm) × 12 Units (1 Unit / Basin)	Replace	• The Same Specifications of the Existing
		• Drain Valve : D80 mm Sluice Valve with Manual Operating Stand × 12 Units (1 Unit / Basin)	Replace	• The Same Specifications of the Existing
Back Washing Equipment	Back Wash Pumping Equipment	• Backwash Pump : Vertical Turbine Selfwater Lubricated Pump D??? mm × D??? mm × 7.92 m^3/min × 17.1 m × 28.2 kW × 4 Units (1-Standby)	Replace	• The Same Specifications of the Existing
	Back Wash Pump Sump	• Capacity = 40 m^3	Reuse	—
	Backwash Flow Control Valve	• Not Provided	Improve	• Flow Control Valve : D400 mm Air-Pneumatic Operate Butterfly Valve × 1 Unit
	Back Wash Flow Meter	• Not Provided	Improve	• D400 mm Orifice Type × 1 Unit
Air Scouring Equipment	Air Blower	• Air Blower : D??? mm Roots-type 13.6 m^3/min × 3,500 mmWG × 37 kW × 3 Units (1-Stand-by)	Replace	• The Same Specifications of the Existing
	Air Scouring Flow Meter	• Not Provided	Improve	• D150 mm Orifice Type × 1 Unit
	Air Scouring	• Not Provided	Improve	• Utilizing D150 mm Air

Name of Facility / Equipment		Component of Existing	Component of Rehabilitation Work	
	Flow Control Valve			Scouring Valve × 12 Units
Transmission Facilities	Filtered Water Outlet Channel	• RC Structure、2 Lines - 1 Line for Clear Water Reservoir (1) - 1 Line for Clear Water Reservoir (2)	Reuse	—
	Parshal Flume & Flow Meter	• RC Structure、1 Basin for Filtered Water Channel (1)	Reuse	—
		• Flow Meter for Filtered Water Channel (1) : 1 Unit - Not Working	Replace	• The Same Specifications of the Existing
	Clear Water Reservoir	• RC Structure、2 Basins • Effective Capacity = 6,745 m^3 - (1) Basin : Capacity = 3,370 m^3 (Dimension : Width 31.2 m × Length 24.0 m × Depth 4.50 m) - (2) Basin : Capacity = 3,375 m^3 (Dimension : Width 50.0 m × Length15.0 m × Depth 4.50 m) • Detention Time = 1.0 hr	Reuse	—
	Maintenance Valve Equipment	• Inlet Gate (1) : MS Fabricate □1,500 mm × 1,200 mm Sluice Gate with Manual Operating Stand × 2 Units	Reuse	—
		• Inlet Gate (2) : MS Fabricate □1,200 mm × 1,200 mm Sluice Gate with Manual Operating Stand × 1 Unit	Reuse	—
		• Outlet Gate (1) : MS Fabricated D1,200 mm Sluice Gate with Manual Operating Stand × 2 Units	Reuse	—
		• Outlet Gate (2) : MS Fabricated D1,200 mm Sluice Gate with Manual Operating Stand × 1 Unit	Reuse	—
	Utility Water Pump	• 2 Units	Replace	• The Same Specifications of the Existing
Chemical Feeding Facilities	Chemical & Administration Building	• Chemical Feeding Room for Aluminum Sulfate, Lime & Chlorine, Chemical Storage, Chlorination & Chlorine Tonner Room, Laboratory & Office	Reuse	—
	Solution Tank	• Aluminium Sulfate : ?.? m^3 × 4 Units • Lime : ?.? m^3 × 4 Units • Chlorine : 1 Ton (Net : 900 kg) Container	Reuse	• Reuse after Renovation of the Existing
	Chemical Feeding Equipment	• Aluminium Sulfate : Mixer : 4 Units • Lime : Mixer : 4 Units • Chlorine : 7.0 kg / hr × 5 Units (3 Units for Pre-Cl, 2 Units for Post-Cl)	Replace	• The Same Specifications of the Existing
	Neutralization Facility	• Neutralization Tank with Caustic Soda Solution : Not Available	Improve	• Reuse after Improvement and Renovation of the Existing
		• Safty Measures (Protection Masks : Inappropriate Location)		
Laboratory	Laboratory Room	• Located in Administration Building	Reuse	—
	Laboratory Equipment		Replace	• The Same Specifications of the Existing

Appendix F32

Comparative Study on Treatment Process

Contents for Appendix F32

Appendix F32 Comparative Study on Treatment Process

F32.1 Rapid Mixing

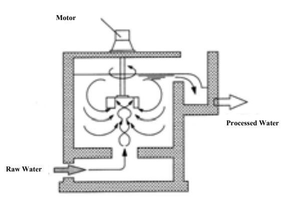
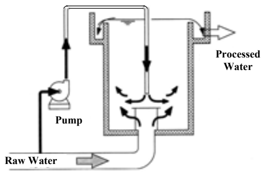
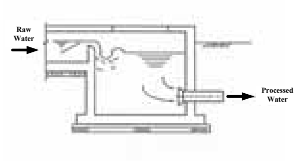
The coagulation-sedimentation process involves three processes; mixing, flocculation and sedimentation. The mixing of chemicals and the coagulation process coagulates the fine particles or colloidal particles to minute flocs by the rapid mixing after feeding coagulant to raw water. Available mixing types are:

a. Machinery mixing,
b. Pump power mixing, and
c. Gravitational force mixing by weir.

Although there are three kinds of the rapid mixing such as mixing by machine, pump or gravity, the mixing by gravity is recommended for the study, taking into account the required future maintenance. Comparison of the mixing types is as shown in Table F32.1.1.

Table F32.1.1 Comparative Table of Rapid Mixing

	Machinery Mixing	Pump Power Mixing	Gravity Weir Mixing
Mixing	• Driving device • Supporting • Axis with screw • Electrical equipment	• Injection pump • Piping and installation • Agitator • Electrical equipment	• Weir plate
Mechanism	• Agitation by a mixer	• A part of raw water taken from inlet is injected to the bell mouth by booster pump.	• Mixing is done in the turbulence caused by gravity fall after a weir.
Advantages	• Capable in response to fluctuation of inflow quantity. • No hydraulic head is required.	• Capable in response to fluctuation of inflow quantity. • No hydraulic head is required.	• Small construction cost • Machinery trouble will not occur • Less maintenance cost • Small installation area
Disadvantages	• High construction cost • High power cost • Countermeasures against noise are required. • Periodic maintenance is required. • High maintenance cost	• High construction cost • High power cost • Large area is requried. • Periodic maintenance is required. • High maintenance cost	• Measures to adjust inflow quantity fluctuation are needed. • Hydraulic head is required.
Evaluation	• Construction, power and maintenance costs are high. • Countermeasures against noise are required. • High skills for operation are required.	• Almost same as the left. • Pump installation area is additionally required. • High skills for operation are required.	• By regulating a height, sufficient hydraulic head can be secured. • Construction cost is small, and power and maintenance costs are smaller
	not recommendable	not recommendable	recommendable

	Machinery Mixing	Pump Power Mixing	Gravity Weir Mixing
Drawing			

F32.2 Sedimentation

One of the most common water and wastewater treatment unit processes is sedimentation, also known as clarification. Sedimentation is broadly defined as the separation into a clarified fluid and a more concentrated suspension.

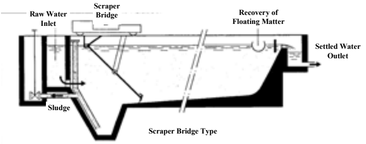
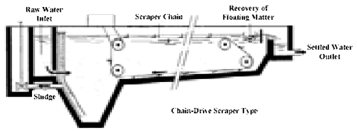
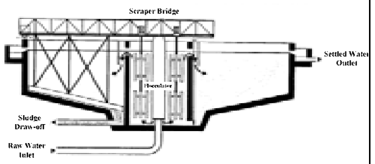
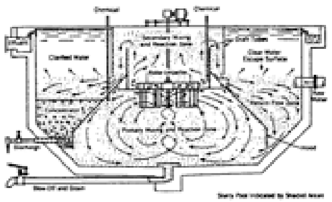
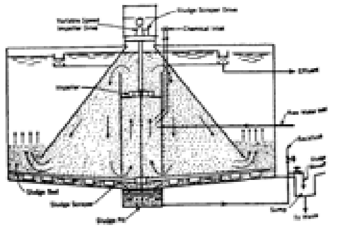
The sedimentation process is designed to remove a majority of the settleable solids by gravitational settling, thereby maximizing downstream unit processes such as filtration. Available sedimentation types are:

a. Rectangular type (Horizontal flow),
b. Radial-upflow type (Clariflocculator),
c. Reactor clarifier type, and
d. Sludge blanket clarifier type.

The radial-upflow type (Clariflocculator) for sedimentation basin which is applied for the existing Salaulim WTP is apopted for the proposed sedimentation process. Comparison of sedimentation types is as shown in Table F32.2.1

Table F32.2.1 Comparative Table of Sedimentation

		Rectangular Basin (Horizontal Flow)	Radial-upflow Type (Clariflocculator)	Reactor Clarifiers	Sludge Blanket Clarifiers
Shape		Square Shape	Circular (or Square)	Circular	Circular
Main Design Criteria	**Flocculation Time**	–	Approx. 20 min	Approx. 20 min	Approx. 20 min
	Surface Loading	19.92 – 60 $m^3/d/m^2$	31.2 – 45.6 $m^3/d/m^2$	48.0 – 72.0 $m^3/d/m^2$	48.0 – 72.0 $m^3/d/m^2$
	Water Depth	3.0 – 5.0 m	3.0 – 5.0 m	–	–
	Detention Time or Settling Time	1.5 – 3.0 hr	1.0 – 3.0 hr	1.0 – 2.0 hr	1.0 – 2.0 hr
	Width/Length	＞1/5	–	–	–
	Weir Loading	＜264 $m^3/d/m$	168 $m^3/d/m$	175.2 – 360.0 $m^3/d/m$	48.0 – 72.0 $m^3/d/m$
	Upflow Velocity	–	–	＜50 mm/min	＜10 mm/min
	Slurry Circulation Rate	–	–	–	Up to 3 - 5 times the raw water inflow rate
Advantages and Disadvantages	**Advantages**	• More tolerance to shock loads • Predictable performance under most conditions • Easy operation and low maintenance costs • Easy adaptation to high-rate settler modules	• Economical compact geometry • Incorporates flocculation and clarification in one unit • Easy sludge removal • High clarification efficiency	• Incorporates flocculation and clarification in one unit • Good flocculation and clarification efficiency due to a seeding effect • Some ability to take shock loads	• Good softening turbidity removal • Compact economical design • Tolerates limited changes in raw water quality and flow rate
	Disadvantages	• Subject to density flow creation in the basin • Requires careful design of the inlet and outlet structures • Usually requires separate flocculation facilities	• Problems of flow short-circuiting • Less tolerance to shock loads • A need for more careful operation • Limitation on the practical size of the unit • Less reliability than conventional due to a dependency on one mixing motor • May require separate flocculation facilities	• Requires greater operator skill • Less reliability than conventional due to a dependency on one mixing motor • Subject to upsets due to thermal effects	• Very sensitive to shock loads • Sensitive to temperature change • Several days required to build up the necessary sludge blanket • Plant operation depends on a single mixing flocculation unit motor • Higher maintenance costs and a need for greater operator skill
Proper Application		• Most municipal and industrial water works • Particularly suited to larger capacity plants	• Best suited where the rate of flow and raw water quality are constant • Small to mid-sized municipal and industrial treatment plants • Most popular in Indian water works	• Water softening • A plant that treats a steady quality and quantity of raw water	• Water softening • Flocculation/sedimentation treatment of raw water with a constant quality and rate of flow • Plant treating a raw water with a low content of solids

	Rectangular Basin (Horizontal Flow)	**Radial-upflow Type (Clariflocculator)**	**Reactor Clarifiers**	**Sludge Blanket Clarifiers**
Construction Cost Ratio	1.00	0.80	0.85	0.85
Maintenance Cost Ratio	1.00	1.10	1.10	1.15
Evaluation	• Construction cost is high. • Usually requires separate flocculation facilities • Easy operation and low maintenance costs	• Construction cost is small. • The flow rate and raw water quality are constant. • Incorporates flocculation and clarification in one unit • Well knowledge for the operation and maintenance due to the same type of the existing Salaulim plant.	• Construction cost is rather small. • Requires greater operator skill • Incorporates flocculation and clarification in one unit • Subject to upsets due to thermal effects	• Construction cost is rather small. • Higher maintenance costs and a need for greater operator skill • Very sensitive to shock loads • Sensitive to temperature change • Incorporates flocculation and clarification in one unit
	not recommendable	recommendable	not recommendable	not recommendable
Drawing	 Scraper Bridge Type  Chain-Drive Scraper Type			

F32.3 Filtration

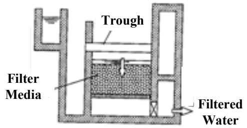
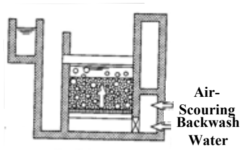
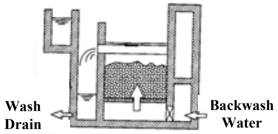
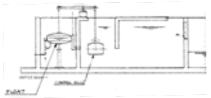
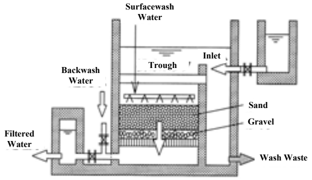
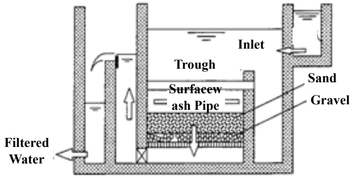
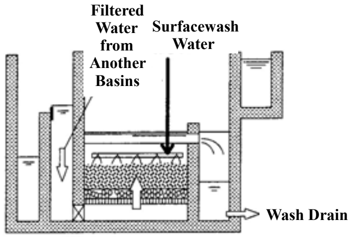
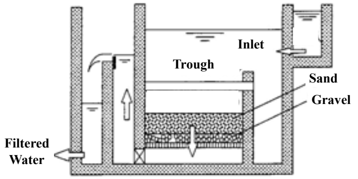
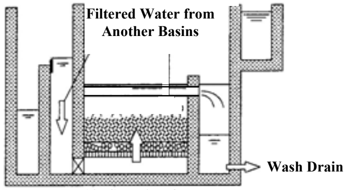
Rapid sand filtration is the final process to finish and obtain safe and hygienic water; the fundamental objective of waterworks for supplying clean water to the user by improving water quality to the required level. In the process, the fine flocs not removed in the sedimentation basin are removed by passing through a filter medium such as a sand layer; at the same time, the substances inside the flocs might consume the free residual chlorine and make the water non-resistant to the contamination from outside of the distribution pipes as well, as cause secondary affections inside the pipes, are removed. Available rapid sand filtration types are:

a. Air scouring type (existing Salaulim WTP Type),
b. Standard-type,
c. Automatic backwashing type, and
d. Automatic backwashing and air scouring type.

Among these types, the air scouring type (a) and standard-type (b) of rapid sand filtration process requires high levels of technical skills in adjustment of the filtration volume as well as in operational control due to the number of devices used. The automatic backwashing type (c) and the automatic backwashing and air scouring type (d) have the characteristics of easy operation, control, and require less frequent maintenance practice owing to less system devices. The automatic backwashing and air scouring type (d) has the advantages of using less backwashing water. The examination and comparison of these 4 types is shown in Table F32.3.1. In consequence, the automatic backwashing and air scouring type (d) is recommended to be adopted in the proposed process for the filtration.

Taable F32.3.1 Comparative Table of Filtration

		Air-scouring Type (Salaulim Type)	**Standard Type**	**Automatic Backwash Type**	**Automatic Backwash and Air-scouring Type (by Valve)**
Filtration	**Raw Water Inlet**	• By gate or valve	• By valve or gate	• By movable adjusting weir and valve	
	Filtration Velocity Control	• By Control Float and Valve	• Flow meter and Operation valve	• Movable adjusting weir	
	Filtration Velocity Control Mechanism	• Water level in the basin is kept constant. • Constant filtration velocity by controlling the constant water level in the filtered cell with the float and valve against the filtration clogging.	• Water level in the basin is kept constant. • Constant filtration velocity by controlling valve with flow meter against the filtration clogging.	• Constant filtration velocity by keeping required hydraulic head by raising water level in the basin when filter clogged.	
Filer Washing	**Washing Method**	• Air Scouring by Air Blower and Back Wash Water by Pump	• Surfacewash Water by Pump and Back Wash Water by Pump	• Surfacewash Water by Pump and Back Wash Water by Pump	• Air Scouring by Air Blower and Back Wash Water by Pump
	Backwashing Discharge	• By valve or gate		• By valve	
	Washing Rates	• Back Wash Rate: 0.40 ～ 0.60 $m^3/min/m^3$ • Air Scouring Rate: 0.60 ～ 0.90 $m^3/min/m^3$	• Surface Wash Rate: 0.15～0.20 $m^3/min/m^3$ • Back Wash Rate: 0.60～0.90 $m^3/min/m^3$		• Back Wash Rate: 0.40 ～ 0.65 $m^3/min/m^3$ • Air Scouring Rate: 0.80 ～ 1.00 $m^3/min/m^3$
	Backwashing Mechanism	• Responding to an increment of head-loss to the set point, backwashing starts. • The backwashing water is pumped from the reservoir after the chlorination.		• Responding to an increment of head-loss to the highest level, operation of discharge gate lowers water level to the drainage trough level, then backwashing starts. • Backwashing water with head comes from other filters in operation.	
Filtration Layer		• Effective Diameter: 0.6-0.7 mm, Uniformity Coefficient: < 1.7, Layer Thickness: 0.6-0.7 m			
Water Collecting Device		• Perforated Block, Strainer or Perforated Board		• Automatic Washing Type of Perforated Block, Perforated Board or Strainer	
Space Necessary for Installation		• Large space including corridor for maintenance and inspection is needed because of many installation of big pumps/valves.		• Large space is not required, due to installation of pipes and gate both for inlet and outlet.	
Construction Cost		• Height of filter structure is less 4.5 m. • Large clear water conduit down to the filtration basin as well as the complicated structure will cause higher construction costs. • The different big-size equipment is required, and their control panels should be of high standard. • Two kinds of pumps (backwash pump and surface washing pump or air blower) are required • Construction cost is rather high.		• Height of filter structure is around 5.5 m with a simple design. • Construction cost is rather small. • Only four kinds of valves (for inflow, outflow, drainage and surface washing or air-scouring) are required in each basin. • Only one kind of pump (surface washing pump or air blower) and their control panels are required.	
Construction Cost Ratio		0.95	1.0	0.90	0.85
Maintenance Cost Ratio		0.90	1.0	0.85	0.80

	Air-scouring Type (Salaulim Type)	**Standard Type**	**Automatic Backwash Type**	**Automatic Backwash and Air-scouring Type (by Valve)**
Evaluation	• Bigger pumps and back washing valves will make cost higher. • Costs of both construction and maintenance are rather high. • No frequent maintenance practice is required due to well knowledge of existing system. • The amount of back washing water is less than other types.	• High-level skills are needed in flow control. • Bigger pumps and back washing valves will make cost higher. • High-level skills for O/M and frequent maintenance will be needed. • Costs of both construction and maintenance are large.	• Only three valves; inlet, drainage and surface washing are required. • Without complicated outflow adjusting mechanism, no high-level technical skills are needed. • Costs of both construction and maintenance are small. • No frequent maintenance is required due to less use of devices.	• Only three valves; inlet, drainage and air-scouring are required. • Without complicated outflow adjusting mechanism, no high-level technical skills are needed. • Costs of both construction and maintenance are small. • No frequent maintenance is required due to less use of devices. • The amount of back washing water is less than other types.
	not recommendable	not recommendable	not recommendable	recommendable
Drawing	 Water Declining Process  Air-Scouring and Backwashing Process  Backwashing Process 	 	 Filtration Process  Washing Process	 Filtration Process  Air-Scouring & Backwashing Washing Process

Appendix F33

Design Sheet for the Salaulim WTP

Contents for Appendix F33

F33.1 Design Sheet for the Salaulim WTP

Ⅰ Design Criteria

1 Capacity

		1st Stage	2nd Stage	Total
Planed Daily Max. Supply Capacity	:	100,000 m^3/d	100,000 m^3/d	200,000 m^3/d
Planed Daily Max. Treated Capacity	:	110,000 m^3/d	110,000 m^3/d	220,000 m^3/d
		(Loss: 10.0 %)		

2 Water Level in Salaulim Dam

HWL EL+ 42.50 m : Assumption due to No Data

LWL EL+ 21.50 m : Assumption due to No Data

Ⅱ Calculation on Demensions of Intake and Treatment Facilities

1 Intake Facility

1) Intake for 200 MLD

a) Type of Structure

＊Reinforced Concrete

b) Dimension

Width 8.80 m × Length 5.00 m × Height 26.20 m × 2 Basins

2) Incidental Equipment of Intake for 200 MLD

a) Inlet Opening

1st Lower (Butterfly Valve) : Diameter 2.00 m × 2 Units Section Area ＝ 3.142 m^2 /unit

2nd Lower (Butterfly Valve) Diameter 2.00 m × 2 Units Section Area ＝ 3.142 m^2 /unit

3rd Lower (Opening) : Width 2.00 m × Height 1.50 m × 2 Units Section Area ＝ 3.000 m^2 /unit

＊Inlet Velocuity (V_i) at LWL

＊In case of 200 MLD

V_i＝ Flow ／Section Area ＝ 1.273 ／ 3.142 ＝ 0.405 m/sec

＊In case of 1 Unit Vacant for 200 MLD

V_i＝ Flow ／Section Area ＝ 2.546 ／ 3.142 ＝ 0.811 m/sec

＊In case of 100 MLD

V_i＝ Flow ／Section Area ＝ 0.637 ／ 3.142 ＝ 0.203 m/sec

b) Interconnecting Valve (Butterfly Valve)

Diameter 1.80 m × 1 Unit Section Area ＝ 2.545 m^2 /unit

＊Velocuity (V_{ic}) at LWL

＊In case of 200 MLD

V_{ic}＝ Flow ／Section Area ＝ 2.546 ／ 2.545 ＝ 1.001 m/sec

＊In case of 100 MLD

V_i＝ Flow ／Section Area ＝ 1.273 ／ 2.545 ＝ 0.500 m/sec

3) Raw Water Intake Pump

a) Type : Vertical Turbine Selfwater Lubricared Pump

b) Specifications

＊In case of 200 MLD

S. Diameter 500 mm × D. Diameter 450 mm × Capacity 25.5 m^3/min × Rated Head m × 8 Units

＊In case of 100 MLD

S. Diameter 500 mm × D. Diameter 450 mm × Capacity 25.5 m^3/min × Rated Head 0.000 m × 4 Units

2 Raw Water Transmission Facility

1) Raw Water Transmission Pipe

a) Pipe Material

＊MS (Mild Steel) Pipe

b) Specifications

＊In case of 200 MLD

MSP: Diameter 1.40 m × Length 80.00 m × Section Area ＝ 1.539 m^2

＊In case of 100 MLD for Flow Meter & Flow Control Valve Line

MSP: Diameter 0.80 m × Length 15.00 m × Section Area ＝ 0.503 m^2

c) Velocuity ($V_{1\ or\ 2}$)

＊In case of 200 MLD

V_1＝ Flow ／Section Area ＝ 2.546 ／ 1.539 ＝ 1.654 m/sec

＊In case of 100 MLD

V_2＝ Flow ／Section Area ＝ 1.273 ／ 0.503 ＝ 2.533 m/sec

2) Incidental Equipment of Transmission Main

a) Flow Meter

＊In case of 100 MLD

Type : Ultrasonic Flow Meter

Diameter : 0.80 m × Section Area ＝ 0.503 m^2

＊Velocuity (V_{ic})

V_1＝ Flow ／Section Area ＝ 1.273 ／ 0.503 ＝ 2.533 m/sec

e) Flow Control Valve

Type : Tooth-shaped Disk Type Butterfly Valve

Diameter : 0.80 m × Section Area ＝ 0.503 m^2

＊Velocuity (V_{ic})

V_1＝ Flow ／Section Area ＝ 1.273 ／ 0.503 ＝ 2.533 m/sec

3 Treatment Facility

1) Receiving Well for 200 MLD

a) Type of Structure

＊Reinforced Concrete

b) Distribution Method

＊By Weir

c) Dimension

Receiving Well : Width 5.60 m × Length 5.60 m × Effective Depth 5.00 m × 1 Basin

Distribution Weir : Width 2.65 m × Height 4.55 m × 2 Units (Rectangular Type)

d) Volume of Receiving Well

V_r= 5.60 m × 5.60 m × 5.00 m ＝ 156.80 m^3

e) Detention Time of Receiving Well

＊In case of 200 MLD

T_r= 156.80 m^3 ／ 152.78 m^3/min ＝ 1.03 min

＊In case of 100 MLD

T_r= 156.80 m^3 ／ 76.39 m^3/min ＝ 2.05 min

f) Overflow Weir

Rectangular : Width 5.60 m × Height 5.10 m × 1 Unit

g) Inlet & Outlet Pipe for 200 MLD

☆Pipe Material : MS Pipe

☆Inlet Pipe

＊Specifications ;

＊In case of 200 MLD

MSP: Diameter 1.40 m × Section Area ＝ 1.539 m^2

＊Velocity in case of 200 MLD

V_1＝ Flow ／ Section Area ＝ 2.546 ／ 1.539 ＝ 1.654 m/sec

☆Outlet Pipe

＊Specifications ;

＊In case of 100 MLD

MSP: Diameter 1.35 m × Section Area ＝ 1.431 m^2 × 1 Lines / 100 MLD

＊Velocity in case of 100 MLD

V_2＝ Flow ／ Section Area ＝ 1.273 ／ 1.431 ＝ 0.889 m/sec

2) Connection Pipe ① (Receiving Well to Bio-Contact Filtration Basin)

☆Pipe Material : MS Pipe

☆Pipe Specifications

D_1＝ Diameter 1.35 m × Length 50.00 m × Section Area ＝ 1.431 m^2

V_1＝ Flow ／ Section Area ＝ 1.273 m^3/sec ／ 1.431 m^2 ＝ 0.889 m/sec

D_2＝ Diameter 1.80 m × Length 10.00 m × Section Area ＝ 2.545 m^2

V_2＝ Flow ／ Section Area ＝ 2.546 m^3/sec ／ 2.545 m^2 ＝ 1.001 m/sec

3) Connection Pipe ② (By-Pass Pipe：Receiving Well to Mixing & Distribution Chamber)

☆Pipe Material : MS Pipe

☆Pipe Specifications

D_3＝ Diameter 1.20 m × Length 50.00 m × Section Area ＝ 1.131 m^2

V_3＝ Flow ／ Section Area ＝ 2.546 m^3/sec ／ 1.131 m^2 ＝ 2.251 m/sec

4) Bio-Contact Filtration Basin

a) Type of Structure

＊Reinforced Concrete

b) Filtration Method

＊Self-Backwash Filter Type

c) Washing Method

＊Backwash Water & Air Scouring Type

d) Dimensions

Width 4.50 m × Length 11.60 m × Depth 6.70 m × 10 Basins / 100 MLD

e) Filtration Area

Width 4.50 m × Length 11.60 m ＝ 52.20 m^2/Basin

f) Filtration Rate

V_{ave} = 11,000 m^3/d/Basin ／ 52.20 ㎡/Basin ＝ 210.7 m/d :at Normal

V_{max} = 12,222 m^3/d/Basin ／ 52.20 ㎡/Basin ＝ 234.1 m/d :at 1 Basin during Washing

g) Depth of Filter Media & Water Depth above Filter Media

Depth of Media : D_s = 1.500 m
Water Depth above Media : H_{wd} = 3.300 m

h) Specifications of Media

Effective Size of Media : 6.00 mm
Coefficient of Uniformity : 1.40 less than

i) Underdrain Devices

Strainer with Air Distribution Type :
Collecting Chamber : Width 4.50 m × Depth 0.80 m × Length 11.60 m
Air Scouring & Backwash Chamber : Width 1.50 m × Depth 1.00 m
Diffusing Gravel : 0.100 m

j) Wash Gutter & Wash Trough

Wash Gutter : Width 1.50 m × Length 9.00 m × Depth 3.00 m × 10 Basins / 100 MLD

Wash Trough : Width 0.60 m × Length 4.80 m × Depth 0.50 m × 8 Units / Basin

k) Washing Method

①Rate of Air Scouring : 1.00 m^3/min/㎡ 2 min ← 0.8〜1.0 m^3/min/㎡
②Rate of Air Scouring : 1.00 m^3/min/㎡ }→ 5 min ← 0.8〜1.0 m^3/min/㎡
②Rate of Backwash Water : 0.40 m^3/min/㎡ ← 0.2〜0.4 m^3/min/㎡
③Rate of Backwash Water : 0.50 m^3/min/㎡ → 8 min ← 0.4〜0.6 m^3/min/㎡

l) Inlet and Outlet Pipe & Valve of Filter Basin for 100 MLD

Diameter 1.350 m Section Area of Pipe = 1.431 ㎡/basin

＊Flow Velocity :
V = 1.273 m^3/sec/basin ／ 1.431 ㎡/Basin = 0.889 m/sec :at Normal

m) Inlet Pipe & Valve of Each Filter Basin

Diameter 0.600 m Section Area of Pipe = 0.283 ㎡/basin

＊Flow Velocity :
V_{ave} = 0.127 m^3/sec/basin ／ 0.283 ㎡/Basin = 0.450 m/sec :at Normal
V_{max} = 0.141 m^3/sec/basin ／ 0.283 ㎡/Basin = 0.500 m/sec :at 1 Basin during Washing

n) Filtered (Backwash) Pipe & Valve

＊Filtered Pipe (Backwash Pipe)
Diameter 0.600 m Section Area of Pipe = 0.283 ㎡/basin

＊Flow Velocity at Filtration :
V_{ave} = 0.127 m^3/sec/basin ／ 0.283 ㎡/basin = 0.500 m/sec :at Normal
V_{max} = 0.141 m^3/sec/basin ／ 0.283 ㎡/basin = 0.500 m/sec :at 1 Basin during Washing

＊Flow Velocity at Backwashing :
V_{bw} = 0.435 m^3/sec/basin ／ 0.283 ㎡/basin = 1.500 m/sec

o) Air Scouring Pipe & Valve

Diameter 0.300 m Section Area of Pipe = 0.071 ㎡/basin

＊Flow Velocity at Air Scouring :
V_{as} = 0.870 m^3/sec/basin ／ 0.071 ㎡/basin = 12.308 m/sec

p) Outlet Weir

Width 10.00 m × Height 4.661 m × 1 Place / 50 MLD

q) Wash Water Drain Pipe & Valve

Diameter 0.800 m   **Section Area of Pipe** ＝ 0.503 m^2/basin

＊Flow Velocity at Backwashing :

V_{as} = 0.435 m^3/sec/basin ／ 0.503 m^2/basin = 0.865 m/sec

r) Drain Pipe & Valve

Diameter 0.150 m × 1 Place / Basin   **Section Area of Pipe** ＝ 0.018 m^2/basin

5) Connection Pipe ③ (Bio-Contact Filtration Basin to Mixing & Distribution Chamber)

☆Pipe Material : MS Pipe

☆Pipe Specifications

D_1＝ Diameter 1.35 m × Length 60.00 m × Section Area ＝ 1.431 m^2

V_1＝ Flow ／ Section Area ＝ 1.273 m^3/sec ／ 1.431 m^2 ＝ 0.889 m/sec

D_2＝ Diameter 1.80 m × Length 40.00 m × Section Area ＝ 2.545 m^2

V_2＝ Flow ／ Section Area ＝ 2.546 m^3/sec ／ 2.545 m^2 ＝ 1.001 m/sec

6) Mixing and Distribution Chamber for 100 MLD

a) Type of Structure

＊Reinforced Concrete

b) Mixing Method

＊Gravitational Force Mixing by Weir

c) Dimention

Mixing Chamber :	Width	4.00	m ×	Length	4.00	m ×	Effective Depth	5.000	m ×	1	Basin
Distribution Chamber :	Diameter	3.50	m ×	Depth	7.70	m ×	Effective Depth	6.966	m ×	1	Basin
Collecting Chamber :	Diameter	6.50	m ×	Depth	2.20	m ×	Effective Depth	1.258	m ×	1	Basin
Mixing Weir :	Width	4.00	m ×	Height	4.440	m ×	1	Unit	(Rectangular Type)		
Distribution Weir :	Width	2.60	m ×	Height	6.716	m ×	4	Units	(Rectangular Type)		

d) Volume of Mixing Chamber

V_r= 4.00 m × 4.00 m × 5.00 m ＝ 80.00 m^3

e) Detention Time of Mixing Chamber

＊In case of 100 MLD

T_r= 80.00 m^3 ／ 76.39 m^3/min ＝ 1.05 min

f) Perforated Baffle Wall of Mixing Chamber

＊Opening Section Total Area of Perforated Baffle Wall (m^2) : ＝ 1.327 m^2 Equivalent of : 7%

Diameter of Opening : 0.100 m   Section Area of opening : 0.00785 m^2/piece

Number of Row : 13 Row

Number of Stage : 13 Stage

Total Section Area : Width 4.00 m × Effective Depth 5.00 m ＝ 20.00 m^2

g) Overflow Weir

Rectangular : Width 4.00 m × Height 5.10 m × 1 Units

h) Piping & Channel

＊Pipe Material : MS Pipe

＊Channel Material : Reinforced Concrete

＊Specifications ;

＊Inlet Pipe of Mixing Chamber in case of 100 MLD

MSP : Diameter 1.35 m × **Section Area ＝** 1.431 m^2

＊Interconnecting Pipe of Mixing & Distribution Chamber in case of 100 MLD

MSP : Diameter 1.35 m × **Section Area ＝** 1.431 m^2

＊Inlet Pipe of Clariflocculator in case of 25 MLD

MSP : Diameter 0.70 m × **Section Area ＝** 0.385 m^2

＊Outlet Channel of Clariflocculator in case of 25 MLD

RC : Width 1.00 m × Height 1.20 m **Section Area ＝** 1.200 m^2

＊Outlet Pipe to Filtration Basin in case of 100 MLD

MSP : Diameter 1.35 m × **Section Area ＝** 1.431 m^2

＊Velocuity (V_0)

＊Inlet Pipe (In case of 100 MLD)

V_{in}＝ **Flow ／ Section Area** ＝ 1.273 ／ 1.431 ＝ 0.889 m/sec

＊Interconnecting Pipe (In case of 100 MLD)

V_{ic}＝ **Flow ／ Section Area** ＝ 1.273 ／ 1.431 ＝ 0.889 m/sec

＊Inlet Pipe of Clariflocculator (In case of 25 MLD)

V_i＝ **Flow ／ Section Area** ＝ 0.318 ／ 0.385 ＝ 0.827 m/sec

＊Outlet Channel of Clariflocculator (In case of 25 MLD)

V_i＝ **Flow ／ Section Area** ＝ 0.318 ／ 1.200 ＝ 0.265 m/sec

＊Outlet Pipe to Filtration Basin (In case of 100 MLD)

V_{in}＝ **Flow ／ Section Area** ＝ 1.273 ／ 1.431 ＝ 0.889 m/sec

7) Clariflocculator Basin

a) Type of Structure

＊Reinforced Concrete

b) Dimensions for 100 MLD

Flocculation Basin : Diameter 10.40 m × Effective Depth 4.50 m × 4 **Basins**

Sedimentation Inlet Zone : Diameter 10.40 m × Diameter 13.40 m × Effective Depth 3.50 m × 4 **Basins**

Sedimentation Basin : Diameter 13.40 m × Diameter 31.40 m × Effective Depth 3.50 m × 4 **Basins**

c) Volume of Clariflocculator Basin

Flocculation Basin : V_f＝ 1／4 π × (10.40 $)^2$ × 4.50 ＝ 382.3 m^3/Basin

Sedimentation Basin : V_{s1}＝ 1／4 π ×{ (31.40 $)^2$ －(10.40 $)^2$ } × 3.50 ＝ 2,413.0 m^3/Basin

d) Detention Time of Clariflocculator Basin

＊In case of 100 MLD

Flocculation Basin : T_f＝ 382.27 m^3 ／ 19.10 m^3/min ＝ 20.0 min

Sedimentation Basin : T_s＝ 2,412.98 m^3 ／ 1,145.83 m^3/hr ＝ 2.11 hr

e) Perforated Baffle Wall of Sedimentation Basin

＊Opening Section Total Area of Perforated Baffle Wall (m^2) : ＝ 9.189 m^2 **Equivalent of :** 6%

Diameter of Opening : 0.100 m **Section Area of opening :** 0.00785 m^2/piece

Number of Row : 130 Row

Number of Stage : 9 Stage

Total Section Area : Diameter 14.40 m × Effective Depth 3.50 m ＝ 158.34 m^2

f) Outlet Weir
＊Rectangular
Width 98.65 m × Height 0.70 m × 1 Unit / Basin

g) Weir Loading
L_W= 27,500 m^3/d ／ 98.65 m = 278.8 m^3/d／m

h) Surface Loading
＊Surface Area of Sedimentation Basin
A= 1／4 π×{ (31.40)^2 − (10.40)^2 } = 689.4 m^2/basin

＊Surface Loading of Sedimentation
S_L= 19.10 m^3/min ／ 689.4 m^2/basin = 27.7 mm/min :at Nomal (15-30)
S_L= 25.46 m^3/min ／ 689.4 m^2/basin = 36.9 mm/min :at 1 Basin out of Operation

i) Sludge Drain Pipe
Diameter 0.300 m × 1 Unit/Basin

8) Connection Pipe ④ (Distribution Chamber to Rapid Sand Filtlation Basin)

☆Pipe Material : MS Pipe

☆Pipe Specifications
D_1= Diameter 0.90 m × Length 25.00 m × Section Area = 0.636 m^2
V_1= Flow ／ Section Area = 0.637 m^3/sec ／ 0.636 m^2 = 1.001 m/sec

D_2= Diameter 1.35 m × Length 45.00 m × Section Area = 1.431 m^2
V_2= Flow ／ Section Area = 1.273 m^3/sec ／ 1.431 m^2 = 0.889 m/sec

9) Rapid Sand Filtration Basin

a) Type of Structure
＊Reinforced Concrete

b) Filtration Method
＊Self-Backwash Filter Type

c) Washing Method
＊Backwash Water & Air Scouring Type

d) Dimensions
Width 4.50 m × Length 9.00 m × Depth 6.20 m × 10 Basins / 50 MLD
20 Basins / 100 MLD

e) Filtration Area
Width 4.50 m × Length 9.00 m = 40.50 m^2/Basin

f) Filtration Rate
V_{ave}= 5,500 m^3/d/Basin ／ 40.50 m^2/Basin = 135.8 m/d :at Normal
V_{max}= 6,111 m^3/d/Basin ／ 40.50 m^2/Basin = 150.9 m/d :at 1 Basin during Washing

g) Depth of Sand & Water Depth above Sand
Depth of Sand : D_s= 0.700 m
Water Depth above Sand : H_{wd}= 3.600 m

h) Specification of Sand
Effective Size of Sand : 0.70 mm
Coefficient of Uniformity : 1.40 less than

i) Underdrain Devices

Strainer with Air Distribution Type :

Collecting Chamber : Width **4.50** m × Depth **0.80** m × Length **9.00** m

Air Scouring & Backwash Chamber : Width **1.50** m × Depth **1.00** m

Diffusing Gravel : **0.100** m

j) Wash Gutter & Wash Trough

Wash Gutter : Width **1.50** m × Length **9.00** m × Depth **1.40** m × **10** Basins / 50 MLD

20 Basins / 100 MLD

Wash Trough : Width **0.60** m × Length **4.80** m × Depth **0.50** m × **8** Units / Basin

k) Washing Method

①Rate of Air Scouring :	**1.00**	m^3/min/㎡		**2 min**	←	**0.8～1.0**	m^3/min/㎡
②Rate of Air Scouring :	**1.00**	m^3/min/㎡	}→	**5 min**	←	**0.8～1.0**	m^3/min/㎡
②Rate of Backwash Water :	**0.40**	m^3/min/㎡			←	**0.2～0.4**	m^3/min/㎡
③Rate of Backwash Water :	**0.65**	m^3/min/㎡	→	**8 min**	←	**0.6～0.8**	m^3/min/㎡

l) Inlet Pipe & Valve of Filter Basin for 50 MLD

Diameter **0.900** m   **Section Area of Pipe = 0.636** ㎡/basin

＊Flow Velocity :

V = **0.637** m^3/sec/basin ／ **0.636** ㎡/Basin = **1.001** m/sec   :at Normal

m) Inlet Pipe & Valve of Each Filter Basin

Diameter **0.400** m   **Section Area of Pipe = 0.126** ㎡/basin

＊Flow Velocity :

V_{ave} = **0.064** m^3/sec/basin ／ **0.126** ㎡/Basin = **0.507** m/sec   :at Normal

V_{max} = **0.067** m^3/sec/basin ／ **0.126** ㎡/Basin = **0.533** m/sec   :at 1 Basin during Washing

n) Filtered (Backwash) Pipe & Valve

＊Filtered Pipe (Backwash Pipe)

Diameter **0.600** m   **Section Area of Pipe = 0.283** ㎡/basin

＊Flow Velocity at Filtration :

V_{ave} = **0.064** m^3/sec/basin ／ **0.283** ㎡/basin = **0.225** m/sec   :at Normal

V_{max} = **0.067** m^3/sec/basin ／ **0.283** ㎡/basin = **0.237** m/sec   :at 1 Basin during Washing

＊Flow Velocity at Backwashing :

V_{bw} = **0.439** m^3/sec/basin ／ **0.283** ㎡/basin = **1.552** m/sec

o) Air Scouring Pipe & Valve

Diameter **0.250** m   **Section Area of Pipe = 0.049** ㎡/basin

＊Flow Velocity at Air Scouring :

V_{as} = **0.675** m^3/sec/basin ／ **0.049** ㎡/basin = **13.751** m/sec

p) Outlet Weir

Width **10.00** m × Height **3.00** m × **1** Place / 50 MLD

q) Wash Water drain Pipe & Valve

Diameter **0.800** m   **Section Area of Pipe = 0.503** ㎡/basin

＊Flow Velocity at Backwashing :

V_{as} = **0.439** m^3/sec/basin ／ **0.503** ㎡/basin = **0.873** m/sec

r) **Drain Pipe & Valve**

Diameter **0.150** m × **1** Place / Basin Section Area of Pipe = **0.018** ㎡/basin

10) Connection Pipe ⑤ (Rapid Sand Filtration Basin to Clear Water Reservoir)

☆Pipe Material : MS Pipe

☆Pipe Specifications

D_1= Diameter 0.90 m × Length 35.00 m × Section Area = 0.636 m^2
V_1= Flow ／ Section Area = 0.637 m^3/sec ／ 0.636 m^2 = 1.001 m/sec

D_2= Diameter 1.35 m × Length 35.00 m × Section Area = 1.431 m^2
V_2= Flow ／ Section Area = 1.273 m^3/sec ／ 1.431 m^2 = 0.889 m/sec

D_3= Diameter 1.80 m × Length 50.00 m × Section Area = 2.545 m^2
V_3= Flow ／ Section Area = 2.546 m^3/sec ／ 2.545 m^2 = 1.001 m/sec

11) Clear Water Reservoir

a) **Type of Structure**

＊Reinforced Concrete

b) **Dimensions**

Reservoir : Width 20.00 m × Length 30.00 m × Water Depth 4.00 m × 2 Basins / 100 MLD
Pumping Well : Width 30.00 m × Length 5.00 m × Water Depth 4.00 m × 1 Basin / 100 MLD

c) **Volume of Clear Water Reservoir**

V_r= 20.00 m × 30.00 m × 4.00 m × 2.00 Basin = 4,800 m^3

d) **Detention Time of Clear Water Reservoir**

T_r= 4,800.0 m^3 ／ 4,166.7 m^3/hr = 1.15 hr

e) **Inlet Pipe & Valve**

Diameter 1.350 m Section Area of Pipe = 1.431 ㎡/basin

＊Flow Velocity at Backwashing :

V_i = 1.273 m^3/sec/basin ／ 1.431 ㎡/basin = 0.889 m/sec

12) Transmission Pumping House

a) **Type of Structure**

＊Reinforced Concrete

b) **Dimensions**

Width 40.00 m × Length 10.00 m × 1 House / 200 MLD

Ⅲ Hydraulic Calculation of Intake & Treatment Plant

1 Intake & Transmission Facility

1) Intake Facility

a) Flow Velocity of Inlet Pipe (V_i) at LWL

Vi= Q／A

Where, Q; Planed Max. Intake Capacity 2.546 m^3/sec

A; Section Area of Intake Pipe 3.142 m^2 × 2 Units ＝ 6.283 m^2

Vi= 2.546 m^3/sec ／ 6.283 m^2 = 0.405 m/sec

b) Head Loss of Inlet Pipe (H_i) at LWL

H_i= $f_i * V_i^2$ ／ 2 * g

where, f_i ; Coefficient of Inlet ＝ 0.50

V_i ; Flow Velocity through Inlet Pipe (m/sec) ＝ 0.405 m/sec

g ; Accerated Gravity (m/sec^2) ＝ 9.81 m/sec^{-2}

H_i= $f_i * V_i^2$ ／ 2 * g ＝ 0.004 m

c) Head Loss of Butterfly Valve (H_{iv}) at LWL

H_{iv}= $f_v * V_i^2$ ／ 2 * g

where, f_v ; Coefficient of Butterfly Valve ＝ 0.25

V_i ; Flow Velocity through Inlet Pipe (m/sec) ＝ 0.405 m/sec

g ; Accerated Gravity (m/sec^2) ＝ 9.81 m/sec^{-2}

H_{iv}= $f_v * V_i^2$ ／ 2 * g ＝ 0.002 m

d) Friction Loss of Inlet Pipe (H_{fr})

Hazen & William's Formula

H_{fr}= 10.666 ＊ $C^{-1.85}$ ＊ $D^{-4.87}$ ＊ $Q^{1.85}$ ＊L

where, C; Coefficient of Velocity ＝ 130

D; Pipe Diameter (m) ＝ 2.000 m

Q; Flow Capacity (m^3/sec) ＝ 2.546 m^3/sec

L; Length of Inlet Pipe (m) ＝ 1.50 m

H_{fr}= 10.666 * (130)$^{-1.85}$*(2.000)$^{-4.87}$*(2.546)$^{1.85}$* 1.50 = 0.000 m

e) Head Loss of Outlet to the Pumping Well (H_o)

H_o= $f_o * V_o^2$ ／ 2 * g

where, f_o ; Coefficient of Outlet ＝ 1.00

V_o ; Flow Velocity through Inlet Pipe (m/sec) ＝ 0.405 m/sec

g ; Accerated Gravity (m/sec^2) ＝ 9.81 m/sec^{-2}

H_o= $f_o * V_o^2$ ／ 2 * g ＝ 0.008 m

f) Total Head Loss of Intake Pipe & Valve (ΣH)

ΣH＝ H_i＋ H_{iv}＋ H_{fr}＋ H_o＝ 0.015 m

g) Water Level of Intake Pumping Well（LWL)

Design LWL in Salaulim Dam : 21.500 m

Therefore,

LWL of Intake Pumping Well : 21.500 m - 0.015 m ＝ 21.485 m

2) Raw Water Transmission Pipe

a) Head Loss of Bend (H_{b1}) D 1.400 m× 90° 2 Set × R 0.900 m R/D= 0.6

H_{b1}= $f_{b1} * f_{b2} * V_i^2 ／ 2 * g * n$

Where, f_{b1} ; Coefficient of 90°Bend =	0.20	
f_{b2} ; Coefficient of 90°Bend =	1.00	
V_i ; Flow Velocity through Pipe (m/sec) =	1.654	m/sec
g ; Accerated Gravity (m/sec^2) =	9.81	m/sec^2
n ; Number of 90°Bend =	2	set
H_{b1}= $f_{b1} * f_{b2} * V_i^2 ／ 2 * g * n$ =	0.056	m

b) Head Loss of Bend (H_{b2}) D 1.400 m× 45° 1 Set × R 1.500 m R/D= 1.1

H_{b2}= $f_{b1} * f_{b2} * V_i^2 ／ 2 * g * n$

Where, f_{b1} ; Coefficient of 45°Bend =	0.15	
f_{b2} ; Coefficient of 45°Bend =	0.70	
V_i ; Flow Velocity through Pipe (m/sec) =	1.654	m/sec
g ; Accerated Gravity (m/sec^2) =	9.81	m/sec^2
n ; Number of 45°Bend =	1	set
H_{b2}= $f_{b1} * f_{b2} * V_i^2 ／ 2 * g * n$ =	0.015	m

c) Head Loss of Bend (H_{b3}) D 0.800 m× 45° 1 Set × R 1.100 m R/D= 1.4

H_{b3}= $f_{b1} * f_{b2} * V_i^2 ／ 2 * g * n$

Where, f_{b1} ; Coefficient of 45°Bend =	0.15	
f_{b2} ; Coefficient of 45°Bend =	0.70	
V_i ; Flow Velocity through Pipe (m/sec) =	2.533	m/sec
g ; Accerated Gravity (m/sec^2) =	9.81	m/sec^2
n ; Number of 45°Bend =	1	set
H_{b3}= $f_{b1} * f_{b2} * V_i^2 ／ 2 * g * n$ =	0.034	m

d) Head Loss of Bend (H_{b4}) D 1.400 m× 22.5° 2 Set × R 3.000 m R/D= 2.1

H_{b4}= $f_{b1} * f_{b2} * V_i^2 ／ 2 * g * n$

Where, f_{b1} ; Coefficient of 45°Bend =	0.09	
f_{b2} ; Coefficient of 45°Bend =	0.40	
V_i ; Flow Velocity through Pipe (m/sec) =	1.654	m/sec
g ; Accerated Gravity (m/sec^2) =	9.81	m/sec^2
n ; Number of 45°Bend =	2	set
H_{b4}= $f_{b1} * f_{b2} * V_i^2 ／ 2 * g * n$ =	0.010	m

e) Head Loss of Converging Duct（H_{sc}）

H_{sc}= $f_{sc} * V_2^2 ／ 2 * g$

Where, f_{sc} ; Coefficient of Converging Duct =		0.24	
V_2 ; Flow Velocity after Converging (m/sec) =		2.533	m/sec
g ; Accerated Gravity (m/sec^2) =		9.81	m/sec^{-2}
A_1 ; Section Area before Converging (m^2)	D 1.400	1.539	m^2
A_2 ; Section Area after Converging (m^2)	D 0.800	0.503	m^2
A_2/ A_1 ;		0.33	
H_{sc}= $f_o * V_o^2 ／ 2 * g$ =		0.078	m

f) Head Loss of Diverging Duct（H_{se}）

H_{se}= $f_{se} * V_1^2 ／ 2 * g$

Where, f_{se} ; Coefficient of Diverging Duct =	（ 1 － （A_1/ A_2）)＾2 =	0.45	
V_1 ; Flow Velocity before Diverging (m/sec) =		2.533	m/sec
g ; Accerated Gravity (m/sec^2) =		9.81	m/sec^{-2}
A_1 ; Section Area before Diverging (m^2)	D 0.800	0.503	m^2
A_2 ; Section Area after Diverging (m^2)	D 1.400	1.539	m^2
A_1/ A_2 ;		0.33	
H_{se}= $f_o * V_o^2 ／ 2 * g$ =		0.148	m

g) Friction Loss of Raw Water Transmission Pipe (H_{fr})

Hazen & William's Formula

H_{fr}= 10.666 ∗ $C^{-1.85}$ ∗ $D^{-4.87}$ ∗ $Q^{1.85}$ ∗L

Where,	C; Coefficient of Velocity =	130	130	
	D; Pipe Diameter (m) =	1.400	0.800	m
	Q; Flow Capacity (m^3/sec) =	2.546	1.273	m^3/sec
	L; Length of Raw Water Transmission Pipe (m) =	80.0	15.0	m

H_{fr1}= 10.666 * (130 $)^{-1.85}$*(1.400 $)^{-4.87}$*(2.546 $)^{1.85}$* 80.0 = 0.115 m

H_{fr2}= 10.666 * (130 $)^{-1.85}$*(0.800 $)^{-4.87}$*(1.273 $)^{1.85}$* 15.0 = 0.091 m

H_{fr}= H_{fr1} + H_{fr2} = 0.206 m

h) Head Loss of Butterfly Valve (H_{sv}) D 0.800 m × 2 places

H_{sv}= $f_i * V_i^2 ／ 2 * g * n$

Where,	f_{sv} ; Coefficient of Butterfly Valve =	0.25	
	V_i ; Flow Velocity through Inlet Pipe (m/sec) =	2.533	m/sec
	g ; Accerated Gravity (m/sec^2) =	9.81	m/sec^2
	n ; Number of Butterfly Valve =	2	set

H_{sv}= $f_{sv} * V_i^2 ／ 2 * g * n$ = 0.041 m

i) Head Loss of Outlet (H_o)

H_o= $f_o * V_o^2 ／ 2 * g$

Where,	f_o ; Coefficient of Outlet =	1.00	
	V_o ; Flow Velocity through Transmission Pipe (m/sec) =	1.654	m/sec
	g ; Accerated Gravity (m/sec^2) =	9.81	m/sec^{-2}

H_o= $f_o * V_o^2 ／ 2 * g$= 0.139 m

j) Total Head Loss of Raw Water Transmission Pipe & Valve (ΣH)

ΣH= H_{b1} + H_{b2} + H_{b4} + H_{b2} + H_{sc} + H_{se} + H_{fr} + H_{sv} + H_o = 0.728 m

2 Treatment Facilities

1) Receiving Well

a) Water Level of Receiving Well

＊Assuming that the Water Level of Receiving Well is as follows : $\boxed{58.800}$ **m**

b) Calculation of Broad Crested Rectangular Weir

＊Ishihara & Ida's Formula

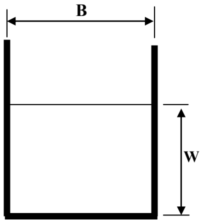
$$Q = C \times B \times h^{3/2}$$

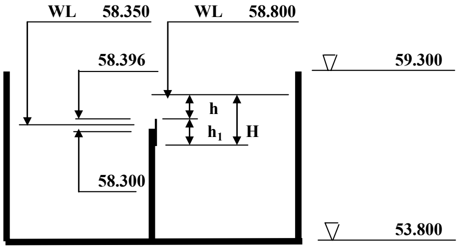
$$C = 1.785 + ((0.00295/h + 0.237 \times (h/W)) \times (1+\varepsilon)$$

whrer, Q; Over Flow Capacity (m^3/sec) =	1.2731	m^3/sec
B; Width of Weir (m) =	2.650	m
h; Water Depth of Weir (m) =	0.404	m
C; Coefficient of Flow ($m^{1/2}$/sec) =	1.869	$m^{1/2}$/sec
W; Height from Bottom of Receiving Well (m) =	4.60	m
ε; Correction Factor、when W＞1m, ε= 0.55*(W-1) =	1.978	

$\therefore Q = C \times B \times h^{3/2}$ = 1.2731 m^3/sec

$\therefore C = 1.785 + ((0.00295/h + 0.237 \times (h/W)) \times (1+\varepsilon)$ = 1.869





Therefore, assuming that Head Loss of Distribution Weir (H_w) is as follows : H_w = $\boxed{0.450}$ m

c) Water Level after Distribution Weir

Therefore,

Water Level after Distribution Weir : $\boxed{58.800}$ m - $\boxed{0.450}$ m = $\boxed{58.350}$ m

2) Connection Pipe ① (Receiving Well to Bio-Contact Filtration Basin)

a) Head Loss of Inlet (H_i)

＊Flow Velocity of Inlet (V_i) D_1 1.350 m

V_i= Q／A

where, Q; Planed Max. Treated Capacity (m^3/sec) = 1.273 m^3/sec

D_1 ; Diameter of Connecting Pipe ① (m) = 1.350 m

A; Section Area of Connecting Pipe ① (m^2) = 1.431 m^2

V_i= 1.273 m^3/sec ／ 1.431 m^2 = 0.889 m/sec

H_i= f_i * (V_i^2／2*g)

where, f_i; Coefficient of Inlet = 0.50

V_i; Flow Velocity through Inlet Pipe (m/sec) = 0.889 m/sec

g; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

H_i= 0.50 * (0.889)^2／(2 * 9.81)= 0.020 m

b) Head Loss of Butterfly Valve (H_{bv1}) D_1 1.350 m

H_{bv1}= f_v * V_i^2 ／ 2 * g

where, f_v ; Coefficient of Butterfly Valve = 0.25

V_i ; Flow Velocity through Inlet Pipe (m/sec) = 0.889 m/sec

g ; Accerated Gravity (m/sec^2) = 9.81 m/sec^{-2}

H_{bv1}= f_v * V_i^2 ／ 2 * g = 0.010 m

c) Head Loss of Bend (H_{b1}) D_1 1.350 m× 90° 2 Set × R 0.900 m R/D= 0.7

H_{b1}= f_{b1} * f_{b2} * V_i^2 ／ 2 * g * n

where, f_{b1} ; Coefficient of 90°Bend = 0.20

f_{b2} ; Coefficient of 90°Bend = 1.00

V_i ; Flow Velocity through Pipe (m/sec) = 0.889 m/sec

g ; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

n ; Number of 90°Bend = 2 set

H_{b1}= f_{b1} * f_{b2} * V_i^2 ／ 2 * g * n = 0.016 m

d) Head Loss of Diverging Duct (H_{se})

H_{se}= f_{se} * V_1^2 ／ 2 * g

Where, f_{se} ; Coefficient of Diverging Duct = (1 − (A_1/ A_2))^2 = 0.19

V_1 ; Flow Velocity before Diverging (m/sec) = 0.889 m/sec

g ; Accerated Gravity (m/sec^2) = 9.81 m/sec^{-2}

A_1; Section Area before Diverging (m^2) D_1 1.350 1.431 m^2

A_2; Section Area after Diverging (m^2) D_2 1.800 2.545 m^2

A_1/ A_2; 0.56

H_{se}= f_o * V_o^2 ／ 2 * g = 0.008 m

e) Head Loss of Inlet Connection (H_{ir}) D_2 1.800 m

H_{ir}= f_{ir} * (V_i^2／2*g)

where, f_{ir} ; Coefficient of Combined = 0.53

V_i; Flow Velocity after Combined (m/sec) = 1.654 m/sec

g; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

Q ; Flow Capacity after Combined (m^3/sec)= 2.546 m^3/sec

Q_a ; Combined Flow Capacity (m^3/sec)= 1.273 m^3/sec

Q_a ／Q = 0.50

H_{ir}= 0.53 * (1.654)^2／(2 * 9.81)= 0.074 m

f) Head Loss of Outlet Connection (H_{or}) D_2 1.800 m

H_{or}= f_{or} * (V_i^2／2*g)

where, f_{or} ; Coefficient of Diversion = 0.10

V_i; Flow Velocity before Diversion (m/sec) = 1.654 m/sec

g; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

Q ; Flow Capacity before Diversion (m^3/sec)= 2.546 m^3/sec

Q_a ; Diversion Flow Capacity (m^3/sec)= 1.273 m^3/sec

Q_a ／Q = 0.50

H_{or}= 0.10 * (1.654)^2／(2 * 9.81)= 0.014 m

g) Head Loss of Converging Duct (H_{sc})

$H_{sc}= f_{sc} * V_2^2 ／ 2 * g$

Where, f_{sc} ; Coefficient of Converging Duct ＝ 0.24

V_2 ; Flow Velocity after Converging (m/sec) ＝ 0.889 m/sec

g ; Accerated Gravity (m/sec^2) ＝ 9.81 m/sec^{-2}

A_1 ; Section Area before Converging (m^2) D 1.800 2.545 m^2

A_2 ; Section Area after Converging (m^2) D 1.350 1.431 m^2

A_2/ A_1 ; 0.56

$H_{sc}= f_o * V_o^2 ／ 2 * g =$ 0.010 m

h) Head Loss of Butterfly Valve (H_{bv2}) at LWL D_I 1.350 m

$H_{bv2}= f_v * V_i^2 ／ 2 * g$

where, f_v ; Coefficient of Butterfly Valve ＝ 0.25

V_i ; Flow Velocity through Inlet Pipe (m/sec) ＝ 0.889 m/sec

g ; Accerated Gravity (m/sec^2) ＝ 9.81 m/sec^{-2}

$H_{bv2}= f_v * V_i^2 ／ 2 * g$ ＝ 0.010 m

i) Friction Loss of Raw Water Transmission Pipe (H_{fr})

Hazen & William's Formula

$H_{fr}= 10.666 \ast C^{-1.85} \ast D^{-4.87} \ast Q^{1.85} \ast L$

Where,

C; Coefficient of Velocity ＝	130	130	
D; Pipe Diameter (m) ＝	1.350	1.800	m
Q; Flow Capacity (m^3/sec) ＝	1.273	2.546	m^3/sec
L; Length of Connection Pipe ① (m) ＝	50.0	10.0	m

$H_{fr1}= 10.666 * (130)^{-1.85} * (1.350)^{-4.87} * (1.273)^{1.85} * 50.0 = 0.024$ m

$H_{fr2}= 10.666 * (130)^{-1.85} * (1.800)^{-4.87} * (2.546)^{1.85} * 10.0 = 0.004$ m

$H_{fr}= H_{fr1} + H_{fr2} =$ 0.028 m

j) Head Loss of Outlet (H_o)

$H_o= f_o * V_o^2 ／ 2 * g$

Where, f_o ; Coefficient of Outlet ＝ 1.00

V_o ; Flow Velocity through Connection Pipe (m/sec) ＝ 0.889 m/sec

g ; Accerated Gravity (m/sec^2) ＝ 9.81 m/sec^{-2}

$H_o= f_o * V_o^2 ／ 2 * g =$ 0.040 m

k) Total Head Loss of Connection Pipe ① (ΣH)

$\Sigma H ＝ H_{bv1} ＋ H_{b1} ＋ H_{se} ＋ H_{ir} ＋ H_{or} ＋ H_{sc} ＋ H_{bv2} ＋ H_{fr} ＋ H_o$ ＝ 0.210 m

l) Inlet Part's Water Level of Bio-Contact Filtration Basin

Therefore,

Inlet Part's Water Level of Bio-Contact Filtration Basin : 58.350 m - 0.210 m = 58.140 m

3) Connection Pipe ② (Receiving Well to Mixing & Distribution Chamber)

4) Bio-Contact Filtration Basin

☆ Calculation of Inlet Devices

a) Head Loss of Inlet Valve (H_i)

＊Flow Velocity of Inlet (V_i) D_1 0.600 m

V_i= Q／A

where, Q; Planed Max. Treated Capacity (m^3/sec) = 0.127 m^3/sec

D_1 ; Diameter of Connecting Pipe ① (m) = 0.600 m

A; Section Area of Connecting Pipe ① (m^2) = 0.283 m^2

V_i= 0.127 m^3/sec ／ 0.283 m^2 = 0.450 m/sec

H_i= f_i * (V_i^2／2*g)

where, f_i; Coefficient of Inlet = 1.00

V_i; Flow Velocity through Inlet Pipe (m/sec) = 0.450 m/sec

g; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

H_i= 1.00 * (0.450)^2／(2 * 9.81)= 0.010 m

b) Head Loss of Butterfly Valve (H_{bv}) D_1 0.600 m

H_{bv1}= f_v * V_i^2 ／ 2 * g

where, f_v ; Coefficient of Butterfly Valve = 0.25

V_i ; Flow Velocity through Inlet Pipe (m/sec) = 0.450 m/sec

g ; Accerated Gravity (m/sec^2) = 9.81 m/sec^{-2}

H_{bv1}= f_v * V_i^2 ／ 2 * g = 0.003 m

c) Head Loss of Outlet (H_o)

H_o= f_o * V_o^2 ／ 2 * g

Where, f_o ; Coefficient of Outlet = 1.00

V_o ; Flow Velocity through Inlet Pipe (m/sec) = 0.450 m/sec

g ; Accerated Gravity (m/sec^2) = 9.81 m/sec^{-2}

H_o= f_o * V_o^2 ／ 2 * g = 0.010 m

d) Total Head Loss of Inlet Valve (ΣH)

ΣH= H_i＋ H_{bv1}＋ H_o = 0.023 m

e) Water Level after Inlet Valve

Therefore,

Water Level after Inlet Valve : 58.140 m - 0.023 m = 58.117 m

f) Calculation of Water Depth in Broad Crested Rectangular Weir (Distribution Weir)

＊Ishihara & Ida's Formula

Q= C×B×$h^{3/2}$

C= 1.785＋ ((0.00295／h ＋ 0.237 × (h／W))× (1＋ε)

whrer, Q; Over Flow Capacity (m^3/sec) = 0.12731 m^3/sec

B; Width of Weir (m) = 1.500 m

h; Water Depth of Weir (m) = 0.129 m

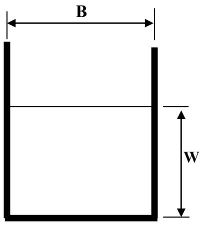
C; Coefficient of Flow ($m^{1/2}$/sec) = 1.839 $m^{1/2}$/sec

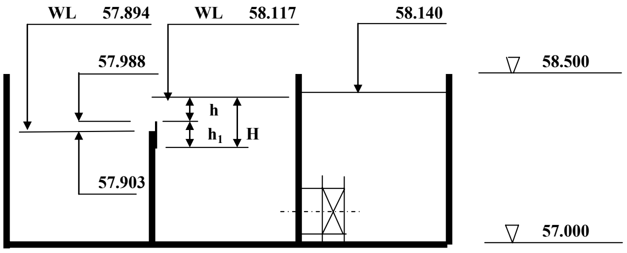
W; Height from Bottom of Receiving Well (m) = 0.99 m

ε; Correction Factor、when W≦1m, ε= 0 0

∴Q= C×B×$h^{3/2}$ = 0.12740 m^3/sec

∴C= 1.785＋ ((0.00295／h ＋ 0.237 × (h／W))× (1＋ε) = 1.839





Therefore, assuming that Head Loss of Distribution Weir (H_w) is as follows : H_w = 0.223 m

g) Water Level after Distribution Weir

Therefore,

Water Level after Distribution Weir : 58.117 m - 0.223 m = **57.894** m

h) Head Loss of Inlet Pipe (H_{ip})

$H_{ip} = f_i * (V_i^2 ／ 2*g)$

where,
f_i; Coefficient of Inlet = 0.50
V_i; Flow Velocity through Inlet Pipe (m/sec) = 0.450 m/sec
g; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

H_{ip}= 0.50 * (0.450)^2／(2 * 9.81)= 0.005 m

i) Friction Loss of Inlet Pipe (H_{fr})

Hazen & William's Formula

$H_{fr} = 10.666 * C^{-1.85} * D^{-4.87} * Q^{1.85} * L$

where,
C; Coefficient of Velocity = 130
D; Pipe Diameter (m) = 0.600 m
Q; Flow Capacity (m^3/sec) = 0.127 m^3/sec
L; Length of Inlet Pipe (m) = 1.30 m

H_{fr}= 10.666 * (130)$^{-1.85}$*(0.600)$^{-4.87}$*(0.127)$^{1.85}$* 1.30 = 0.000 m

j) Head Loss of Outlet (H_{op})

$H_{op} = f_o * V_o^2 ／ 2 * g$

Where,
f_o ; Coefficient of Outlet = 1.00
V_o ; Flow Velocity through Inlet Pipe (m/sec) = 0.450 m/sec
g ; Accerated Gravity (m/sec^2) = 9.81 m/sec^{-2}

$H_{op} = f_o * V_o^2 ／ 2 * g$ = 0.010 m

k) Total Head Loss of Inlet Pipe (Σ H)

$\Sigma H = H_{ip} + H_{fr} + H_o =$ 0.016 m

l) Water Level in Bio-Contact Filtration Basin

Therefore,

Water Level in Bio-Contact Filtration basin : 57.894 m - 0.016 m = **57.878** m

☆ Calculation of Bio-Contact Filtration Basin

a) Total Head Loss of Bio-Contact Filtration Basin

H_f= 1.20 m

Therefore,

Water Level before Filtered Water Outlet Weir :

57.878 m - 1.200 m = **56.678** m

b) Calculation of Water Depth in Outlet Weir

＊Itaya & Tejima's Formula

$Q = C * b * h^{3/2} =$

$C = 1.785 + (0.00295 / h) + 0.237 * (h / W)$

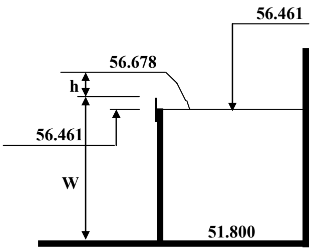
$- 0.428 * \sqrt{(B - b) * h / B * W} + 0.034 * \sqrt{B/W}$

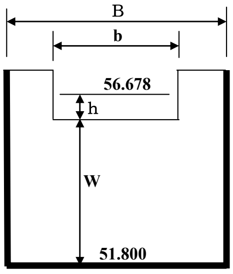
Where,	**Q; Over Flow Capacity (m^3/sec) =**	**1.27315**	**m^3/sec**			
	b; Width of Weir (m) =	**10.000**	**m**			
	B; Width of Filtered Water Chamber (m) =	**28.500**	**m**			
	h; Water Depth of Weir (m) =	**0.169**	**m**	→	**0.217**	**m : Assumption**
	C; Coefficient of Flow ($m^{1/2}$/sec) =	**1.839**	**$m^{1/2}$/sec**			
	W; Height from Bottom of Chamber (m) =	**3.000**	**m**			

$\therefore Q = C * b * h^{3/2} =$ **1.27315 m^3/sec**

$\therefore C = 1.785 + (0.00295 / h) + 0.237 * (h / W)$

$- 0.428 * \sqrt{(B - b) * h / B * W} + 0.034 * \sqrt{B/W} =$ **1.8389**





Therefore,

Water Level after Filtered Water Outlet Weir : 56.678 m - 0.217 m = 56.461 m

5) Connection Pipe ③ (Bio-Contact Filtration Basin to Mixing & Distribution Chamber)

a) Head Loss of Inlet (H_i)

＊Flow Velocity of Inlet (V_i) D_I 1.350 m

V_i= Q／A

where, Q; Planed Max. Treated Capacity (m^3/sec) ＝ 1.273 m^3/sec

D_I ; Diameter of Connecting Pipe ① (m) ＝ 1.350 m

A; Section Area of Connecting Pipe ① (m^2) ＝ 1.431 m^2

V_i= 1.273 m^3/sec ／ 1.431 m^2 = 0.889 m/sec

H_i= f_i＊(V_i^2／2*g)

where, f_i; Coefficient of Inlet ＝ 0.50

V_i; Flow Velocity through Inlet Pipe (m/sec) ＝ 0.889 m/sec

g; Accerated Gravity (m/sec^2) ＝ 9.81 m/sec^2

H_i= 0.50 * (0.889)^2／(2 * 9.81)= 0.020 m

b) Head Loss of Butterfly Valve (H_{bv1}) D_I 1.350 m

H_{bv1}= f_v * V_i^2 ／ 2 * g

where, f_v ; Coefficient of Butterfly Valve ＝ 0.25

V_i ; Flow Velocity through Inlet Pipe (m/sec) ＝ 0.889 m/sec

g ; Accerated Gravity (m/sec^2) ＝ 9.81 m/sec^{-2}

H_{bv1}= f_v * V_i^2 ／ 2 * g ＝ 0.010 m

c) Head Loss of Bend (H_{b1}) D_I 1.350 m× 90° 3 Set × R 0.900 m R/D＝ 0.7

H_{b1}= f_{b1} * f_{b2} * V_i^2 ／ 2 * g * n

where, f_{b1} ; Coefficient of 90°Bend ＝ 0.20

f_{b2} ; Coefficient of 90°Bend ＝ 1.00

V_i ; Flow Velocity through Pipe (m/sec) ＝ 0.889 m/sec

g ; Accerated Gravity (m/sec^2) ＝ 9.81 m/sec^2

n ; Number of 90°Bend ＝ 3 set

H_{b1}= f_{b1} * f_{b2} * V_i^2 ／ 2 * g * n ＝ 0.024 m

d) Head Loss of Butterfly Valve (H_{bv2}) at LWL D_I 1.350 m

H_{bv2}= f_v * V_i^2 ／ 2 * g

where, f_v ; Coefficient of Butterfly Valve ＝ 0.25

V_i ; Flow Velocity through Inlet Pipe (m/sec) ＝ 0.889 m/sec

g ; Accerated Gravity (m/sec^2) ＝ 9.81 m/sec^{-2}

H_{bv2}= f_v * V_i^2 ／ 2 * g ＝ 0.010 m

e) Friction Loss of Raw Water Transmission Pipe (H_{fr})

Hazen & William's Formula

H_{fr}= 10.666 ＊ $C^{-1.85}$ ＊ $D^{-4.87}$ ＊ $Q^{1.85}$ ＊L

where, C; Coefficient of Velocity ＝ 130

D; Pipe Diameter (m) ＝ 1.350 m

Q; Flow Capacity (m^3/sec) ＝ 1.273 m^3/sec

L; Length of Inlet Pipe (m) ＝ 60.00 m

H_{fr}= 10.666 * (130)$^{-1.85}$*(1.350)$^{-4.87}$*(1.273)$^{1.85}$* 60.00 ＝ 0.028 m

f) Head Loss of Outlet (H_o)

H_o= f_o * V_o^2 ／ 2 * g

Where, f_o ; Coefficient of Outlet ＝ 1.00

V_o ; Flow Velocity through Connection Pipe (m/sec) ＝ 0.889 m/sec

g ; Accerated Gravity (m/sec^2) ＝ 9.81 m/sec^{-2}

H_o= f_o * V_o^2 ／ 2 * g = 0.040 m

g) Total Head Loss of Connection Pipe ③ (ΣH)

ΣH= H_i＋ H_{bv1}＋ H_{b1}＋ H_{bv2}＋ H_{fr}＋ H_o ＝ 0.133 m

h) Water Level of Mixing Chamber's Inlet part

Therefore,

Inlet Part's Water Level of Mixing Chamber : 56.461 m - 0.133 m = 56.328 m

6) Mixing Chamber

a) Head Loss of Perforated Baffle Wall (H_p)

＊Inlet Flow Velocity of Perforated Baffle Holes (V_p)

V_p= Q／A

Where, Q; Planed Max. Treated Capacity (m^3/sec) ＝ 1.273 m^3/sec

A; Section Area of Perforated Baffle Wall (m^2) ＝ 1.327 m^2 Equivalent of : 7%

V_p= 1.273 m^3/sec ／ 1.327 m^2 = 0.959 m/sec

H_p= $1／C^2 \times (V_p{}^2／2 \times g)$

Where, C; Coefficient of Oriffice ＝ 0.60

V_p; Inlet Flow Velocity of Perforated Baffle Holes (m/sec) ＝ 0.959 m/sec

g; Accerated Gravity (m/sec^2) ＝ 9.81 m/sec^2

H_p= 1／(0.60 $)^2\times($ 0.959 $)^2$／(2 * 9.81)= 0.130 m

b) Water Level after Perforated Baffle Wall

Therefore,

Water Level after Perforated Baffle Wall : 56.328 m - 0.130 m = 56.197 m

c) Calculation of Broad Crested Rectangular Weir

＊Ishihara & Ida's Formula

$Q= C\times B\times h^{3/2}$

C= 1.785＋ ((0.00295／h ＋ 0.237 × (h／W))× (1＋ε)

whrer, Q; Over Flow Capacity (m^3/sec) ＝ 1.27315 m^3/sec

B; Width of Weir (m) ＝ 4.000 m

h; Water Depth of Weir (m) ＝ 0.308 m

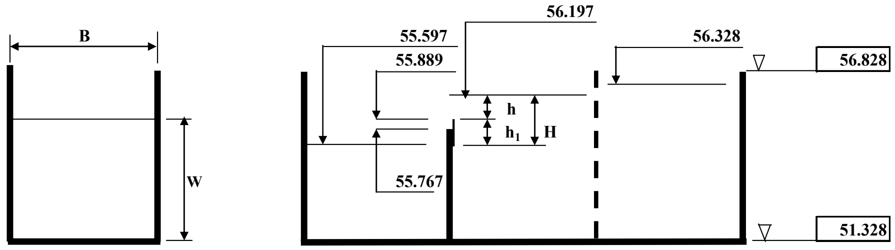
C; Coefficient of Flow ($m^{1/2}$/sec) ＝ 1.861 $m^{1/2}$/sec

W; Height from Bottom of Receiving Well (m) ＝ 4.56 m

ε; Correction Factor、when W＞1m, ε= 0.55*(W-1) ＝ 1.959

∴$Q= C\times B\times h^{3/2}$ = 1.27315 m^3/sec

∴C= 1.785＋ ((0.00295／h ＋ 0.237 × (h／W))× (1＋ε) = 1.861



d) Calculation of G-Value for Coagulation :Generally Allowable G＝300～500sec^{-1}

G= $(\rho * g * h／\mu * t)^{1/2}$:General Formula

ここで、 G; Velocity Gradient (sec^{-1}) ＝

ρ; Decsity of Water at 25℃ (kg/m^3) ＝ 997.1 kg/m^3

g; Accerated Gravity (m/sec^2) ＝ 9.81 m/sec^2

H; Head Loss (m) ＝ 0.600 m

μ; Dynamic Viscosity at 25℃ (kg/m･sec) ＝ 0.000898 kg/m･sec

t; Detention Time of Mixing Chamber (sec) ＝ 62.8 sec

∴G= $(\rho * g * h／\mu * t)^{1/2}$= 323 sec^{-1} OK or $G=（P／\mu*V）^{1/2}$:Other Formula

ここで、 G; Velocity Gradient (sec^{-1}) ＝

P; Mixing power (kgf･m/sec) ＝ $\rho*B*(2*g)^{1/2}*(2／3*h_1*h^{3/2}+2／5*h^{5/2})$

＝ 17,666 × (0.03328 ＋ 0.02108)＝ 960.466 kgf･m/sec

ρ; Decsity of Water at 25℃ (kg/m^3) ＝ 997.1 kg/m^3

B; Width of Weir (m) ＝ 4.000 m

g; Accerated Gravity (m/sec^2) ＝ 9.81 m/sec^2

h; Water Depth of Weir (m) ＝ 0.308 m

H; Head Loss (m) ＝ 0.600 m

h_1; ＝H－h ＝ 0.292 m

μ; Dynamic Viscosity at 25℃ (kg/m･sec) ＝ 0.00009157 kgf･sec/m^2

V; Volume of Mixing Chamber (m^3) ＝ 80.00 m^3

$\therefore G=（P／\mu*V）^{1/2}$ ＝ 362 sec^{-1} OK

e) Water Level of Mixing Chamber
Therefore,
Water Level of Mixing Chamber : 56.197 m - 0.600 m = 55.597 m

7) Distribution Chamber

☆ Calculation of Inter-Connection Pipe

a) Head Loss of Inlet (H_i)

＊Flow Velocity of Inlet (V_i) D_1 1.350 m

V_i= Q／A

where, Q; Planed Max. Treated Capacity (m^3/sec) ＝ 1.273 m^3/sec

D_1 ; Diameter of Connecting Pipe ① (m) ＝ 1.350 m

A; Section Area of Connecting Pipe ① (m^2) ＝ 1.431 m^2

V_i= 1.273 m^3/sec ／ 1.431 m^2 = 0.889 m/sec

$H_i= f_i*(V_i^2／2*g)$

where, f_i; Coefficient of Inlet ＝ 0.50

V_i; Flow Velocity through Inlet Pipe (m/sec) ＝ 0.889 m/sec

g; Accerated Gravity (m/sec^2) ＝ 9.81 m/sec^2

H_i= 0.50 * (0.889 $)^2$／(2 * 9.81)= 0.020 m

b) Friction Loss of Raw Water Transmission Pipe (H_{fr})

Hazen & William's Formula

$H_{fr}= 10.666 * C^{-1.85} * D^{-4.87} * Q^{1.85} * L$

where, C; Coefficient of Velocity ＝ 130

D; Pipe Diameter (m) ＝ 1.350 m

Q; Flow Capacity (m^3/sec) ＝ 1.273 m^3/sec

L; Length of Inlet Pipe (m) ＝ 2.80 m

H_{fr}= 10.666 * (130 $)^{-1.85}$*(1.350 $)^{-4.87}$*(1.273 $)^{1.85}$* 2.80 = 0.001 m

c) Head Loss of Outlet (H_o)

$H_o= f_o * V_o^2 ／ 2 * g$

Where, f_o ; Coefficient of Outlet ＝ 1.00

V_o ; Flow Velocity through Connection Pipe (m/sec) ＝ 0.889 m/sec

g ; Accerated Gravity (m/sec^2) ＝ 9.81 m/sec^{-2}

$H_o= f_o * V_o^2 ／ 2 * g$ = 0.040 m

d) Total Head Loss of Connection Pipe ③ (ΣH)

$\Sigma H= H_i + H_{fr} + H_o$ ＝ 0.062 m

e) Water Level of Distribution Chamber's Inlet part
Therefore,
Inlet Part's Water Level of Distribution Chamber : 55.597 m - 0.062 m ＝ 55.536 m

☆ Calculation of Distribution Chamber

a) Calculation of Broad Crested Rectangular Weir

＊Ishihara & Ida's Formula

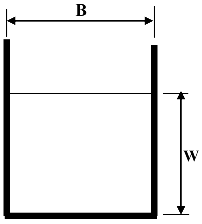
$Q= C\times B\times h^{3/2}$

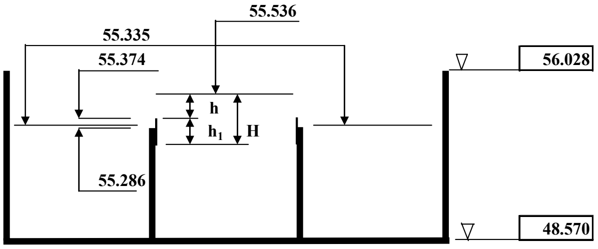
$C= 1.785+ ((0.00295／h + 0.237\times (h／W))\times (1+\varepsilon)$

whrer, Q; Over Flow Capacity (m^3/sec) = 0.31829 m^3/sec
B; Width of Weir (m) = 2.600 m
h; Water Depth of Weir (m) = 0.162 m
C; Coefficient of Flow ($m^{1/2}$/sec) = 1.885 $m^{1/2}$/sec
W; Height from Bottom of Receiving Well (m) = 6.80 m
ε; Correction Factor、when W＞1m, ε= 0.55*(W-1) = 3.192

$\therefore Q= C\times B\times h^{3/2}$ = 0.31848 m^3/sec

$\therefore C= 1.785+ ((0.00295／h + 0.237\times (h／W))\times (1+\varepsilon)$ = 1.885





b) Water Level after Distribution Weir

Therefore, assuming that Head Loss of Distribution Weir (H_w) is as follows : H_w = 0.201 m

Therefore,

Water Level after Distribution Weir : 55.536 m - 0.201 m = 55.335 m

☆ Calculation of Inter-Connecting Pipe to Clariflocculator

a) Head Loss of Inlet (H_i)

＊Flow Velocity of Inlet (V_i) D_1 0.700 m

V_i= Q／A

where, Q; Planed Max. Treated Capacity (m^3/sec) = 0.318 m^3/sec
D_1 ; Diameter of Connecting Pipe ① (m) = 0.700 m
A; Section Area of Connecting Pipe ① (m^2) = 0.385 m^2
V_i= 0.318 m^3/sec ／ 0.385 m^2 = 0.827 m/sec

$H_i= f_i * (V_i^2／2*g)$

where, f_i; Coefficient of Inlet = 0.50
V_i; Flow Velocity through Inlet Pipe (m/sec) = 0.827 m/sec
g; Accerated Gravity (m/sec^2) = 9.81 m/sec^2
H_i= 0.50 * (0.827)^2／(2 * 9.81)= 0.017 m

b) Friction Loss of Raw Water Transmission Pipe (H_{fr})

Hazen & William's Formula

$H_{fr}= 10.666 * C^{-1.85} * D^{-4.87} * Q^{1.85} * L$

where, C; Coefficient of Velocity = 130
D; Pipe Diameter (m) = 0.700 m
Q; Flow Capacity (m^3/sec) = 0.318 m^3/sec
L; Length of Inlet Pipe (m) = 24.00 m

H_{fr}= 10.666 * (130)$^{-1.85}$*(0.700)$^{-4.87}$*(0.318)$^{1.85}$* 24.00 = 0.021 m

c) Head Loss of Outlet (H_o)

$H_o = f_o * V_o^2 ／ 2 * g$

Where,	**f_o ; Coefficient of Outlet ＝**	**1.00**	
	V_o ; Flow Velocity through Connection Pipe (m/sec) ＝	**0.827**	**m/sec**
	g ; Accerated Gravity (m/sec^2) ＝	**9.81**	**m/sec^{-2}**
$H_o = f_o * V_o^2 ／ 2 * g =$		**0.035**	**m**

d) Total Head Loss of Connection Pipe ③ (Σ H)

$\Sigma H = H_i + H_{fr} + H_o =$ **0.074** **m**

e) Water Level of Clariflocculator's Flocculation Basin

Therefore,

Water Level of Clariflocculator's Flocculation Basin : **55.335** **m -** **0.074** **m ＝** **55.261** **m**

8) Clariflocculator Basin

☆ Calculation of Flocculation Basin

Water Level of Flocculation Basin

Water Level of Flocculation Basin : 55.261 m

☆ Calculation of Sedimentation Basin

a) Head Loss of Perforated Baffle Wall (H_p)

＊Inlet Flow Velocity of Perforated Baffle Holes (V_p)

V_p= Q／A

Where, Q; Planed Max. Treated Capacity (m^3/sec) = 0.318 m^3/sec

A; Section Area of Perforated Baffle Wall (m^2) = 9.189 m^2 Equivalent of : 6%

V_p= 0.318 m^3/sec ／ 9.189 m^2 = 0.035 m/sec

H_p= 1／C^2×(V_p^2／2×g)

Where, C; Coefficient of Oriffice = 0.60

V_p; Inlet Flow Velocity of Perforated Baffle Holes (m/sec) = 0.035 m/sec

g; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

H_p= 1／(0.60)^2×(0.035)^2／(2 * 9.81)= 0.000 m

b) Water Level of Sedimentation Basin

Therefore,

Water Level Sedimentation Basin : 55.261 m - 0.000 m = 55.261 m

c) Calculation of Broad Crested Rectangular Weir

＊Ishihara & Ida's Formula

Q= C×B×$h^{3/2}$

C= 1.785+ ((0.00295／h + 0.237 × (h／W))× (1+ε)

whrer, Q; Over Flow Capacity (m^3/sec) = 0.3183 m^3/sec

B; Width of Weir (m) = 98.646 m

h; Water Depth of Weir (m) = 0.023 m

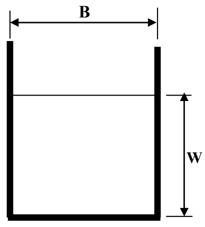
C; Coefficient of Flow ($m^{1/2}$/sec) = 1.920 $m^{1/2}$/sec

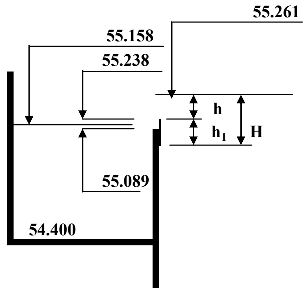
W; Height from Bottom of Receiving Well (m) = 0.70 m

ε; Correction Factor、when W≦1m, ε= 0 0

∴Q= C×B×$h^{3/2}$ = 0.6663 m^3/sec

∴C= 1.785+ ((0.00295／h + 0.237 × (h／W))× (1+ε) = 1.920





d) Water Level after Outlet Weir

Therefore, assuming that Head Loss of Outlet Weir (H_w) is as follows : H_w = 0.103 m

Therefore,

Water Level after Outlet Weir : 55.261 m - 0.103 m = 55.158 m

9) Connection Pipe ④ (Distribution Chamber to Rapid Sand Filtlation Basin)

a) Head Loss of Inlet (H_i)

＊Flow Velocity of Inlet (V_i) D_1 1.350 m

V_i= Q／A

where, Q; Planed Max. Treated Capacity (m^3/sec) = 1.273 m^3/sec

D_1 ; Diameter of Connecting Pipe ① (m) = 1.350 m

A; Section Area of Connecting Pipe ① (m^2) = 1.431 m^2

V_i= 1.273 m^3/sec ／ 1.431 m^2 = 0.889 m/sec

H_i= f_i＊(V_i^2／2＊g)

where, f_i; Coefficient of Inlet = 0.50

V_i; Flow Velocity through Inlet Pipe (m/sec) = 0.889 m/sec

g; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

H_i= 0.50 ＊(0.889)^2／(2 ＊ 9.81)= 0.020 m

b) Head Loss of Butterfly Valve (H_{bv1}) D_1 1.350 m

H_{bv1}= f_v ＊ V_i^2 ／ 2 ＊ g

where, f_v ; Coefficient of Butterfly Valve = 0.25

V_i ; Flow Velocity through Inlet Pipe (m/sec) = 0.889 m/sec

g ; Accerated Gravity (m/sec^2) = 9.81 m/sec^{-2}

H_{bv1}= f_v ＊ V_i^2 ／ 2 ＊ g = 0.010 m

c) Head Loss of Bend (H_{b1}) D_1 1.350 m× 90° 1 Set × R 0.900 m R/D= 0.7

H_{b1}= f_{b1} ＊ f_{b2} ＊ V_i^2 ／ 2 ＊ g ＊ n

where, f_{b1} ; Coefficient of 90°Bend = 0.20

f_{b2} ; Coefficient of 90°Bend = 1.00

V_i ; Flow Velocity through Pipe (m/sec) = 0.889 m/sec

g ; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

n ; Number of 90°Bend = 1 set

H_{b1}= f_{b1} ＊ f_{b2} ＊ V_i^2 ／ 2 ＊ g ＊ n = 0.008 m

d) Head Loss of Outlet Connection (H_{or}) D_2 1.350 m

H_{or}= f_{or} ＊ (V_i^2／2＊g)

where, f_{or} ; Coefficient of Diversion = 0.10

V_i; Flow Velocity before Diversion (m/sec) = 0.889 m/sec

g; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

Q ; Flow Capacity before Diversion (m^3/sec)= 1.273 m^3/sec

Q_a ; Diversion Flow Capacity (m^3/sec)= 0.637 m^3/sec

Q_a ／Q = 0.50

H_{or}= 0.10 ＊(0.889)^2／(2 ＊ 9.81)= 0.004 m

e) Head Loss of Converging Duct (H_{sc})

H_{sc}= f_{sc} ＊ V_2^2 ／ 2 ＊ g

Where, f_{sc} ; Coefficient of Converging Duct = 0.24

V_2 ; Flow Velocity after Converging (m/sec) = 0.889 m/sec

g ; Accerated Gravity (m/sec^2) = 9.81 m/sec^{-2}

A_1; Section Area before Converging (m^2) D 1.350 1.431 m^2

A_2; Section Area after Converging (m^2) D 0.900 0.636 m^2

A_2/ A_1; 0.44

H_{sc}= f_o ＊ V_o^2 ／ 2 ＊ g = 0.010 m

f) Head Loss of Bend (H_{b2}) D_1 0.900 m× 90° 1 Set × R 0.900 m R/D= 1.0

H_{b2}= f_{b1} ＊ f_{b2} ＊ V_i^2 ／ 2 ＊ g ＊ n

where, f_{b1} ; Coefficient of 90°Bend = 0.20

f_{b2} ; Coefficient of 90°Bend = 1.00

V_i ; Flow Velocity through Pipe (m/sec) = 1.001 m/sec

g ; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

n ; Number of 90°Bend = 1 set

H_{b2}= f_{b1} ＊ f_{b2} ＊ V_i^2 ／ 2 ＊ g ＊ n = 0.010 m

g) Head Loss of Butterfly Valve (H_{bv2}) at LWL D_1 **0.900** m

$H_{bv2} = f_v * V_i^2 ／ 2 * g$

where, f_v ; Coefficient of Butterfly Valve ＝ **0.25**

V_i ; Flow Velocity through Inlet Pipe (m/sec) ＝ **1.001** m/sec

g ; Accerated Gravity (m/sec^2) ＝ **9.81** m/sec^{-2}

$H_{bv2} = f_v * V_i^2 ／ 2 * g$ ＝ **0.013** m

h) Friction Loss of Raw Water Transmission Pipe (H_{fr})

Hazen & William's Formula

$H_{fr} = 10.666 \ * C^{-1.85} \ * D^{-4.87} \ * Q^{1.85} \ * L$

Where,

C; Coefficient of Velocity ＝	130	130	
D; Pipe Diameter (m) ＝	1.350	0.900	m
Q; Flow Capacity (m^3/sec) ＝	1.273	0.637	m^3/sec
L; Length of Connection Pipe ① (m) ＝	45.0	25.0	m

$H_{fr1} = 10.666 \ * \ (\ 130 \ )^{-1.85} * (\ 1.350 \ )^{-4.87} * (\ 1.273 \ )^{1.85} * \ 45.0 \ = \ 0.021$ m

$H_{fr2} = 10.666 \ * \ (\ 130 \ )^{-1.85} * (\ 0.900 \ )^{-4.87} * (\ 0.637 \ )^{1.85} * \ 25.0 \ = \ 0.024$ m

$H_{fr} = H_{fr1} + H_{fr2} =$ **0.045** m

i) Head Loss of Outlet (H_o)

$H_o = f_o * V_o^2 ／ 2 * g$

Where, f_o ; Coefficient of Outlet ＝ **1.00**

V_o ; Flow Velocity through Connection Pipe (m/sec) ＝ **1.001** m/sec

g ; Accerated Gravity (m/sec^2) ＝ **9.81** m/sec^{-2}

$H_o = f_o * V_o^2 ／ 2 * g =$ **0.051** m

j) Total Head Loss of Connection Pipe ④ (Σ H)

$\Sigma H = H_i + H_{bv1} + H_{b1} + H_{or} + H_{sc} + H_{b2} + H_{bv2} + H_{fr} + H_o =$ **0.171** m

k) Inlet Part's Water Level of Rapid Sand Filtration Basin

Therefore,

Inlet Part's Water Level of Rapid sand Filtration Basin : 55.158 m - 0.171 m = **54.987** m

10) Rapid Sand Filtration Basin

☆ Calculation of Inlet Devices

a) Head Loss of Inlet Valve (H_i)

＊Flow Velocity of Inlet (V_i) D_1 0.400 m

V_i= Q／A

where, Q; Planed Max. Treated Capacity (m^3/sec) = 0.064 m^3/sec

D_1 ; Diameter of Connecting Pipe ① (m) = 0.400 m

A; Section Area of Connecting Pipe ① (m^2) = 0.126 m^2

V_i= 0.064 m^3/sec ／ 0.126 m^2 = 0.507 m/sec

H_i= f_i * (V_i^2／2*g)

where, f_i; Coefficient of Inlet = 1.00

V_i; Flow Velocity through Inlet Pipe (m/sec) = 0.507 m/sec

g; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

H_i= 1.00 * (0.507 $)^2$／(2 * 9.81)= 0.013 m

b) Head Loss of Butterfly Valve (H_{bv}) D_1 0.400 m

H_{bv1}= f_v * V_i^2 ／ 2 * g

where, f_v ; Coefficient of Butterfly Valve = 0.25

V_i ; Flow Velocity through Inlet Pipe (m/sec) = 0.507 m/sec

g ; Accerated Gravity (m/sec^2) = 9.81 m/sec^{-2}

H_{bv1}= f_v * V_i^2 ／ 2 * g = 0.003 m

c) Head Loss of Outlet (H_o)

H_o= f_o * V_o^2 ／ 2 * g

Where, f_o ; Coefficient of Outlet = 1.00

V_o ; Flow Velocity through Inlet Pipe (m/sec) = 0.507 m/sec

g ; Accerated Gravity (m/sec^2) = 9.81 m/sec^{-2}

H_o= f_o * V_o^2 ／ 2 * g = 0.013 m

d) Total Head Loss of Inlet Valve (ΣH)

ΣH= H_i + H_{bv1} + H_o = 0.029 m

e) Water Level after Inlet Valve

Therefore,

Water Level after Inlet Valve : 54.987 m - 0.029 m = 54.957 m

f) Calculation of Water Depth in Broad Crested Rectangular Weir (Distribution Weir)

＊Ishihara & Ida's Formula

Q= C×B×$h^{3/2}$

C= 1.785+ ((0.00295／h + 0.237 × (h／W))× (1+ε)

whrer, Q; Over Flow Capacity (m^3/sec) = 0.06366 m^3/sec

B; Width of Weir (m) = 1.500 m

h; Water Depth of Weir (m) = 0.081 m

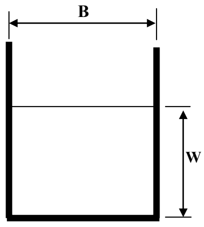
C; Coefficient of Flow ($m^{1/2}$/sec) = 1.843 $m^{1/2}$/sec

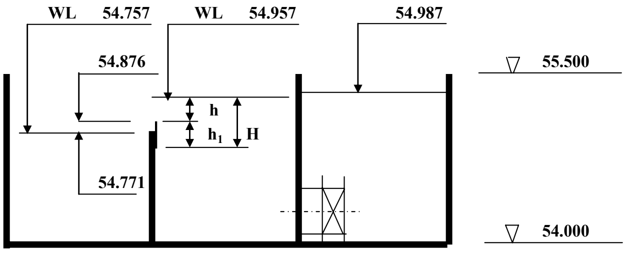
W; Height from Bottom of Receiving Well (m) = 0.88 m

ε; Correction Factor、when W≦1m, ε= 0 0

∴Q= C×B×$h^{3/2}$ = 0.06369 m^3/sec

∴C= 1.785+ ((0.00295／h + 0.237 × (h／W))× (1+ε) = 1.843





Therefore, assuming that Head Loss of Distribution Weir (H_w) is as follows : H_w = 0.200 m

g) Water Level after Distribution Weir

Therefore,

Water Level after Distribution Weir : 54.957 m - 0.200 m = **54.757** m

h) Head Loss of Inlet Pipe (H_{ip}) D_1 0.400 m

$H_{ip} = f_i * (V_i^2 / 2*g)$

where,	f_i; Coefficient of Inlet =	0.50	
	V_i; Flow Velocity through Inlet Pipe (m/sec) =	0.507	m/sec
	g; Accerated Gravity (m/sec^2) =	9.81	m/sec^2

H_{ip}= 0.50 * (0.507)^2 / (2 * 9.81) = 0.007 m

i) Friction Loss of Inlet Pipe (H_{fr})

Hazen & William's Formula

$H_{fr} = 10.666 * C^{-1.85} * D^{-4.87} * Q^{1.85} * L$

where,	C; Coefficient of Velocity =	130	
	D; Pipe Diameter (m) =	0.400	m
	Q; Flow Capacity (m^3/sec) =	0.064	m^3/sec
	L; Length of Inlet Pipe (m) =	1.30	m

H_{fr}= 10.666 * (130)$^{-1.85}$*(0.400)$^{-4.87}$*(0.064)$^{1.85}$* 1.30 = 0.001 m

j) Head Loss of Outlet (H_{op})

$H_{op} = f_o * V_o^2 / 2 * g$

Where,	f_o ; Coefficient of Outlet =	1.00	
	V_o ; Flow Velocity through Inlet Pipe (m/sec) =	0.507	m/sec
	g ; Accerated Gravity (m/sec^2) =	9.81	m/sec^{-2}

$H_{op} = f_o * V_o^2 / 2 * g$ = 0.013 m

k) Total Head Loss of Inlet Pipe (Σ H)

$\Sigma H = H_{ip} + H_{fr} + H_o$ = 0.021 m

l) Water Level in Filtration Basin

Therefore,

Water Level in Filtration basin : 54.757 m - 0.021 m = **54.737** m

☆ Calculation of Rapid Sand Filtration Basin

a) Total Head Loss of Rapid Sand Filtration Basin

H_f= 2.00 m

Therefore,

Water Level before Filtered Water Outlet Weir :

54.737 m - 2.000 m = **52.737** m

b) Calculation of Water Depth in Outlet Weir

＊Itaya & Tejima's Formula

$Q= C*b*h^{3/2} =$

$C= 1.785 + (0.00295 / h) + 0.237 * (h / W) - 0.428 * \sqrt{(B - b) * h / B * W} + 0.034 * \sqrt{B/W}$

Where,

Q; Over Flow Capacity (m^3/sec) = 0.63657 m^3/sec

b; Width of Weir (m) = 10.000 m

B; Width of Filtered Water Chamber (m) = 23.300 m

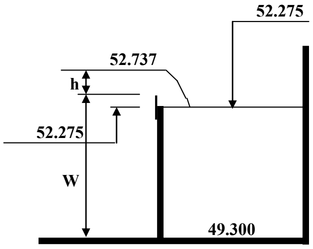
h; Water Depth of Weir (m) = 0.106 m → 0.462 m : Assumption

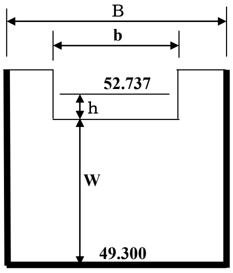
C; Coefficient of Flow ($m^{1/2}$/sec) = 1.855 $m^{1/2}$/sec

W; Height from Bottom of Chamber (m) = 3.000 m

$\therefore Q= C*b*h^{3/2} =$ 0.63657 m^3/sec

$\therefore C= 1.785 + (0.00295 / h) + 0.237 * (h / W) - 0.428 * \sqrt{(B - b) * h / B * W} + 0.034 * \sqrt{B/W} =$ 1.8554





c) Calculation of G-Value for Coagulation :Generally Allowable $G=300\sim500sec^{-1}$

$G= (\rho*g*h/\mu*t)^{1/2}$:General Formula

ここで、

G; Velocity Gradient (sec^{-1}) =

ρ; Decsity of Water at 25℃ (kg/m^3) = 997.1 kg/m^3

g; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

H; Head Loss (m) = 0.462 m

μ; Dynamic Viscosity at 25℃ (kg/m･sec) = 0.000898 kg/m･sec

t; Detention Time of Mixing Chamber (sec) = 217.3 sec

$\therefore G= (\rho*g*h/\mu*t)^{1/2} =$ 152 sec^{-1} OK

or $G= (P/\mu*V)^{1/2}$:Other Formula

ここで、

G; Velocity Gradient (sec^{-1}) =

P; Mixing power (kgf･m/sec) = $\rho*B*(2*g)^{1/2}*(2/3*h_1*h^{3/2}+2/5*h^{5/2})$

= 44,166 × (0.00815 + 0.00145) = 424.055 kgf･m/sec

ρ; Decsity of Water at 25℃ (kg/m^3) = 997.1 kg/m^3

b; Width of Weir (m) = 10.000 m

g; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

h; Water Depth of Weir (m) = 0.106 m

H; Head Loss (m) = 0.462 m

h_1; = H－h = 0.356 m

μ; Dynamic Viscosity at 25℃ (kg/m･sec) = 0.00009157 kgf･sec/m^2

V; Volume of Mixing Chamber (m^3) = 138.3 m^3

$\therefore G= (P/\mu*V)^{1/2} =$ 183 sec^{-1} OK

Therefore,

Water Level after Filtered Water Outlet Weir : 52.737 m - 0.462 m = 52.275 m

11) Connection Pipe ⑤ (Rapid Sand Filtration Basin to Clear Water Reservoir)

a) Head Loss of Inlet (H_i)

＊Flow Velocity of Inlet (V_i) D_1 0.900 m

V_i= Q／A

where, Q; Planed Max. Treated Capacity (m^3/sec) = 0.637 m^3/sec

D_1 ; Diameter of Connecting Pipe ① (m) = 0.900 m

A; Section Area of Connecting Pipe ① (m^2) = 0.636 m^2

V_i= 0.637 m^3/sec ／ 0.636 m^2 = 1.001 m/sec

H_i= f_i * (V_i^2／2*g)

where, f_i; Coefficient of Inlet = 0.50

V_i; Flow Velocity through Inlet Pipe (m/sec) = 1.001 m/sec

g; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

H_i= 0.50 * (1.001)^2／(2 * 9.81)= 0.026 m

b) Head Loss of Butterfly Valve (H_{bv1}) D_1 0.900 m

H_{bv1}= f_v * V_i^2 ／ 2 * g

where, f_v ; Coefficient of Butterfly Valve = 0.25

V_i ; Flow Velocity through Inlet Pipe (m/sec) = 1.001 m/sec

g ; Accerated Gravity (m/sec^2) = 9.81 m/sec^{-2}

H_{bv1}= f_v * V_i^2 ／ 2 * g = 0.013 m

c) Head Loss of Bend (H_{b1}) D_1 0.900 m× 90° 1 Set × R 0.900 m R/D= 1.0

H_{b1}= f_{b1} * f_{b2} * V_i^2 ／ 2 * g * n

where, f_{b1} ; Coefficient of 90°Bend = 0.20

f_{b2} ; Coefficient of 90°Bend = 1.00

V_i ; Flow Velocity through Pipe (m/sec) = 1.001 m/sec

g ; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

n ; Number of 90°Bend = 1 set

H_{b1}= f_{b1} * f_{b2} * V_i^2 ／ 2 * g * n = 0.010 m

d) Head Loss of Diverging Duct (H_{se1})

H_{se1}= f_{se1} * V_1^2 ／ 2 * g

Where, f_{se1} ; Coefficient of Diverging Duct = (1 － (A_1/ A_2))^2 = 0.31

V_1 ; Flow Velocity before Diverging (m/sec) = 1.001 m/sec

g ; Accerated Gravity (m/sec^2) = 9.81 m/sec^{-2}

A_1 ; Section Area before Diverging (m^2) D 0.900 0.636 m^2

A_2 ; Section Area after Diverging (m^2) D 1.350 1.431 m^2

A_1/ A_2 ; 0.44

H_{se1}= f_o * V_o^2 ／ 2 * g = 0.016 m

e) Head Loss of Inlet Connection (H_{ir}) D_2 1.350 m

H_{ir}= f_{ir} * (V_i^2／2*g)

where, f_{ir} ; Coefficient of Combined = 0.53

V_i; Flow Velocity after Combined (m/sec) = 0.889 m/sec

g; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

Q ; Flow Capacity after Combined (m^3/sec)= 1.273 m^3/sec

Q_a ; Combined Flow Capacity (m^3/sec)= 0.637 m^3/sec

Q_a ／Q = 0.50

H_{ir}= 0.53 * (0.889)^2／(2 * 9.81)= 0.021 m

f) Head Loss of Diverging Duct (H_{se2})

H_{se2}= f_{se2} * V_1^2 ／ 2 * g

Where, f_{se2} ; Coefficient of Diverging Duct = (1 － (A_1/ A_2))^2 = 0.19

V_1 ; Flow Velocity before Diverging (m/sec) = 0.889 m/sec

g ; Accerated Gravity (m/sec^2) = 9.81 m/sec^{-2}

A_1 ; Section Area before Diverging (m^2) D 1.350 1.431 m^2

A_2 ; Section Area after Diverging (m^2) D 1.800 2.545 m^2

A_1/ A_2 ; 0.56

H_{se2}= f_o * V_o^2 ／ 2 * g = 0.008 m

g) Head Loss of Symmetrical Converging Flow (H_{sc}) D 1.800 m

H_{sc}= f_{sc} * (V_i^2／2*g)

where, f_{sc} ; Coefficient of Convergion = $2 + 3\{(K_1)^2 - K_2\}$ 1.25

V_i; Flow Velocity of Total Flow Rate (m/sec) = 1.001 m/sec

g; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

Q ; Total Flow Capacity (m^3/sec)= 2.546 m^3/sec

Q_{a1} ; Convergion Flow Capacity (m^3/sec)= 1.273 m^3/sec

Q_{a2} ; Convergion Flow Capacity (m^3/sec)= 1.273 m^3/sec

$K_1 = Q_{a1}$ ／ Q = 0.50

$K_2 = Q_{a2}$ ／ Q = 0.50

H_{sc}= 1.25 * (1.001)^2／(2 * 9.81)= 0.064 m

h) Head Loss of Outlet Connection (H_{or}) D_2 1.800 m

H_{or}= f_{or} * (V_i^2／2*g)

where, f_{or} ; Coefficient of Diversion = 0.10

V_i; Flow Velocity before Diversion (m/sec) = 1.001 m/sec

g; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

Q ; Flow Capacity before Diversion (m^3/sec)= 2.546 m^3/sec

Q_a ; Diversion Flow Capacity (m^3/sec)= 1.273 m^3/sec

Q_a ／Q = 0.50

H_{or}= 0.10 * (1.001)^2／(2 * 9.81)= 0.005 m

i) Head Loss of Bend (H_{b2}) D_1 1.350 m× 90° 1 Set × R 0.900 m R/D= 0.7

H_{b2}= f_{b1} * f_{b2} * V_i^2 ／ 2 * g * n

where, f_{b1} ; Coefficient of 90°Bend = 0.20

f_{b2} ; Coefficient of 90°Bend = 1.00

V_i ; Flow Velocity through Pipe (m/sec) = 0.889 m/sec

g ; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

n ; Number of 90°Bend = 1 set

H_{b2}= f_{b1} * f_{b2} * V_i^2 ／ 2 * g * n = 0.008 m

j) Head Loss of Butterfly Valve (H_{bv2}) at LWL D_1 1.350 m

H_{bv2}= f_v * V_i^2 ／ 2 * g

where, f_v ; Coefficient of Butterfly Valve = 0.25

V_i ; Flow Velocity through Inlet Pipe (m/sec) = 0.889 m/sec

g ; Accerated Gravity (m/sec^2) = 9.81 m/sec^{-2}

H_{bv2}= f_v * V_i^2 ／ 2 * g = 0.010 m

k) Friction Loss of Raw Water Transmission Pipe (H_{fr})

Hazen & William's Formula

H_{fr}= 10.666 ＊ $C^{-1.85}$ ＊ $D^{-4.87}$ ＊ $Q^{1.85}$ ＊L

Where,				
C; Coefficient of Velocity =	130	130	130	
D; Pipe Diameter (m) =	0.900	1.350	1.800	m
Q; Flow Capacity (m^3/sec) =	0.637	1.273	2.546	m^3/sec
L; Length of Connection Pipe ① (m) =	35.0	35.0	50.0	m

H_{fr1}= 10.666 * (130)$^{-1.85}$*(0.900)$^{-4.87}$*(0.637)$^{1.85}$* 35.0 = 0.033 m

H_{fr2}= 10.666 * (130)$^{-1.85}$*(1.350)$^{-4.87}$*(1.273)$^{1.85}$* 35.0 = 0.017 m

H_{fr2}= 10.666 * (130)$^{-1.85}$*(1.800)$^{-4.87}$*(2.546)$^{1.85}$* 50.0 = 0.021 m

H_{fr}= H_{fr1} + H_{fr2} + H_{fr3} = 0.071 m

l) Head Loss of Outlet (H_o)

H_o= f_o * V_o^2 ／ 2 * g

Where, f_o ; Coefficient of Outlet = 1.00

V_o ; Flow Velocity through Connection Pipe (m/sec) = 0.889 m/sec

g ; Accerated Gravity (m/sec^2) = 9.81 m/sec^{-2}

H_o= f_o * V_o^2 ／ 2 * g = 0.040 m

m) Total Head Loss of Connection Pipe ③ (ΣH)

$$\Sigma H = H_{i} + H_{bv1} + H_{b1} + H_{se1} + H_{ir} + H_{se2} + H_{sc} + H_{or} + H_{b2} + H_{bv2} + H_{fr} + H_{o} = \boxed{0.292}\ \text{m}$$

↓

0.317 m : Assumption

n) Water Level of Clear Water Reservoir

Therefore,

High Water Level of Clear Water Reservoir : 52.275 m − 0.317 m = 51.958 m

Low Water Level of Clear Water Reservoir : 51.958 m − 4.000 m = 47.958 m

Appendix F34

Results of Hydraulic Analysis for Salaulim Sheme

Contents for Appendix F34

F34.1 Results of Hydraulic Analysis for Salaulim Scheme

Figure F34.1.1 Hydraulic Analysis Model for Salaulim Scheme

Table F34.1.1 Junction Details at 06:00 and 12:00 for Salaulim Scheme (1/3)

Junction	Elevation (m)	Base Flow (m^3/day)	Pattern	Demand (m^3/day)	Calculated Hydraulic Grade (m)	Pressure (m H2O)	Junction	Elevation (m)	Base Flow (m^3/day)	Pattern	Demand (m^3/day)	Calculated Hydraulic Grade (m)	Pressure (m H2O)
J-104	10	0	Fixed	0	77.69	67.553	J-104	10	0	Fixed	0	76.67	66.532
J-117	40	0	Fixed	0	105.01	64.876	J-117	40	0	Fixed	0	104.73	64.597
J-123	50	0	Fixed	0	117.19	67.055	J-123	50	0	Fixed	0	54.57	4.565
J-124	98	0	Fixed	0	103.01	4.998	J-124	98	0	Fixed	0	100.28	2.275
J-128	45	0	Fixed	0	45.72	0.719	J-128	45	0	Fixed	0	45.72	0.719
J-130	105	0	Fixed	0	107.91	2.9	J-130	105	0	Fixed	0	105.86	0.86
J-131	7	0	Fixed	0	110.86	103.651	J-131	7	0	Fixed	0	63.68	56.566
J-142	83	0	Fixed	0	86.23	3.223	J-142	83	0	Fixed	0	85.41	2.401
J-143	40	0	Fixed	0	42.33	2.323	J-143	40	0	Fixed	0	43.32	3.316
J-144	30	0	Fixed	0	86.23	56.117	J-144	30	0	Fixed	0	85.45	55.339
J-145	30	0	Fixed	0	32.31	2.305	J-145	30	0	Fixed	0	31.83	1.822
J-147	25	0	Fixed	0	28.5	3.493	J-147	25	0	Fixed	0	28.32	3.31
J-148	61	0	Fixed	0	110.86	49.76	J-148	61	0	Fixed	0	63.68	2.675
J-149	0	0	Fixed	0	78.86	78.703	J-149	0	0	Fixed	0	76.67	76.512
J-150	0	0	Fixed	0	63.15	63.021	J-150	0	0	Fixed	0	62.09	61.969
J-151	58	0	Fixed	0	61.08	3.078	J-151	58	0	Fixed	0	59.28	1.274
J-152	70	0	Fixed	0	73.45	3.442	J-152	70	0	Fixed	0	73.27	3.264
J-153	75	0	Fixed	0	78.04	3.039	J-153	75	0	Fixed	0	76.93	1.923
J-154	56	0	Fixed	0	103.01	46.914	J-154	56	0	Fixed	0	103.29	47.197
J-155	60	0	Fixed	0	60.86	0.862	J-155	60	0	Fixed	0	62.39	2.381
J-156	46	0	Fixed	0	48.46	2.451	J-156	46	0	Fixed	0	47.18	1.176
J-157	42	0	Fixed	0	44.86	2.859	J-157	42	0	Fixed	0	43.66	1.66
J-158	50	0	Fixed	0	52.98	2.97	J-158	50	0	Fixed	0	52.35	2.346
J-159	50	0	Fixed	0	87.69	37.61	J-159	50	0	Fixed	0	130.2	80.041
J-160	32	0	Fixed	0	34.78	2.771	J-160	32	0	Fixed	0	31.35	-0.647
J-161	16	0	Fixed	0	18.34	2.333	J-161	16	0	Fixed	0	17.29	1.286
J-162	41	0	Fixed	0	42.48	1.481	J-162	41	0	Fixed	0	43.84	2.832
J-163	53	0	Fixed	0	54.78	1.781	J-163	53	0	Fixed	0	55.7	2.698
J-164	40	0	Fixed	0	41.68	1.676	J-164	40	0	Fixed	0	40.8	0.798
J-165	58	0	Fixed	0	60.41	2.405	J-165	58	0	Fixed	0	60.97	2.959
J-166	14	0	Fixed	0	16.58	2.575	J-166	14	0	Fixed	0	17.04	3.029
J-167	40	0	Fixed	0	43.46	3.448	J-167	40	0	Fixed	0	43.46	3.451
J-168	55	0	Fixed	0	57.36	2.353	J-168	55	0	Fixed	0	57.34	2.34
J-169	63	0	Fixed	0	65.5	2.495	J-169	63	0	Fixed	0	65.88	2.877
J-170	53	0	Fixed	0	55.9	2.891	J-170	53	0	Fixed	0	55.89	2.885
J-171	55	0	Fixed	0	57.24	2.234	J-171	55	0	Fixed	0	56.59	1.591
J-172	44	0	Fixed	0	46.75	2.741	J-172	44	0	Fixed	0	45.33	1.324
J-173	26	0	Fixed	0	28.2	2.2	J-173	26	0	Fixed	0	28.19	2.184
J-174	55	0	Fixed	0	57.22	2.219	J-174	55	0	Fixed	0	57.94	2.93
J-175	0	0	Fixed	0	42.89	42.806	J-175	0	0	Fixed	0	42.97	42.879
J-176	16	0	Fixed	0	18.62	2.612	J-176	16	0	Fixed	0	18.98	2.977
J-177	62	0	Fixed	0	65.34	3.333	J-177	62	0	Fixed	0	64.11	2.109
J-178	15	0	Fixed	0	18.07	3.06	J-178	15	0	Fixed	0	16.19	1.184
J-179	36	0	Fixed	0	39.07	3.067	J-179	36	0	Fixed	0	37.24	1.24
J-180	36	0	Fixed	0	39.4	3.394	J-180	36	0	Fixed	0	38.71	2.704
J-181	55	0	Fixed	0	58.11	3.107	J-181	55	0	Fixed	0	56.8	1.798
J-182	46	0	Fixed	0	45.18	-0.822	J-182	46	0	Fixed	0	34.4	-11.574
J-183	40	0	Fixed	0	43.5	3.49	J-183	40	0	Fixed	0	43.53	3.523
J-184	95	0	Fixed	0	102.04	7.028	J-184	95	0	Fixed	0	98.46	3.456
J-185	54	0	Fixed	0	57.31	3.3	J-185	54	0	Fixed	0	56.47	2.466
J-186	27	0	Fixed	0	28.56	1.556	J-186	27	0	Fixed	0	33.6	6.582
J-187	50	0	Fixed	0	50.9	0.894	J-187	50	0	Fixed	0	52.48	2.47
J-188	50	0	Fixed	0	52.74	2.739	J-188	50	0	Fixed	0	56.58	6.563
J-189	22	0	Fixed	0	23.61	1.609	J-189	22	0	Fixed	0	23.39	1.389
J-190	52	0	Fixed	0	54.6	2.595	J-190	52	0	Fixed	0	54.59	2.583
J-191	52	0	Fixed	0	54.94	2.929	J-191	52	0	Fixed	0	53.43	1.428
J-192	45	0	Fixed	0	47.39	2.38	J-192	45	0	Fixed	0	47.41	2.407
J-193	31	0	Fixed	0	33.99	2.987	J-193	31	0	Fixed	0	34.24	3.232
J-194	34	0	Fixed	0	35.57	1.566	J-194	34	0	Fixed	0	35.27	1.268
J-195	0	0	Fixed	0	50.34	50.239	J-195	0	0	Fixed	0	50.58	50.477
J-196	40	0	Fixed	0	42.28	2.28	J-196	40	0	Fixed	0	43.52	3.516
J-197	40	0	Fixed	0	42.64	2.634	J-197	40	0	Fixed	0	43.85	3.837
J-198	45	0	Fixed	0	46.98	1.974	J-198	45	0	Fixed	0	45.92	0.916
J-199	0	0	Fixed	0	47.13	47.034	J-199	0	0	Fixed	0	47.6	47.503
J-200	35	0	Fixed	0	37.32	2.315	J-200	35	0	Fixed	0	36.14	1.137
J-201	0	0	Fixed	0	48.15	48.051	J-201	0	0	Fixed	0	49.14	49.043
J-202	55	0	Fixed	0	58.14	3.136	J-202	55	0	Fixed	0	57.49	2.483
J-203	85	0	Fixed	0	118.84	33.774	J-203	85	0	Fixed	0	117.7	32.636
J-204	45	0	Fixed	0	121.89	76.731	J-204	45	0	Fixed	0	120.94	75.786

Table F34.1.1 Junction Details at 06:00 and 12:00 for Salaulim Scheme (2/3)

Junction	Elevation (m)	Base Flow (m^3/day)	Pattern	Demand (m^3/day)	Calculated Hydraulic Grade (m)	Pressure (m H2O)	Junction	Elevation (m)	Base Flow (m^3/day)	Pattern	Demand (m^3/day)	Calculated Hydraulic Grade (m)	Pressure (m H2O)
J-205	45	0	Fixed	0	46.12	1.116	J-205	45	0	Fixed	0	46.74	1.737
J-206	85	0	Fixed	0	118.57	33.507	J-206	85	0	Fixed	0	117.41	32.348
J-207	96.2	0	Fixed	0	106.55	10.324	J-207	96.2	0	Fixed	0	104.64	8.426
J-214	25	0	Fixed	0	107.91	82.739	J-214	25	0	Fixed	0	117.23	92.04
J-215	25	0	Fixed	0	110.86	85.687	J-215	25	0	Fixed	0	63.68	38.602
J-216	0	0	Fixed	0	61.89	61.764	J-216	0	0	Fixed	0	62.53	62.399
J-223	5	0	Fixed	0	97.66	92.471	J-223	5	0	Fixed	0	90.06	84.89
J-225	21.4	0	Fixed	0	117.71	96.115	J-225	21.4	0	Fixed	0	116.47	94.876
J-226	10	0	Fixed	0	112.41	102.2	J-226	10	0	Fixed	0	93.3	83.134
J-227	5	0	Fixed	0	111.76	106.548	J-227	5	0	Fixed	0	88.21	83.045
J-228	10	0	Fixed	0	110.86	100.657	J-228	10	0	Fixed	0	66.88	56.765
T-00	110	117	Pattern - 1	185	114.48	4.476	T-00	110	117	Pattern - 1	139	111.59	1.592
T-01	34	194	Pattern - 1	307	108.23	74.085	T-01	34	194	Pattern - 1	231	106.12	71.978
T-02	21.4	0	Fixed	0	104.36	82.791	T-02	21.4	0	Fixed	0	102.73	81.163
T-03	39	0	Fixed	0	103.45	64.319	T-03	39	0	Fixed	0	101.94	62.813
T-04	43.2	45	Pattern - 1	71	102	58.682	T-04	43.2	45	Pattern - 1	54	100.69	57.372
T-05	17.5	1095	Pattern - 1	1,736	99.85	82.182	T-05	17.5	1095	Pattern - 1	1,303	98.83	81.163
T-06	19.3	0	Fixed	0	98.89	79.434	T-06	19.3	0	Fixed	0	98	78.541
T-08	13.3	386	Pattern - 1	612	96.19	82.726	T-08	13.3	386	Pattern - 1	459	95.32	81.852
T-09	15.1	210	Pattern - 1	333	93.53	78.275	T-09	15.1	210	Pattern - 1	250	92.67	77.416
T-12	57.1	0	Fixed	0	92.81	35.634	T-12	57.1	0	Fixed	0	91.96	34.786
T-13	16.5	10981	Pattern - 1	17,405	89.7	73.049	T-13	16.5	10981	Pattern - 1	13,067	88.9	72.25
T-14	33.5	0	Fixed	0	89.09	55.473	T-14	33.5	0	Fixed	0	88.25	54.644
T-16	33.5	366	Pattern - 1	580	89.08	55.467	T-16	33.5	366	Pattern - 1	436	88.25	54.637
T-17	38.3	636	Composite	986	88.11	49.707	T-17	38.3	636	Composite	750	87.22	48.826
T-18	48.2	0	Fixed	0	87.72	39.445	T-18	48.2	0	Fixed	0	86.82	38.542
T-19	35	0	Fixed	0	85.66	50.562	T-19	35	0	Fixed	0	84.74	49.638
T-20	46	0	Fixed	0	80.5	34.426	T-20	46	0	Fixed	0	79.51	33.439
T-21	10	0	Fixed	0	77.69	67.555	T-21	10	0	Fixed	0	76.67	66.533
T-22	30	255	Pattern - 1	404	74.89	44.799	T-22	30	255	Pattern - 1	303	73.83	43.741
T-23	45	0	Fixed	0	74.49	29.431	T-23	45	0	Fixed	0	73.43	28.368
T-24	37	0	Fixed	0	63.48	26.427	T-24	37	0	Fixed	0	62.27	25.216
T-25	12	2832	Composite	3,197	53.65	41.563	T-25	12	2832	Composite	2,951	53.04	40.955
T-27	8	3541	Composite	3,998	49.77	41.682	T-27	8	3541	Composite	3,689	49.39	41.308
T-28	12	0	Fixed	0	45.18	33.109	T-28	12	0	Fixed	0	45.07	33.004
T-29	18	688	Pattern - 1	1,090	44.24	26.187	T-29	18	688	Pattern - 1	819	44.21	26.159
T-31	69	0	Fixed	0	102.04	32.975	T-31	69	0	Fixed	0	100.08	31.02
T-32	66	2220	Composite	2,539	96.69	30.628	T-32	66	2220	Composite	2,324	94.51	28.448
T-33	64	2220	Composite	2,539	95.05	30.986	T-33	64	2220	Composite	2,324	92.79	28.728
T-34	64	2220	Composite	2,539	93.49	29.435	T-34	64	2220	Composite	2,324	91.15	27.093
T-35	75	2220	Composite	2,539	90.74	15.712	T-35	75	2220	Composite	2,324	88.23	13.203
T-37	72	0	Fixed	0	86.79	14.76	T-37	72	0	Fixed	0	84.01	11.983
T-38	38	0	Fixed	0	86.58	48.483	T-38	38	0	Fixed	0	83.78	45.691
T-39	51	0	Fixed	0	85.14	34.07	T-39	51	0	Fixed	0	82.39	31.326
T-40	41	0	Fixed	0	82.4	41.316	T-40	41	0	Fixed	0	79.89	38.816
T-44	40	0	Fixed	0	77.63	37.553	T-44	40	0	Fixed	0	75.55	35.482
T-45	40	5,286	Composite	6,092	77.38	37.309	T-45	40	5,286	Composite	5,548	75.33	35.261
T-46	38	5,286	Composite	6,092	76.9	38.817	T-46	38	5,286	Composite	5,548	74.88	36.809
T-47	31	0	Fixed	0	76.52	45.424	T-47	31	0	Fixed	0	74.53	43.444
T-48	34	0	Fixed	0	72.69	38.61	T-48	34	0	Fixed	0	70.98	36.906
T-49	7	0	Fixed	0	65.58	58.461	T-49	7	0	Fixed	0	64.39	57.271
T00-11	14	0	Fixed	0	86.2	72.05	T00-11	14	0	Fixed	0	69.42	55.312
T00-14	38	0	Fixed	0	86.14	48.042	T00-14	38	0	Fixed	0	43.49	5.476
T00-17	5	1383	Composite	2,112	109.96	104.746	T00-17	5	1383	Composite	1,620	66.33	61.203
T00-20	6	0	Fixed	0	110.86	104.649	T00-20	6	0	Fixed	0	65.28	59.16
T00-51	15	215	Pattern - 1	341	85.81	70.668	T00-51	15	215	Pattern - 1	256	43.29	28.237
T00-52	30	72	Pattern - 1	114	85.74	55.626	T00-52	30	72	Pattern - 1	86	43.25	13.224
T00-53	83	0	Fixed	0	86.23	3.224	T00-53	83	0	Fixed	0	83.63	0.628
T01-02	35	0	Fixed	0	108.22	73.073	T01-02	35	0	Fixed	0	106.12	70.972
T01-05	26	138	Pattern - 1	219	107.94	81.773	T01-05	26	138	Pattern - 1	164	105.95	79.788
T02-04	36	0	Fixed	0	96.9	60.775	T02-04	36	0	Fixed	0	82.64	46.546
T02-07	42	951	Pattern - 1	1,507	89.44	47.341	T02-07	42	951	Pattern - 1	1,132	62.55	20.511
T03-03	21.4	0	Fixed	0	117.57	95.972	T03-03	21.4	0	Fixed	0	116.03	94.443
T03-05	16	1504	Pattern - 1	2,384	113.85	97.656	T03-05	16	1504	Pattern - 1	1,790	104.75	88.574
T03-11	32	472	Pattern - 1	748	112.48	80.316	T03-11	32	472	Pattern - 1	562	103.94	71.799
T03-12	20	365	Pattern - 1	579	113.05	92.862	T03-12	20	365	Pattern - 1	434	104.28	84.111
T03-13	16	365	Pattern - 1	579	110.08	93.889	T03-13	16	365	Pattern - 1	434	102.53	86.359
T03-14	31	476	Pattern - 1	754	105.87	74.724	T03-14	31	476	Pattern - 1	566	100.06	68.921

Table F34.1.1 Junction Details at 06:00 and 12:00 for Salaulim Scheme (3/3)

Junction	Elevation (m)	Base Flow (m^3/day)	Pattern	Demand (m^3/day)	Calculated Hydraulic Grade (m)	Pressure (m H2O)	Junction	Elevation (m)	Base Flow (m^3/day)	Pattern	Demand (m^3/day)	Calculated Hydraulic Grade (m)	Pressure (m H2O)
T03-15	27	1483	Composite	2,271	88.03	60.909	T03-15	27	1483	Composite	1,739	73.74	46.644
T06-04	37	692	Pattern - 1	1,097	92.82	55.706	T06-04	37	692	Pattern - 1	823	94.43	57.31
T06-05	56	209	Pattern - 1	331	92.74	36.669	T06-05	56	209	Pattern - 1	249	94.38	38.305
T07-10	24	0	Fixed	0	65.85	41.769	T07-10	24	0	Fixed	0	93.98	69.836
T07-11	21	0	Fixed	0	53.08	32.018	T07-11	21	0	Fixed	0	92.42	71.279
T07-18	10	0	Fixed	0	52.78	42.696	T07-18	10	0	Fixed	0	83.72	73.568
T07-23	12	759	Pattern - 1	1,203	52.17	40.088	T07-23	12	759	Pattern - 1	903	65.93	53.821
T07-35	15	0	Fixed	0	18.5	3.493	T07-35	15	0	Fixed	0	15.71	0.704
T07-36	17	0	Fixed	0	117.8	100.6	T07-36	17	0	Fixed	0	114.08	96.882
T07-40	17	768	Pattern - 1	1,217	117.19	99.988	T07-40	17	768	Pattern - 1	914	110.16	92.968
T07-46	31	464	Pattern - 1	735	116.73	85.562	T07-46	31	464	Pattern - 1	552	109.89	78.729
T07-55	29	340	Pattern - 1	539	116.62	87.44	T07-55	29	340	Pattern - 1	405	109.82	80.655
T07-59	33	0	Fixed	0	40.54	7.529	T07-59	33	0	Fixed	0	41.6	8.583
T10-03	27	0	Fixed	0	60.59	33.521	T10-03	27	0	Fixed	0	53.74	26.689
T10-05	30	455	Pattern - 1	721	57.64	27.586	T10-05	30	455	Pattern - 1	541	42.17	12.147
T10-06	8	1051	Pattern - 1	1,666	56.33	48.232	T10-06	8	1051	Pattern - 1	1,251	34.06	26.009
T10-08	8	0	Fixed	0	56.33	48.232	T10-08	8	0	Fixed	0	31.35	23.305
T12-05	16	0	Fixed	0	29.4	13.369	T12-05	16	0	Fixed	0	33.58	17.541
T12-07	16	4729	Pattern - 1	7,495	25.36	9.339	T12-07	16	4729	Pattern - 1	5,628	31.2	15.171
T12-08	16	0	Fixed	0	25.36	9.339	T12-08	16	0	Fixed	0	31.2	15.171
T12-11	18	3529	Pattern - 1	5,593	-1.04	-19.005	T12-11	18	3529	Pattern - 1	4,200	15.67	-2.321
T14-02	22	0	Fixed	0	89.09	66.95	T14-02	22	0	Fixed	0	88.25	66.121
T14-06	42	0	Fixed	0	89.09	46.99	T14-06	42	0	Fixed	0	88.25	46.161
T15-06	32	0	Fixed	0	89.09	56.97	T15-06	32	0	Fixed	0	88.25	56.141
T18-03	48	0	Fixed	0	115.54	67.408	T18-03	48	0	Fixed	0	114.28	66.151
T18-07	55	0	Fixed	0	112.96	57.84	T18-07	55	0	Fixed	0	108.95	53.846
T18-09	18	0	Fixed	0	112.21	94.02	T18-09	18	0	Fixed	0	103.69	85.52
T18-10	15	0	Fixed	0	107.9	92.717	T18-10	15	0	Fixed	0	101.16	85.985
T18-11	16	0	Fixed	0	107.9	91.719	T18-11	16	0	Fixed	0	101.16	84.987
T19-05	20	636	Composite	986	85.33	65.202	T19-05	20	636	Composite	750	84.54	64.409
T20-06	35	0	Fixed	0	107.9	72.757	T20-06	35	0	Fixed	0	101.16	66.026
T20-10	32	317	Composite	492	106.49	74.335	T20-10	32	317	Composite	374	100.32	68.186
T20-13	18	0	Fixed	0	99.68	81.52	T20-13	18	0	Fixed	0	96.32	78.167
T20-15	43	0	Fixed	0	99.68	56.571	T20-15	43	0	Fixed	0	96.32	53.217
T20-16	20	0	Fixed	0	99.17	79.015	T20-16	20	0	Fixed	0	96.02	75.871
T20-19	18	0	Fixed	0	96.15	77.993	T20-19	18	0	Fixed	0	94.25	76.092
T20-20	18	141	Pattern - 1	223	89.09	70.95	T20-20	18	141	Pattern - 1	168	90.1	71.95
T20-22	18	3505	Pattern - 1	5,555	72.47	54.359	T20-22	18	3505	Pattern - 1	4,171	80.32	62.193
T20-23	16	2249	Pattern - 1	3,565	70.83	54.719	T20-23	16	2249	Pattern - 1	2,676	79.35	63.227
T20-25	16	338	Pattern - 1	536	69.75	53.645	T20-25	16	338	Pattern - 1	402	78.72	62.595
T20-29	16	643	Pattern - 1	1,019	68.68	52.571	T20-29	16	643	Pattern - 1	765	78.09	61.963
T20-30	16	1746	Pattern - 1	2,767	68.42	52.31	T20-30	16	1746	Pattern - 1	2,078	77.93	61.809
T20-34	14	0	Fixed	0	68.42	54.305	T20-34	14	0	Fixed	0	77.93	63.805
T20-38	13	0	Fixed	0	68.42	55.303	T20-38	13	0	Fixed	0	77.93	64.803
T20-39	13	0	Fixed	0	68.42	55.303	T20-39	13	0	Fixed	0	77.93	64.803
T21-02	14	0	Fixed	0	77.69	63.563	T21-02	14	0	Fixed	0	76.67	62.54
T21-07	13	0	Fixed	0	77.69	64.56	T21-07	13	0	Fixed	0	76.67	63.538
T21-11	9	62	Pattern - 1	98	77.69	68.551	T21-11	9	62	Pattern - 1	74	76.67	67.53
T21-13	9	0	Fixed	0	77.69	68.551	T21-13	9	0	Fixed	0	76.67	67.53
T21-15	12	0	Fixed	0	77.69	65.557	T21-15	12	0	Fixed	0	76.67	64.536
T24-01	30	0	Fixed	0	30.22	0.224	T24-01	30	0	Fixed	0	51.09	21.051
T31-12	67	0	Fixed	0	100.31	33.239	T31-12	67	0	Fixed	0	95.59	28.533
T31-23	15	0	Fixed	0	98.86	83.691	T31-23	15	0	Fixed	0	91.85	76.692
T38-03	59	0	Fixed	0	86.59	27.535	T38-03	59	0	Fixed	0	83.78	24.735
T38-06	8	0	Fixed	0	86.83	78.671	T38-06	8	0	Fixed	0	83.81	75.653
T38-12	8	0	Fixed	0	90.49	82.32	T38-12	8	0	Fixed	0	85.29	77.13
T38-21	13	0	Fixed	0	93.72	80.558	T38-21	13	0	Fixed	0	86.59	73.446
T38-25	9	0	Fixed	0	98.08	88.9	T38-25	9	0	Fixed	0	90.43	81.269
T38-29	12	0	Fixed	0	98.7	86.529	T38-29	12	0	Fixed	0	91.44	79.283
T38-32	8	0	Fixed	0	86.83	78.671	T38-32	8	0	Fixed	0	83.81	75.653
T38-37	8	0	Fixed	0	86.63	78.469	T38-37	8	0	Fixed	0	83.62	75.471
T38-43	26	0	Fixed	0	86.34	60.221	T38-43	26	0	Fixed	0	83.37	57.254
T38-48	14	0	Fixed	0	85.96	71.812	T38-48	14	0	Fixed	0	83.02	68.881
T38-54	25	0	Fixed	0	52.83	27.775	T38-54	25	0	Fixed	0	53.06	28.006
T38-56	14	0	Fixed	0	85.96	71.812	T38-56	14	0	Fixed	0	83.02	68.881
T38-57	18	0	Fixed	0	48.15	30.087	T38-57	18	0	Fixed	0	49.14	31.08
T39-02	51	0	Fixed	0	72.55	21.511	T39-02	51	0	Fixed	0	60.11	9.095
T44-03	40	0	Fixed	0	54.7	14.668	T44-03	40	0	Fixed	0	54.6	14.566

Table F34.1.2 Junction Details at 18:00 and 24:00 for Salaulim Scheme (1/3)

Junction	Elevation (m)	Base Flow (m^3/day)	Pattern	Demand (m^3/day)	Calculated Hydraulic Grade (m)	Pressure (m H2O)	Junction	Elevation (m)	Base Flow (m^3/day)	Pattern	Demand (m^3/day)	Calculated Hydraulic Grade (m)	Pressure (m H2O)
J-104	10	0	Fixed	0	93.82	83.654	J-104	10	0	Fixed	0	78.43	68.289
J-117	40	0	Fixed	0	104.49	64.365	J-117	40	0	Fixed	0	104.77	64.637
J-123	50	0	Fixed	0	116.45	66.311	J-123	50	0	Fixed	0	117.98	67.843
J-124	98	0	Fixed	0	100.98	2.969	J-124	98	0	Fixed	0	102.18	4.174
J-128	45	0	Fixed	0	48.34	3.33	J-128	45	0	Fixed	0	43.25	-1.746
J-130	105	0	Fixed	0	107.24	2.231	J-130	105	0	Fixed	0	108.35	3.34
J-131	7	0	Fixed	0	113.94	106.729	J-131	7	0	Fixed	0	115.59	108.366
J-142	83	0	Fixed	0	85.87	2.867	J-142	83	0	Fixed	0	85.09	2.087
J-143	40	0	Fixed	0	41.16	1.157	J-143	40	0	Fixed	0	43.13	3.12
J-144	30	0	Fixed	0	86.48	56.369	J-144	30	0	Fixed	0	87.67	57.551
J-145	30	0	Fixed	0	32.53	2.524	J-145	30	0	Fixed	0	32.39	2.384
J-147	25	0	Fixed	0	27.86	2.853	J-147	25	0	Fixed	0	28.5	3.493
J-148	61	0	Fixed	0	113.94	52.838	J-148	61	0	Fixed	0	115.59	54.475
J-149	0	0	Fixed	0	78.26	78.102	J-149	0	0	Fixed	0	77.06	76.905
J-150	0	0	Fixed	0	62.61	62.482	J-150	0	0	Fixed	0	61.62	61.493
J-151	58	0	Fixed	0	61.86	3.855	J-151	58	0	Fixed	0	60.56	2.558
J-152	70	0	Fixed	0	73.15	3.145	J-152	70	0	Fixed	0	73.05	3.047
J-153	75	0	Fixed	0	78.23	3.224	J-153	75	0	Fixed	0	76.25	1.245
J-154	56	0	Fixed	0	103.81	47.713	J-154	56	0	Fixed	0	104.78	48.686
J-155	60	0	Fixed	0	61.85	1.849	J-155	60	0	Fixed	0	61.47	1.468
J-156	46	0	Fixed	0	49.21	3.207	J-156	46	0	Fixed	0	48.26	2.255
J-157	42	0	Fixed	0	44.95	2.945	J-157	42	0	Fixed	0	44.12	2.118
J-158	50	0	Fixed	0	52.19	2.186	J-158	50	0	Fixed	0	50.75	0.753
J-159	50	0	Fixed	0	130.95	80.787	J-159	50	0	Fixed	0	86.88	36.803
J-160	32	0	Fixed	0	35.32	3.313	J-160	32	0	Fixed	0	34.78	2.774
J-161	16	0	Fixed	0	19.47	3.462	J-161	16	0	Fixed	0	19.34	3.335
J-162	41	0	Fixed	0	43.5	2.493	J-162	41	0	Fixed	0	41.74	0.739
J-163	53	0	Fixed	0	54.91	1.902	J-163	53	0	Fixed	0	54.9	1.898
J-164	40	0	Fixed	0	49.34	9.323	J-164	40	0	Fixed	0	41.89	1.886
J-165	58	0	Fixed	0	61.24	3.233	J-165	58	0	Fixed	0	58.57	0.57
J-166	14	0	Fixed	0	14.81	0.804	J-166	14	0	Fixed	0	16.13	2.125
J-167	40	0	Fixed	0	18.9	-21.059	J-167	40	0	Fixed	0	43.49	3.481
J-168	55	0	Fixed	0	58.27	3.264	J-168	55	0	Fixed	0	56.3	1.302
J-169	63	0	Fixed	0	63.67	0.666	J-169	63	0	Fixed	0	64.86	1.853
J-170	53	0	Fixed	0	55.9	2.893	J-170	53	0	Fixed	0	55.89	2.889
J-171	55	0	Fixed	0	57.05	2.043	J-171	55	0	Fixed	0	57.98	2.974
J-172	44	0	Fixed	0	47.49	3.483	J-172	44	0	Fixed	0	45.52	1.522
J-173	26	0	Fixed	0	28.76	2.758	J-173	26	0	Fixed	0	27.35	1.35
J-174	55	0	Fixed	0	57.53	2.529	J-174	55	0	Fixed	0	56.32	1.321
J-175	0	0	Fixed	0	45.26	45.172	J-175	0	0	Fixed	0	44.87	44.779
J-176	16	0	Fixed	0	16.84	0.838	J-176	16	0	Fixed	0	18.34	2.334
J-177	62	0	Fixed	0	63.3	1.293	J-177	62	0	Fixed	0	62.63	0.625
J-178	15	0	Fixed	0	18.23	3.224	J-178	15	0	Fixed	0	17.76	2.758
J-179	36	0	Fixed	0	39.41	3.406	J-179	36	0	Fixed	0	38.41	2.408
J-180	36	0	Fixed	0	38.25	2.244	J-180	36	0	Fixed	0	37.87	1.867
J-181	55	0	Fixed	0	55.93	0.925	J-181	55	0	Fixed	0	58.24	3.236
J-182	46	0	Fixed	0	35.5	-10.481	J-182	46	0	Fixed	0	45.24	-0.759
J-183	40	0	Fixed	0	43.46	3.448	J-183	40	0	Fixed	0	43.5	3.495
J-184	95	0	Fixed	0	98.57	3.558	J-184	95	0	Fixed	0	98.72	3.711
J-185	54	0	Fixed	0	55.91	1.911	J-185	54	0	Fixed	0	55.46	1.455
J-186	27	0	Fixed	0	30.18	3.174	J-186	27	0	Fixed	0	35.35	8.329
J-187	50	0	Fixed	0	52.5	2.498	J-187	50	0	Fixed	0	52.45	2.448
J-188	50	0	Fixed	0	56.24	6.224	J-188	50	0	Fixed	0	53.44	3.436
J-189	22	0	Fixed	0	22.79	0.784	J-189	22	0	Fixed	0	22.82	0.814
J-190	52	0	Fixed	0	54.15	2.147	J-190	52	0	Fixed	0	53.85	1.845
J-191	52	0	Fixed	0	54.81	2.802	J-191	52	0	Fixed	0	53.61	1.606
J-192	45	0	Fixed	0	46.9	1.896	J-192	45	0	Fixed	0	47.55	2.543
J-193	31	0	Fixed	0	34.29	3.28	J-193	31	0	Fixed	0	34.15	3.142
J-194	34	0	Fixed	0	35.48	1.479	J-194	34	0	Fixed	0	36.01	2.003
J-195	0	0	Fixed	0	50.01	49.912	J-195	0	0	Fixed	0	52.24	52.135
J-196	40	0	Fixed	0	42.18	2.18	J-196	40	0	Fixed	0	40.93	0.924
J-197	40	0	Fixed	0	42.19	2.188	J-197	40	0	Fixed	0	40.93	0.924
J-198	45	0	Fixed	0	46.13	1.128	J-198	45	0	Fixed	0	46.92	1.918
J-199	0	0	Fixed	0	46.59	46.495	J-199	0	0	Fixed	0	49.86	49.762
J-200	35	0	Fixed	0	36.88	1.881	J-200	35	0	Fixed	0	38.42	3.41
J-201	0	0	Fixed	0	50.09	49.992	J-201	0	0	Fixed	0	51.91	51.806
J-202	55	0	Fixed	0	56.71	1.71	J-202	55	0	Fixed	0	55.68	0.679
J-203	85	0	Fixed	0	117.54	32.476	J-203	85	0	Fixed	0	117.48	32.412
J-204	45	0	Fixed	0	120.86	75.705	J-204	45	0	Fixed	0	120.86	75.708

Table F34.1.2 Junction Details at 18:00 and 24:00 for Salaulim Scheme (2/3)

Junction	Elevation (m)	Base Flow (m^3/day)	Pattern	Demand (m^3/day)	Calculated Hydraulic Grade (m)	Pressure (m H2O)	Junction	Elevation (m)	Base Flow (m^3/day)	Pattern	Demand (m^3/day)	Calculated Hydraulic Grade (m)	Pressure (m H2O)
J-205	45	0	Fixed	0	47.3	2.299	J-205	45	0	Fixed	0	47.86	2.855
J-206	85	0	Fixed	0	117.42	32.351	J-206	85	0	Fixed	0	117.25	32.184
J-207	96.2	0	Fixed	0	104.28	8.059	J-207	96.2	0	Fixed	0	106.39	10.166
J-214	25	0	Fixed	0	118.14	92.948	J-214	25	0	Fixed	0	108.35	83.179
J-215	25	0	Fixed	0	113.94	88.766	J-215	25	0	Fixed	0	115.59	90.403
J-216	0	0	Fixed	0	62.31	62.185	J-216	0	0	Fixed	0	64.38	64.245
J-223	5	0	Fixed	0	89.32	84.155	J-223	5	0	Fixed	0	90.23	85.062
J-225	21.4	0	Fixed	0	117.36	95.762	J-225	21.4	0	Fixed	0	116.65	95.061
J-226	10	0	Fixed	0	114.73	104.517	J-226	10	0	Fixed	0	115.84	105.629
J-227	5	0	Fixed	0	114.4	109.182	J-227	5	0	Fixed	0	115.74	110.513
J-228	10	0	Fixed	0	113.94	103.735	J-228	10	0	Fixed	0	115.59	105.372
T-00	110	117	Pattern - 1	125	111.29	1.289	T-00	110	117	Pattern - 1	63	112.92	2.915
T-01	34	194	Pattern - 1	207	105.77	71.625	T-01	34	194	Pattern - 1	104	107.78	73.632
T-02	21.4	0	Fixed	0	102.34	80.777	T-02	21.4	0	Fixed	0	104.58	83.014
T-03	39	0	Fixed	0	101.56	62.43	T-03	39	0	Fixed	0	103.82	64.693
T-04	43.2	45	Pattern - 1	48	100.31	56.993	T-04	43.2	45	Pattern - 1	24	102.62	59.296
T-05	17.5	1095	Pattern - 1	1,166	98.45	80.789	T-05	17.5	1095	Pattern - 1	586	100.82	83.153
T-06	19.3	0	Fixed	0	97.63	78.168	T-06	19.3	0	Fixed	0	100.02	80.553
T-08	13.3	386	Pattern - 1	411	95.04	81.576	T-08	13.3	386	Pattern - 1	207	97.51	84.042
T-09	15.1	210	Pattern - 1	224	92.49	77.234	T-09	15.1	210	Pattern - 1	112	95.03	79.773
T-12	57.1	0	Fixed	0	91.74	34.573	T-12	57.1	0	Fixed	0	94.28	37.104
T-13	16.5	10981	Pattern - 1	11,695	90.72	74.067	T-13	16.5	10981	Pattern - 1	5,875	91.05	74.402
T-14	33.5	0	Fixed	0	90.53	56.912	T-14	33.5	0	Fixed	0	90.3	56.683
T-16	33.5	366	Pattern - 1	390	90.53	56.912	T-16	33.5	366	Pattern - 1	196	90.29	56.676
T-17	38.3	636	Composite	675	90.53	52.121	T-17	38.3	636	Composite	357	89.08	50.681
T-18	48.2	0	Fixed	0	94.92	46.624	T-18	48.2	0	Fixed	0	88.6	40.321
T-19	35	0	Fixed	0	94.89	59.773	T-19	35	0	Fixed	0	86.52	51.418
T-20	46	0	Fixed	0	94.84	48.737	T-20	46	0	Fixed	0	81.27	35.203
T-21	10	0	Fixed	0	94.8	84.633	T-21	10	0	Fixed	0	78.43	68.289
T-22	30	255	Pattern - 1	272	94.79	64.654	T-22	30	255	Pattern - 1	136	75.58	45.489
T-23	45	0	Fixed	0	94.78	49.682	T-23	45	0	Fixed	0	75.17	30.114
T-24	37	0	Fixed	0	94.71	57.593	T-24	37	0	Fixed	0	63.96	26.91
T-25	12	2832	Composite	2,873	94.64	82.478	T-25	12	2832	Composite	2,542	53.95	41.867
T-27	8	3541	Composite	3,592	94.63	86.452	T-27	8	3541	Composite	3,178	49.98	41.893
T-28	12	0	Fixed	0	94.62	82.449	T-28	12	0	Fixed	0	45.24	33.173
T-29	18	688	Pattern - 1	733	94.62	76.461	T-29	18	688	Pattern - 1	368	44.27	26.22
T-31	69	0	Fixed	0	99.22	30.159	T-31	69	0	Fixed	0	100.15	31.086
T-32	66	2220	Composite	2,255	89.43	23.384	T-32	66	2220	Composite	1,967	94.62	28.563
T-33	64	2220	Composite	2,255	86.37	22.325	T-33	64	2220	Composite	1,967	92.9	28.845
T-34	64	2220	Composite	2,255	83.41	19.374	T-34	64	2220	Composite	1,967	91.26	27.2
T-35	75	2220	Composite	2,255	78.07	3.062	T-35	75	2220	Composite	1,967	88.3	13.27
T-37	72	0	Fixed	0	70.21	-1.787	T-37	72	0	Fixed	0	83.98	11.955
T-38	38	0	Fixed	0	69.99	31.925	T-38	38	0	Fixed	0	83.75	45.658
T-39	51	0	Fixed	0	68.83	17.798	T-39	51	0	Fixed	0	82.99	31.927
T-40	41	0	Fixed	0	66.65	25.599	T-40	41	0	Fixed	0	81.75	40.67
T-44	40	0	Fixed	0	63.23	23.186	T-44	40	0	Fixed	0	80.07	39.99
T-45	40	5,286	Composite	5,376	63.03	22.98	T-45	40	5,286	Composite	4,645	80.03	39.951
T-46	38	5,286	Composite	5,376	62.61	24.561	T-46	38	5,286	Composite	4,645	79.97	41.887
T-47	31	0	Fixed	0	62.28	31.222	T-47	31	0	Fixed	0	79.94	48.842
T-48	34	0	Fixed	0	61.12	27.07	T-48	34	0	Fixed	0	79.63	45.54
T-49	7	0	Fixed	0	58.97	51.864	T-49	7	0	Fixed	0	79.06	71.912
T00-11	14	0	Fixed	0	85.66	71.514	T00-11	14	0	Fixed	0	69.13	55.017
T00-14	38	0	Fixed	0	85.3	47.2	T00-14	38	0	Fixed	0	43.29	5.284
T00-17	5	1383	Composite	1,464	113.49	108.268	T00-17	5	1383	Composite	803	115.43	110.212
T00-20	6	0	Fixed	0	113.94	107.727	T00-20	6	0	Fixed	0	115.59	109.364
T00-51	15	215	Pattern - 1	229	83.18	68.042	T00-51	15	215	Pattern - 1	115	43.25	28.194
T00-52	30	72	Pattern - 1	77	83.14	53.037	T00-52	30	72	Pattern - 1	39	43.24	13.214
T00-53	83	0	Fixed	0	84.69	1.691	T00-53	83	0	Fixed	0	86.01	3.004
T01-02	35	0	Fixed	0	105.76	70.62	T01-02	35	0	Fixed	0	107.78	72.632
T01-05	26	138	Pattern - 1	147	105.63	79.467	T01-05	26	138	Pattern - 1	74	107.74	81.576
T02-04	36	0	Fixed	0	63.3	27.243	T02-04	36	0	Fixed	0	103.58	67.447
T02-07	42	951	Pattern - 1	1,013	59.73	17.69	T02-07	42	951	Pattern - 1	509	102.59	60.463
T03-03	21.4	0	Fixed	0	117.29	95.692	T03-03	21.4	0	Fixed	0	116.63	95.04
T03-05	16	1504	Pattern - 1	1,602	115.46	99.26	T03-05	16	1504	Pattern - 1	805	116.08	99.88
T03-11	32	472	Pattern - 1	503	114.8	82.635	T03-11	32	472	Pattern - 1	253	115.9	83.729
T03-12	20	365	Pattern - 1	389	115.08	94.884	T03-12	20	365	Pattern - 1	195	115.97	95.781
T03-13	16	365	Pattern - 1	389	113.65	97.456	T03-13	16	365	Pattern - 1	195	115.58	99.376
T03-14	31	476	Pattern - 1	507	111.64	80.477	T03-14	31	476	Pattern - 1	255	115.01	83.845

Table F34.1.2 Junction Details at 18:00 and 24:00 for Salaulim Scheme (3/3)

Junction	Elevation (m)	Base Flow (m^3/day)	Pattern	Demand (m^3/day)	Calculated Hydraulic Grade (m)	Pressure (m H2O)	Junction	Elevation (m)	Base Flow (m^3/day)	Pattern	Demand (m^3/day)	Calculated Hydraulic Grade (m)	Pressure (m H2O)
T03-15	27	1483	Composite	1,571	102.42	75.264	T03-15	27	1483	Composite	857	111.84	84.664
T06-04	37	692	Pattern - 1	737	94.72	57.6	T06-04	37	692	Pattern - 1	370	99.2	62.077
T06-05	56	209	Pattern - 1	223	94.68	38.603	T06-05	56	209	Pattern - 1	112	99.19	43.106
T07-10	24	0	Fixed	0	84.01	59.885	T07-10	24	0	Fixed	0	85.16	61.037
T07-11	21	0	Fixed	0	78.74	57.625	T07-11	21	0	Fixed	0	79.42	58.3
T07-18	10	0	Fixed	0	49.26	39.181	T07-18	10	0	Fixed	0	47.26	37.189
T07-23	12	759	Pattern - 1	808	48.97	36.892	T07-23	12	759	Pattern - 1	406	45.72	33.656
T07-35	15	0	Fixed	0	16.21	1.204	T07-35	15	0	Fixed	0	16.36	1.357
T07-36	17	0	Fixed	0	116.74	99.538	T07-36	17	0	Fixed	0	118.06	100.858
T07-40	17	768	Pattern - 1	818	116.45	99.245	T07-40	17	768	Pattern - 1	411	117.98	100.776
T07-46	31	464	Pattern - 1	494	116.23	85.056	T07-46	31	464	Pattern - 1	248	117.92	86.744
T07-55	29	340	Pattern - 1	362	116.17	86.995	T07-55	29	340	Pattern - 1	182	117.9	88.724
T07-59	33	0	Fixed	0	41.26	8.244	T07-59	33	0	Fixed	0	40.6	7.587
T10-03	27	0	Fixed	0	85.77	58.655	T10-03	27	0	Fixed	0	94.64	67.504
T10-05	30	455	Pattern - 1	485	79.06	48.959	T10-05	30	455	Pattern - 1	243	94.25	64.116
T10-06	8	1051	Pattern - 1	1,119	74.56	66.427	T10-06	8	1051	Pattern - 1	562	94.07	85.896
T10-08	8	0	Fixed	0	73.3	65.168	T10-08	8	0	Fixed	0	94.07	85.896
T12-05	16	0	Fixed	0	34.98	18.942	T12-05	16	0	Fixed	0	40.25	24.197
T12-07	16	4729	Pattern - 1	5,036	33.05	17.012	T12-07	16	4729	Pattern - 1	2,530	39.71	23.658
T12-08	16	0	Fixed	0	33.05	17.012	T12-08	16	0	Fixed	0	39.71	23.658
T12-11	18	3529	Pattern - 1	3,758	20.4	2.399	T12-11	18	3529	Pattern - 1	1,888	36.17	18.137
T14-02	22	0	Fixed	0	70.06	47.965	T14-02	22	0	Fixed	0	90.3	68.16
T14-06	42	0	Fixed	0	18.9	-23.055	T14-06	42	0	Fixed	0	90.3	48.2
T15-06	32	0	Fixed	0	68.75	36.674	T15-06	32	0	Fixed	0	90.3	58.18
T18-03	48	0	Fixed	0	112.53	64.395	T18-03	48	0	Fixed	0	114.04	65.91
T18-07	55	0	Fixed	0	104.41	49.312	T18-07	55	0	Fixed	0	111.8	56.69
T18-09	18	0	Fixed	0	94.59	76.435	T18-09	18	0	Fixed	0	111.7	93.515
T18-10	15	0	Fixed	0	68.39	53.283	T18-10	15	0	Fixed	0	111.13	95.931
T18-11	16	0	Fixed	0	60.79	44.701	T18-11	16	0	Fixed	0	111.13	94.933
T19-05	20	636	Composite	675	94.73	74.58	T19-05	20	636	Composite	357	86.47	66.337
T20-06	35	0	Fixed	0	77.08	41.992	T20-06	35	0	Fixed	0	111.13	75.972
T20-10	32	317	Composite	336	76.4	44.307	T20-10	32	317	Composite	178	110.93	78.775
T20-13	18	0	Fixed	0	73.14	55.029	T20-13	18	0	Fixed	0	110.02	91.839
T20-15	43	0	Fixed	0	73.14	30.079	T20-15	43	0	Fixed	0	110.02	66.889
T20-16	20	0	Fixed	0	72.9	52.789	T20-16	20	0	Fixed	0	109.96	89.775
T20-19	18	0	Fixed	0	71.45	53.34	T20-19	18	0	Fixed	0	109.55	91.367
T20-20	18	141	Pattern - 1	150	68.07	49.967	T20-20	18	141	Pattern - 1	75	108.61	90.424
T20-22	18	3505	Pattern - 1	3,733	60.11	42.023	T20-22	18	3505	Pattern - 1	1,875	106.38	88.205
T20-23	16	2249	Pattern - 1	2,395	59.32	43.235	T20-23	16	2249	Pattern - 1	1,203	106.16	89.982
T20-25	16	338	Pattern - 1	360	58.81	42.721	T20-25	16	338	Pattern - 1	181	106.02	89.838
T20-29	16	643	Pattern - 1	685	58.29	42.207	T20-29	16	643	Pattern - 1	344	105.88	89.694
T20-30	16	1746	Pattern - 1	1,859	58.17	42.082	T20-30	16	1746	Pattern - 1	934	105.84	89.659
T20-34	14	0	Fixed	0	58.17	44.078	T20-34	14	0	Fixed	0	105.84	91.655
T20-38	13	0	Fixed	0	58.17	45.076	T20-38	13	0	Fixed	0	105.84	92.653
T20-39	13	0	Fixed	0	58.17	45.076	T20-39	13	0	Fixed	0	105.84	92.653
T21-02	14	0	Fixed	0	94.48	80.315	T21-02	14	0	Fixed	0	78.43	64.297
T21-07	13	0	Fixed	0	93.82	80.661	T21-07	13	0	Fixed	0	78.43	65.295
T21-11	9	62	Pattern - 1	66	93.82	84.652	T21-11	9	62	Pattern - 1	33	78.43	69.287
T21-13	9	0	Fixed	0	93.82	84.652	T21-13	9	0	Fixed	0	78.43	69.287
T21-15	12	0	Fixed	0	93.82	81.658	T21-15	12	0	Fixed	0	78.43	66.293
T24-01	30	0	Fixed	0	28.6	-1.4	T24-01	30	0	Fixed	0	30.7	0.695
T31-12	67	0	Fixed	0	95.3	28.245	T31-12	67	0	Fixed	0	95.71	28.649
T31-23	15	0	Fixed	0	92.04	76.883	T31-23	15	0	Fixed	0	92	76.849
T38-03	59	0	Fixed	0	69.98	10.958	T38-03	59	0	Fixed	0	83.63	24.581
T38-06	8	0	Fixed	0	69.76	61.633	T38-06	8	0	Fixed	0	80.8	72.655
T38-12	8	0	Fixed	0	75.42	67.289	T38-12	8	0	Fixed	0	83.99	75.833
T38-21	13	0	Fixed	0	80.44	67.303	T38-21	13	0	Fixed	0	86.8	73.655
T38-25	9	0	Fixed	0	90.28	81.113	T38-25	9	0	Fixed	0	90.6	81.436
T38-29	12	0	Fixed	0	91.69	79.525	T38-29	12	0	Fixed	0	91.6	79.444
T38-32	8	0	Fixed	0	69.76	61.633	T38-32	8	0	Fixed	0	80.8	72.655
T38-37	8	0	Fixed	0	67.8	59.681	T38-37	8	0	Fixed	0	76.13	67.99
T38-43	26	0	Fixed	0	65.06	38.986	T38-43	26	0	Fixed	0	69.58	43.496
T38-48	14	0	Fixed	0	53.09	39.015	T38-48	14	0	Fixed	0	57.42	43.332
T38-54	25	0	Fixed	0	44.76	19.718	T38-54	25	0	Fixed	0	57.42	32.355
T38-56	14	0	Fixed	0	41.57	27.51	T38-56	14	0	Fixed	0	43.9	29.844
T38-57	18	0	Fixed	0	50.09	32.029	T38-57	18	0	Fixed	0	49.31	31.247
T39-02	51	0	Fixed	0	58.04	7.03	T39-02	51	0	Fixed	0	60.39	9.371
T44-03	40	0	Fixed	0	51.81	11.79	T44-03	40	0	Fixed	0	59.2	19.159

Table F34.1.3 Pipeline Details at 06:00 for Salaulim Scheme (1/5)

Pipe No.	From Node	To Node	Length (m)	Diameter (mm)	Material	Hazen-Williams C	Control Status	Discharge (m^3/day)	Velocity (m/s)	Pressure Pipe Headloss (m)	Headloss Gradient (m/km)
P-1	T-00	T-01	4,974	1,400	Steel	110	Open	174,111	1.31	6.25	1.26
P-2	T-01	J-207	1,352	1,400	Steel	110	Open	173,585	1.31	1.69	1.25
P-2+	J-207	T-02	1,750	1,400	Steel	110	Open	173,585	1.31	2.19	1.25
P-3	T-02	T-03	740	1,400	PSC	110	Open	172,078	1.29	0.91	1.23
P-4	T-03	T-04	1,178	1,400	PSC	110	Open	172,078	1.29	1.45	1.23
P-5	T-04	T-05	1,752	1,400	PSC	110	Open	172,006	1.29	2.15	1.23
P-6	T-05	T-06	791	1,400	PSC	110	Open	170,271	1.28	0.95	1.21
P-7	T-06	T-08	2,989	1,400	PSC	110	Open	145,741	1.1	2.7	0.9
P-8	T-08	T-09	2,965	1,400	PSC	110	Open	145,130	1.09	2.66	0.9
P-9	T-09	T-12	915	1,400	Steel	110	Open	136,009	1.02	0.73	0.8
P-10	T-12	T-13	3,910	1,400	Steel	110	Open	136,009	1.02	3.11	0.8
P-11	T-13	T-14	990	1,400	PSC	110	Open	118,604	0.89	0.61	0.62
P-12	T-14	T-16	10	1,400	PSC	110	Open	118,604	0.89	0.01	0.62
P-13	T-16	T-17	750	1,200	PSC	110	Open	118,023	1.21	0.97	1.3
P-14	T-17	T-18	300	1,200	PSC	110	Open	117,037	1.2	0.38	1.28
P-15	T-18	T-19	510	1,200	PSC	110	Open	218,083	2.23	2.06	4.04
P-16	T-19	T-20	1,290	1,200	PSC	110	Open	217,096	2.22	5.17	4.01
P-17	T-20	T-21	700	1,200	PSC	110	Open	217,096	2.22	2.8	4.01
P-18	T-21	T-22	700	1,200	PSC	110	Open	216,998	2.22	2.8	4
P-19	T-22	T-23	100	1,200	PSC	110	Open	216,594	2.22	0.4	3.99
P-20	T-23	T-24	2,760	1,200	PSC	110	Open	216,594	2.22	11.01	3.99
P-21	T-24	T-25	2,465	1,200	PSC	110	Open	216,594	2.22	9.83	3.99
P-22	T-25	T-27	1,000	1,200	PSC	110	Open	213,397	2.18	3.88	3.88
P-23	T-27	T-28	1,225	1,200	PSC	110	Open	209,399	2.14	4.59	3.75
P-24	T-28	T-29	250	1,200	PSC	110	Open	209,399	2.14	0.94	3.75
P-25	T-29	J-183	200	1,200	PSC	110	Open	208,308	2.13	0.74	3.71
P-26	Verna MBR	T-31	850	900	PSC	110	Open	50,888	0.93	0.94	1.11
P-27	T-31	T-32	1,700	900	PSC	110	Open	89,441	1.63	5.35	3.15
P-28	T-32	T-33	550	900	PSC	110	Open	86,902	1.58	1.64	2.98
P-29	T-33	T-34	550	900	PSC	110	Open	84,363	1.53	1.55	2.83
P-30	T-34	T-35	1,030	900	PSC	110	Open	81,824	1.49	2.75	2.67
P-31	T-35	T-37	1,570	900	PSC	110	Open	79,286	1.44	3.95	2.52
P-32	T-37	T-38	300	900	PSC	110	Open	39,643	0.72	0.21	0.7
P-33	T-38	T-39	500	900	PSC	110	Open	85,310	1.55	1.44	2.88
P-34	T-39	T-40	1,100	900	PSC	110	Open	78,804	1.43	2.74	2.49
P-35	T-40	T-44	1,800	900	PSC	110	Open	81,502	1.48	4.77	2.65
P-36	T-44	T-45	200	900	PSC	110	Open	53,666	0.98	0.24	1.22
P-37	T-45	T-46	500	900	PSC	110	Open	47,574	0.87	0.49	0.98
P-38	T-46	T-47	500	900	PSC	110	Open	41,482	0.75	0.38	0.76
P-39	T-47	T-48	700	600	PSC	110	Open	41,482	1.7	3.83	5.47
P-40	T-48	T-49	1,300	600	PSC	110	Open	41,482	1.7	7.11	5.47
P-41	T-49	J-202	1,360	600	Steel	110	Open	41,482	1.7	7.44	5.47
P-45	Xelpem	T00-11	3,200	300	Cast iron	110	Open	227	0.04	0.03	0.01
P-47	T00-11	T00-14	1,500	300	Cast iron	110	Open	455	0.07	0.06	0.04
P-49	T-01	T01-02	200	200	Asbestos Ce	110	Open	219	0.08	0.01	0.07
P-50	T01-02	T01-05	1,000	150	Cast iron	110	Open	219	0.14	0.28	0.28
P-52	T-02	T02-04	3,000	200	Cast iron	110	Open	1,507	0.56	7.46	2.49
P-53	T02-04	T02-07	3,000	200	Cast iron	110	Open	1,507	0.56	7.46	2.49
P-58	T03-05	T03-11	6,000	250	Asbestos Ce	110	Open	748	0.18	1.38	0.23
P-61	T07-11	T07-18	2,800	350	Cast iron	110	Open	1203	0.14	0.3	0.11
P-63	T07-18	T07-35	1,650	300	Cast iron	110	Closed	0	0	0	0
P-66	T07-35	Balli Sump	10	300	Cast iron	110	Open	0	0	0	0
P-67	T-06	T06-04	2,700	200	Asbestos Ce	110	Open	1,428	0.53	6.08	2.25
P-68	T06-04	T06-05	500	200	Asbestos Ce	110	Open	331	0.12	0.08	0.15
P-69	T-09	T10-03	1,500	250	Cast iron	110	Open	8,788	2.07	32.94	21.96
P-76	St Jose De A	T12-05	650	300	Asbestos Ce	110	Open	13,089	2.14	12.28	18.9
P-77	T12-05	T12-11	3,200	250	Asbestos Ce	110	Open	5,593	1.32	30.44	9.51
P-79	T-14	T14-02	1,000	300	Cast iron	110	Open	0	0	0	0
P-89	T19-05	T-19	2,100	300	Cast iron	110	Open	-986	0.16	0.33	0.16
P-93	T-21	T21-02	500	400	Cast iron	110	Open	98	0.01	0	0
P-94	T21-02	T21-07	1,000	400	Cast iron	110	Open	98	0.01	0	0
P-101	T14-02	T14-06	2,500	300	Cast iron	110	Open	0	0	0	0
P-106	T-31	T31-12	3,000	600	Cast iron	110	Open	12,335	0.5	1.74	0.58
P-108	T-39	T39-02	1,000	250	Cast iron	110	Open	6,506	1.53	12.58	12.58
P-114	T38-12	T38-06	2,600	500	Cast iron	110	Open	12,335	0.73	3.66	1.41
P-115	T38-06	T38-37	500	500	Cast iron	110	Open	6,310	0.37	0.2	0.41

Table F34.1.3 Pipeline Details at 06:00 for Salaulim Scheme (2/5)

Pipe No.	From Node	To Node	Length (m)	Diameter (mm)	Material	Hazen-Williams C	Control Status	Discharge (m^3/day)	Velocity (m/s)	Pressure Pipe Headloss (m)	Headloss Gradient (m/km)
P-117	T38-43	T38-48	900	400	Cast iron	110	Open	3,612	0.33	0.39	0.43
P-124	T38-54	T38-48	650	150	Cast iron	110	Open	-3,612	2.37	33.13	50.96
P-126	T-44	T44-03	300	300	Cast iron	110	Open	27,836	4.56	22.93	76.44
P-129	T38-48	T38-56	1,000	400	Cast iron	110	Open	0	0	0	0
P-136	Mid-land Sa	Head-land S	1,000	200	Cast iron	110	Closed	0	0	0	0
P-137	Margao MB	T18-07	600	600	Cast iron	110	Open	14,158	0.58	0.45	0.75
P-138	T18-07	T18-09	1,000	600	Cast iron	110	Open	14,158	0.58	0.75	0.75
P-139	Margao MB	Vasant Naga	500	150	Cast iron	110	Closed	0	0	0	0
P-142	T07-59	Khanaguinin	1,800	300	Cast iron	110	Open	0	0	0	0
P-143	T-24	T24-01	500	250	Cast iron	110	Closed	0	0	0	0
P-144	T24-01	Nuvem	300	200	Cast iron	110	Open	0	0	0	0
P-145	T20-13	T20-15	600	500	Cast iron	110	Open	0	0	0	0
P-148	T-14	T15-06	3,000	600	Cast iron	110	Open	0	0	0	0
P-152	T18-10	T18-11	700	400	Cast iron	110	Open	0	0	0	0
P-153	T-21	T18-10	1,000	400	Cast iron	110	Closed	0	0	0	0
P-154	T38-29	T38-25	3,200	750	Cast iron	110	Open	12,335	0.32	0.62	0.2
P-156	T38-21	T38-12	2,300	500	Cast iron	110	Open	12,335	0.73	3.23	1.41
P-162	Salaulim WT	FCV-1	10	1,400	Steel	110	Open	146,982	1.11	0.01	0.92
P-163	FCV-1	Salaulim Res	10	1,400	Steel	110	Open	146,982	1.11	0.01	0.92
P-164	Salaulim Res	T-00	10	1,400	Steel	110	Open	174,297	1.31	0.01	1.26
P-166	T21-13	T21-15	400	250	Cast iron	110	Open	0	0	0	0
P-167	T31-12	T31-23	2,500	600	Cast iron	110	Open	12,335	0.5	1.45	0.58
P-168	T31-23	T38-29	800	750	Cast iron	110	Open	12,335	0.32	0.16	0.2
P-169	T21-13	J-104	1,900	400	Cast iron	110	Open	0	0	0	0
P-170	J-104	T31-23	10,100	750	Cast iron	110	Closed	0	0	0	0
P-171	Gogol Sump	PMP-1	10	300	Steel	110	Open	32,923	5.39	1.04	104.31
P-173	Gogol Sump	PMP-2	10	300	Steel	110	Open	0	0	0	0
P-175	Verna Sump	PMP-3	10	500	Steel	110	Open	46,409	2.74	0.16	16.36
P-177	Verna Sump	PMP-4	10	500	Steel	110	Open	46,409	2.74	0.16	16.36
P-179	Verna Sump	PMP-5	10	500	Steel	110	Open	0	0	0	0
P-181	Verna Sump	PMP-6	10	500	Steel	110	Open	0	0	0	0
P-183	T38-43	T-40	1,600	250	Cast iron	110	Open	2,698	0.64	3.94	2.46
P-185	T-03	T03-03	1,000	300	Cast iron	110	Closed	0	0	0	0
P-186	T38-37	T38-43	700	500	Cast iron	110	Open	6,310	0.37	0.28	0.41
P-187	T03-03	T03-05	2,600	450	Ductile Iron	110	Open	9,427	0.69	3.71	1.43
P-188	T03-05	T03-12	1,500	300	Asbestos Ce	110	Open	1,912	0.31	0.8	0.54
P-189	T03-12	T03-13	1,500	200	Asbestos Ce	110	Open	1333	0.49	2.97	1.98
P-190	T03-13	T03-14	1,500	150	Asbestos Ce	110	Open	754	0.49	4.2	2.8
P-191	T-06	T07-10	4,400	450	Cast iron	110	Open	23101	1.68	33.04	7.51
P-192	T07-10	T07-11	500	350	Cast iron	110	Open	23101	2.78	12.77	25.54
P-193	T12-05	T12-07	600	300	Asbestos Ce	110	Open	7,495	1.23	4.04	6.73
P-194	T12-07	T12-08	1,100	250	Asbestos Ce	110	Open	0	0	0	0
P-195	PMP-2	T18-03	10	300	Steel	110	Open	0	0	0	0
P-196	PMP-1	T18-03	10	300	Steel	110	Open	32,923	5.39	1.04	104.31
P-197	T18-03	Margao MB	600	600	Cast iron	110	Open	32,923	1.35	2.14	3.56
P-199	T20-10	T20-13	4,000	500	Cast iron	110	Open	13,666	0.81	6.8	1.7
P-200	T20-13	T20-16	300	500	Cast iron	110	Open	13,666	0.81	0.51	1.7
P-201	T20-16	T20-19	600	400	PSC	110	Open	13,666	1.26	3.02	5.04
P-203	T20-38	T20-39	500	200	Cast iron	110	Open	0	0	0	0
P-204	T20-34	T20-38	1,500	300	Cast iron	110	Open	0	0	0	0
P-205	T-38	T38-03	140	700	Cast iron	110	Open	-6,025	0.18	0.01	0.07
P-206	T38-03	T38-06	1,560	600	Cast iron	110	Open	-6,025	0.25	0.24	0.15
P-207	T38-06	T38-32	500	200	Cast iron	110	Open	0	0	0	0
P-210	T38-56	T38-57	1,500	300	Cast iron	110	Closed	0	0	0	0
P-211	PMP-3	J-117	10	500	Steel	110	Open	46,409	2.74	0.16	16.36
P-214	J-117	Verna MBR	600	900	Steel	110	Open	92,817	1.69	2.02	3.37
P-215	PMP-4	J-117	10	500	Steel	110	Open	46,409	2.74	0.16	16.36
P-216	PMP-5	J-117	10	500	Steel	110	Open	0	0	0	0
P-217	PMP-6	J-117	10	500	Steel	110	Open	0	0	0	0
P-218	T00-11	T00-17	2,500	300	Cast iron	110	Closed	0	0	0	0
P-222	T07-36	T07-40	700	300	Cast iron	110	Open	2,492	0.41	0.61	0.88
P-224	T07-40	T07-46	1,800	300	Cast iron	110	Open	1274	0.21	0.46	0.25
P-225	T07-46	T07-55	2,300	300	Cast iron	110	Open	539	0.09	0.12	0.05
P-226	T07-55	T07-59	1,200	300	Cast iron	110	Closed	0	0	0	0
P-229	T00-14	T00-51	3,600	250	Ductile Iron	110	Open	455	0.11	0.33	0.09

Table F34.1.3 Pipeline Details at 06:00 for Salaulim Scheme (3/5)

Pipe No.	From Node	To Node	Length (m)	Diameter (mm)	Material	Hazen-Williams C	Control Status	Discharge (m^3/day)	Velocity (m/s)	Pressure Pipe Headloss (m)	Headloss Gradient (m/km)
P-230	T00-51	J-128	8,300	150	Ductile Iron	110	Closed	0	0	0	0
P-231	J-128	NS1	400	150	Ductile Iron	110	Open	0	0	0	0
P-232	T00-51	T00-52	3,500	200	Ductile Iron	110	Open	114	0.04	0.07	0.02
P-235	T00-53	NS4 300GL	100	200	Ductile Iron	110	Open	0	0	0	0
P-237	J-130	NS5	50	250	Ductile Iron	110	Open	0	0	0	0
P-239	J-124	NQ4	50	150	Ductile Iron	110	Open	0	0	0	0
P-240	T07-40	J-123	2,500	200	Ductile Iron	110	Open	0	0	0	0
P-245	T10-03	T10-05	1,500	250	Cast iron	110	Open	2,387	0.56	2.95	1.97
P-247	T21-07	T21-11	1,700	400	Cast iron	110	Open	98	0.01	0	0
P-248	T21-11	T21-13	800	400	Cast iron	110	Open	0	0	0	0
P-249	T20-19	T20-20	1,400	400	PSC	110	Open	13666	1.26	7.06	5.04
P-251	T10-05	T10-06	1,300	250	Cast iron	110	Open	1,666	0.39	1.31	1.01
P-252	T10-06	T10-08	800	250	Cast iron	110	Open	0	0	0	0
P-254	T20-25	T20-29	2,300	400	PSC	110	Open	3787	0.35	1.08	0.47
P-256	T07-18	T07-23	2,700	300	Cast iron	110	Open	1,203	0.2	0.61	0.23
P-258	T20-29	T20-30	1,000	400	PSC	110	Open	2767	0.25	0.26	0.26
P-259	T20-30	T20-34	1,500	400	PSC	110	Open	0	0	0	0
P-260	T20-20	T20-22	3,400	400	PSC	110	Open	13442	1.24	16.62	4.89
P-261	T20-22	T20-23	900	400	PSC	110	Open	7,887	0.73	1.64	1.82
P-262	T20-23	T20-25	1,800	400	PSC	110	Open	4,322	0.4	1.08	0.6
P-263	T-00	J-142	400	300	Cast iron	110	Closed	0	0	0	0
P-264	J-142	Xelpem	10	300	Cast iron	110	Open	0	0	0	0
P-265	T00-14	J-143	10	300	Cast iron	110	Closed	0	0	0	0
P-266	J-143	Sanguem	10	300	Cast iron	110	Open	0	0	0	0
P-267	T00-52	J-145	100	200	Ductile Iron	110	Closed	0	0	0	0
P-268	J-144	T00-53	1,900	200	Ductile Iron	110	Open	0	0	0	0
P-269	J-145	NS3	10	200	Ductile Iron	110	Open	0	0	0	0
P-270	NS3	PMP-7	10	200	Steel	110	Open	0	0	0	0
P-271	PMP-7	J-144	100	200	Ductile Iron	110	Open	0	0	0	0
P-278	NS6	PMP-8	10	250	Steel	110	Open	0	0	0	0
P-281	J-147	NS6	10	300	Ductile Iron	110	Open	0	0	0	0
P-282	T00-20	J-148	500	300	Cast iron	110	Open	0	0	0	0
P-284	NS1	PMP-9	10	150	Steel	110	Open	0	0	0	0
P-285	PMP-9	NS2	1,300	150	Ductile Iron	110	Open	0	0	0	0
P-286	T01-02	J-149	200	200	Asbestos Ce	110	Closed	0	0	0	0
P-287	J-149	Malkarnem	10	200	Asbestos Ce	110	Open	0	0	0	0
P-288	T02-07	J-150	200	200	Cast iron	110	Closed	0	0	0	0
P-289	J-150	Rivona	10	200	Cast iron	110	Open	0	0	0	0
P-290	T02-04	J-151	200	200	Cast iron	110	Closed	0	0	0	0
P-291	J-151	Zambaulim	92	200	Cast iron	110	Open	0	0	0	0
P-292	T-03	J-152	500	200	Cast iron	110	Closed	0	0	0	0
P-293	J-152	Shivoi	10	200	Cast iron	110	Open	0	0	0	0
P-294	T-06	J-153	1,350	200	Ductile Iron	110	Closed	0	0	0	0
P-295	J-153	NQ1	50	200	Ductile Iron	110	Open	0	0	0	0
P-297	J-154	J-124	3,300	150	Ductile Iron	110	Open	0	0	0	0
P-298	NQ4/S	PMP-10	10	150	Steel	110	Open	0	0	0	0
P-299	PMP-10	J-154	25	150	Ductile Iron	110	Open	0	0	0	0
P-300	T06-05	J-155	25	150	Ductile Iron	110	Closed	0	0	0	0
P-301	J-155	NQ4/S	10	150	Ductile Iron	110	Open	0	0	0	0
P-302	T07-11	J-156	200	350	Cast iron	110	Open	21898	2.63	4.63	23.13
P-303	J-156	Veroda	10	350	Cast iron	110	Open	21898	2.63	0.23	23.13
P-304	T07-23	J-157	4,300	300	Cast iron	110	Closed	0	0	0	0
P-305	J-157	Velim	10	300	Cast iron	110	Open	0	0	0	0
P-306	J-123	J-158	100	200	Ductile Iron	110	Closed	0	0	0	0
P-307	J-158	NQ2	10	200	Ductile Iron	110	Open	0	0	0	0
P-309	J-159	NQ3	4,700	200	Ductile Iron	110	Closed	0	0	0	0
P-310	NQ2	PMP-11	10	200	Steel	110	Open	0	0	0	0
P-311	PMP-11	J-159	100	200	Ductile Iron	110	Open	0	0	0	0
P-312	T10-08	J-160	2,000	150	Cast iron	110	Closed	0	0	0	0
P-313	J-160	Deusa	10	150	Cast iron	110	Open	0	0	0	0
P-314	T10-08	J-161	1,400	200	Cast iron	110	Closed	0	0	0	0
P-315	J-161	Baida	10	200	Cast iron	110	Open	0	0	0	0
P-316	T10-03	J-162	500	200	Cast iron	110	Open	6,401	2.36	18.1	36.21
P-317	J-162	Sarzora	10	200	Cast iron	110	Open	6401	2.36	0.36	36.21
P-318	T-09	J-163	2,800	250	Asbestos Ce	110	Closed	0	0	0	0

Table F34.1.3 Pipeline Details at 06:00 for Salaulim Scheme (4/5)

Pipe No.	From Node	To Node	Length (m)	Diameter (mm)	Material	Hazen-Williams C	Control Status	Discharge (m^3/day)	Velocity (m/s)	Pressure Pipe Headloss (m)	Headloss Gradient (m/km)
P-319	J-163	Chandor	10	250	Asbestos Ce	110	Open	0	0	0	0
P-320	T-12	J-164	50	250	Cast iron	110	Closed	0	0	0	0
P-321	J-164	St Jose De A	10	250	Cast iron	110	Open	0	0	0	0
P-322	T14-02	J-165	3,500	300	Cast iron	110	Closed	0	0	0	0
P-323	J-165	Girdolim	10	300	Cast iron	110	Open	0	0	0	0
P-324	T14-06	J-166	200	300	Cast iron	110	Closed	0	0	0	0
P-325	J-166	Curtorim	10	300	Cast iron	110	Open	0	0	0	0
P-326	T14-06	J-167	3,200	200	Cast iron	110	Closed	0	0	0	0
P-327	J-167	Makazana	10	200	Cast iron	110	Open	0	0	0	0
P-328	T15-06	J-168	500	600	Cast iron	110	Closed	0	0	0	0
P-329	J-168	Borda/Monte	10	600	Cast iron	110	Open	0	0	0	0
P-330	T15-06	J-169	700	600	Cast iron	110	Closed	0	0	0	0
P-331	J-169	Aquem	10	600	Cast iron	110	Open	0	0	0	0
P-332	T-18	J-170	200	600	Steel	110	Closed	0	0	0	0
P-333	J-170	Gogol Sump	10	600	Steel	110	Open	0	0	0	0
P-334	T18-07	J-171	600	300	Cast iron	110	Closed	0	0	0	0
P-335	J-171	Near MBR	10	300	Cast iron	110	Open	0	0	0	0
P-336	T18-09	J-172	2,700	400	Cast iron	110	Closed	0	0	0	0
P-337	J-172	Monte Hill	10	400	Cast iron	110	Open	0	0	0	0
P-338	T18-11	J-173	950	400	Cast iron	110	Closed	0	0	0	0
P-339	J-173	Dongar Wad	10	400	Cast iron	110	Open	0	0	0	0
P-340	T18-11	J-174	300	400	Cast iron	110	Closed	0	0	0	0
P-341	J-174	Fatorda	10	400	Cast iron	110	Open	0	0	0	0
P-342	T20-15	J-175	10	500	Cast iron	110	Closed	0	0	0	0
P-343	J-175	Colva	10	500	Cast iron	110	Open	0	0	0	0
P-344	T20-15	J-176	3,500	200	Cast iron	110	Closed	0	0	0	0
P-345	J-176	Betalbatim	10	200	Cast iron	110	Open	0	0	0	0
P-346	T21-02	J-177	300	150	Cast iron	110	Closed	0	0	0	0
P-347	J-177	Damon Raia	130	150	Cast iron	110	Open	0	0	0	0
P-348	T21-07	J-178	1,000	150	Cast iron	110	Closed	0	0	0	0
P-349	J-178	Collea Dong	10	150	Cast iron	110	Open	0	0	0	0
P-350	T21-15	J-179	100	250	Cast iron	110	Closed	0	0	0	0
P-351	J-179	Camurlim	10	250	Cast iron	110	Open	0	0	0	0
P-352	T21-15	J-180	1,400	250	Cast iron	110	Closed	0	0	0	0
P-353	J-180	Loutoulim	10	250	Cast iron	110	Open	0	0	0	0
P-354	T-23	J-181	50	250	Cast iron	110	Closed	0	0	0	0
P-355	J-181	Manora Raia	10	250	Cast iron	110	Open	0	0	0	0
P-356	T-28	J-182	1,300	200	Asbestos Ce	110	Open	0	0	0	0
P-357	J-182	Consua	10	300	Ductile Iron	110	Closed	0	0	0	0
P-358	T-31	J-184	500	200	Cast iron	110	Open	0	0	0	0
P-359	J-183	Verna Sump	10	1,200	PSC	110	Open	208308	2.13	0.04	3.71
P-360	J-184	Upasnagar, S	10	200	Cast iron	110	Closed	0	0	0	0
P-361	T31-12	J-185	1,600	250	Cast iron	110	Closed	0	0	0	0
P-362	J-185	Nagao	10	250	Cast iron	110	Open	0	0	0	0
P-363	T38-29	J-186	100	100	Cast iron	110	Closed	0	0	0	0
P-364	J-186	Quelossim	10	100	Cast iron	110	Open	0	0	0	0
P-365	T38-25	J-187	500	150	Cast iron	110	Closed	0	0	0	0
P-366	J-187	Sancole	10	150	Cast iron	110	Open	0	0	0	0
P-367	T38-21	J-188	500	100	Cast iron	110	Closed	0	0	0	0
P-368	J-188	Rua Escirand	10	100	Cast iron	110	Open	0	0	0	0
P-369	T38-12	J-189	600	80	Cast iron	110	Closed	0	0	0	0
P-370	J-189	St Jacinto I.	10	80	Cast iron	110	Open	0	0	0	0
P-371	T-37	J-190	150	300	Steel	110	Closed	0	0	0	0
P-372	J-190	Dabolim	10	300	Steel	110	Open	0	0	0	0
P-373	T39-02	J-191	300	250	Cast iron	110	Closed	0	0	0	0
P-374	J-191	Issorcim	10	250	Cast iron	110	Open	0	0	0	0
P-375	T39-02	J-192	2,000	250	Cast iron	110	Open	6506	1.53	25.17	12.58
P-376	J-192	Bogmalo	10	250	Cast iron	110	Open	6506	1.53	0.13	12.58
P-377	T-47	J-193	400	250	Cast iron	110	Closed	0	0	0	0
P-378	J-193	Mangor	10	250	Cast iron	110	Open	0	0	0	0
P-379	T-48	J-194	70	250	Cast iron	110	Closed	0	0	0	0
P-380	J-194	Gandhi Naga	10	250	Cast iron	110	Open	0	0	0	0
P-381	T44-03	J-195	100	300	Cast iron	110	Open	20,551	3.36	4.36	43.58
P-382	J-195	New Vadden	39	300	Cast iron	110	Open	20,551	3.36	1.7	43.58
P-383	T44-03	J-196	800	250	Cast iron	110	Open	7,285	1.72	12.41	15.52

Table F34.1.3 Pipeline Details at 06:00 for Salaulim Scheme (5/5)

Pipe No.	From Node	To Node	Length (m)	Diameter (mm)	Material	Hazen-Williams C	Control Status	Discharge (m^3/day)	Velocity (m/s)	Pressure Pipe Headloss (m)	Headloss Gradient (m/km)
P-384	J-196	New Vadden	10	250	Cast iron	110	Open	7285	1.72	0.16	15.52
P-385	T38-54	J-197	200	150	Cast iron	110	Open	3612	2.37	10.19	50.96
P-386	J-197	New Vadden	10	150	Cast iron	110	Open	3612	2.37	0.51	50.96
P-387	T38-32	J-198	300	200	Cast iron	110	Closed	0	0	0	0
P-388	J-198	Chicalim	10	200	Cast iron	110	Open	0	0	0	0
P-389	T38-32	J-199	1,000	200	Cast iron	110	Closed	0	0	0	0
P-390	J-199	Chicalim 60(	10	200	Cast iron	110	Open	0	0	0	0
P-391	T38-56	J-200	100	300	Cast iron	110	Closed	0	0	0	0
P-392	J-200	INS Gomant	10	300	Cast iron	110	Open	0	0	0	0
P-393	T-49	J-201	2,100	300	Cast iron	110	Closed	0	0	0	0
P-394	J-201	Mid-land Sa	201	300	Cast iron	110	Open	0	0	0	0
P-396	J-202	Head-land S	10	600	Steel	110	Open	41482	1.7	0.05	5.47
P-397	Salaulim WT	FCV-2	10	1,400	Steel	110	Open	90000	0.68	0	0.37
P-398	FCV-2	T-70	10	1,400	Steel	110	Open	90000	0.68	0	0.37
P-399	T-70	J-205	10	1,400	Steel	110	Open	96334	0.72	0	0.42
P-400	J-205	PMP-12	10	1,100	Steel	110	Open	48167	0.59	0	0.38
P-401	PMP-12	J-204	10	1,100	Steel	110	Open	48,167	0.59	0	0.38
P-402	J-205	PMP-13	10	1,100	Steel	110	Open	48,167	0.59	0	0.38
P-403	PMP-13	J-204	10	1,100	Steel	110	Open	48,167	0.59	0	0.38
P-404	J-204	J-203	7,250	1,400	Steel	110	Open	96,334	0.72	3.04	0.42
P-405	J-203	New Sirvoi N	250	1,400	Steel	110	Open	96,334	0.72	0.1	0.42
P-406	New Sirvoi N	J-206	300	1,400	Steel	110	Open	110,473	0.83	0.16	0.54
P-408	Xelpem	T00-11	3,200	300	Ductile Iron	110	Open	227	0.04	0.03	0.01
P-410	T07-18	T07-35	1,650	200	Ductile Iron	110	Closed	0	0	0	0
P-411	T07-10	T07-11	500	200	Ductile Iron	110	Closed	0	0	0	0
P-412	T07-11	T07-18	2,800	200	Ductile Iron	110	Closed	0	0	0	0
P-413	Balli Sump	PMP-14	10	300	Steel	110	Open	0	0	0	0
P-414	PMP-14	Balli	450	300	Ductile Iron	110	Open	0	0	0	0
P-415	Balli	T07-36	450	300	Cast iron	110	Open	2492	0.41	0.39	0.88
P-416	Verna MBR	T-31	850	900	Ductile Iron	110	Open	50888	0.93	0.94	1.11
P-422	T-37	T-38	300	900	Ductile Iron	110	Open	39643	0.72	0.21	0.7
P-429	T-31	J-184	500	300	Ductile Iron	110	Open	0	0	0	0
P-430	T38-21	J-188	500	150	Ductile Iron	110	Closed	0	0	0	0
P-432	T38-43	J-199	100	200	Cast iron	110	Closed	0	0	0	0
P-433	T38-57	Mid-land Sa	2,500	250	Cast iron	110	Open	0	0	0	0
P-442	J-131	J-215	1,050	250	Ductile Iron	110	Open	0	0	0	0
P-443	J-214	J-130	2,500	250	Ductile Iron	110	Open	0	0	0	0
P-445	J-215	J-147	50	250	Ductile Iron	110	Closed	0	0	0	0
P-446	PMP-8	J-214	50	250	Ductile Iron	110	Open	0	0	0	0
P-447	J-148	J-131	1,500	250	Ductile Iron	110	Open	0	0	0	0
P-448	J-228	T00-20	500	300	Ductile Iron	110	Open	0	0	0	0
P-449	T00-20	J-148	500	300	Ductile Iron	110	Open	0	0	0	0
P-450	J-148	J-216	100	300	Cast iron	110	Closed	0	0	0	0
P-451	J-216	Pentemol(Cu	10	300	Cast iron	110	Open	0	0	0	0
P-454	T38-25	J-223	300	500	Cast iron	110	Open	12,335	0.73	0.42	1.41
P-455	J-223	T38-21	2,800	500	Cast iron	110	Open	12,335	0.73	3.94	1.41
P-458	J-225	PBV-1	17,300	1,400	Steel	110	Open	101046	0.76	7.94	0.46
P-459	PBV-1	T-18	10	1,400	Steel	110	Open	101046	0.76	0	0.46
P-468	J-206	J-225	1,600	1,400	Steel	110	Open	110,473	0.83	0.87	0.54
P-470	J-225	T03-03	100	450	Ductile Iron	110	Open	9427	0.69	0.14	1.43
P-471	T03-05	J-226	2,700	150	Cast iron	110	Open	309	0.2	1.45	0.54
P-472	J-226	J-227	1,200	150	Cast iron	110	Open	309	0.2	0.64	0.54
P-473	J-227	T03-15	1,100	150	Cast iron	110	Open	2,271	1.49	23.73	21.57
P-474	T03-05	J-226	2,700	400	Ductile Iron	110	Open	4075	0.38	1.45	0.54
P-475	T00-17	J-228	1,400	300	Cast iron	110	Open	-2112	0.35	0.9	0.64
P-476	J-228	T00-20	500	300	Cast iron	110	Open	0	0	0	0
P-477	J-227	J-228	1,400	300	Ductile Iron	110	Open	2,113	0.35	0.9	0.64
P-478	J-226	J-227	1,200	400	Ductile Iron	110	Open	4075	0.38	0.64	0.54
P-479	T-20	T20-06	1,600	600	Cast iron	110	Closed	0	0	0	0
P-480	T20-06	T20-10	1,900	600	Cast iron	110	Open	14,158	0.58	1.42	0.75
P-481	T18-09	T20-06	800	400	Cast iron	110	Open	14,158	1.3	4.31	5.38
P-482	T20-06	T18-10	800	400	Cast iron	110	Open	0	0	0	0

Table F34.1.4 Pipeline Details at 12:00 for Salaulim Scheme (1/5)

Pipe No.	From Node	To Node	Length (m)	Diameter (mm)	Material	Hazen-Williams C	Control Status	Discharge (m^3/day)	Velocity (m/s)	Pressure Pipe Headloss (m)	Headloss Gradient (m/km)
P-1	T-00	T-01	4,974	1,400	Steel	110	Open	162,040	1.22	5.47	1.1
P-2	T-01	J-207	1,352	1,400	Steel	110	Open	161,645	1.22	1.48	1.1
P-2+	J-207	T-02	1,750	1,400	Steel	110	Open	161,645	1.22	1.92	1.1
P-3	T-02	T-03	740	1,400	PSC	110	Open	159,071	1.2	0.79	1.06
P-4	T-03	T-04	1,178	1,400	PSC	110	Open	159,071	1.2	1.25	1.06
P-5	T-04	T-05	1,752	1,400	PSC	110	Open	159,018	1.2	1.86	1.06
P-6	T-05	T-06	791	1,400	PSC	110	Open	157,715	1.19	0.83	1.05
P-7	T-06	T-08	2,989	1,400	PSC	110	Open	145,169	1.09	2.68	0.9
P-8	T-08	T-09	2,965	1,400	PSC	110	Open	144,710	1.09	2.65	0.89
P-9	T-09	T-12	915	1,400	Steel	110	Open	134,843	1.01	0.72	0.78
P-10	T-12	T-13	3,910	1,400	Steel	110	Open	134,843	1.01	3.06	0.78
P-11	T-13	T-14	990	1,400	PSC	110	Open	121,776	0.92	0.64	0.65
P-12	T-14	T-16	10	1,400	PSC	110	Open	121,776	0.92	0.01	0.65
P-13	T-16	T-17	750	1,200	PSC	110	Open	121,340	1.24	1.02	1.36
P-14	T-17	T-18	300	1,200	PSC	110	Open	120,590	1.23	0.4	1.35
P-15	T-18	T-19	510	1,200	PSC	110	Open	219,296	2.24	2.08	4.08
P-16	T-19	T-20	1,290	1,200	PSC	110	Open	218,546	2.24	5.23	4.06
P-17	T-20	T-21	700	1,200	PSC	110	Open	218,546	2.24	2.84	4.06
P-18	T-21	T-22	700	1,200	PSC	110	Open	218,472	2.24	2.84	4.05
P-19	T-22	T-23	100	1,200	PSC	110	Open	218,169	2.23	0.4	4.04
P-20	T-23	T-24	2,760	1,200	PSC	110	Open	218,169	2.23	11.16	4.04
P-21	T-24	T-25	2,465	1,200	PSC	110	Open	209,298	2.14	9.23	3.74
P-22	T-25	T-27	1,000	1,200	PSC	110	Open	206,348	2.11	3.65	3.65
P-23	T-27	T-28	1,225	1,200	PSC	110	Open	202,658	2.07	4.32	3.53
P-24	T-28	T-29	250	1,200	PSC	110	Open	199,787	2.04	0.86	3.43
P-25	T-29	J-183	200	1,200	PSC	110	Open	198,968	2.04	0.68	3.41
P-26	Verna MBR	T-31	850	900	PSC	110	Open	59,423	1.08	1.25	1.48
P-27	T-31	T-32	1,700	900	PSC	110	Open	91,447	1.66	5.58	3.28
P-28	T-32	T-33	550	900	PSC	110	Open	89,124	1.62	1.72	3.13
P-29	T-33	T-34	550	900	PSC	110	Open	86,800	1.58	1.64	2.98
P-30	T-34	T-35	1,030	900	PSC	110	Open	84,477	1.54	2.92	2.83
P-31	T-35	T-37	1,570	900	PSC	110	Open	82,153	1.49	4.22	2.69
P-32	T-37	T-38	300	900	PSC	110	Open	41,077	0.75	0.22	0.75
P-33	T-38	T-39	500	900	PSC	110	Open	83,781	1.52	1.39	2.79
P-34	T-39	T-40	1,100	900	PSC	110	Open	74,925	1.36	2.49	2.27
P-35	T-40	T-44	1,800	900	PSC	110	Open	77,445	1.41	4.34	2.41
P-36	T-44	T-45	200	900	PSC	110	Open	50,929	0.93	0.22	1.11
P-37	T-45	T-46	500	900	PSC	110	Open	45,381	0.83	0.45	0.9
P-38	T-46	T-47	500	900	PSC	110	Open	39,833	0.72	0.35	0.7
P-39	T-47	T-48	700	600	PSC	110	Open	39,833	1.63	3.55	5.07
P-40	T-48	T-49	1,300	600	PSC	110	Open	39,833	1.63	6.59	5.07
P-41	T-49	J-202	1,360	600	Steel	110	Open	39,833	1.63	6.9	5.07
P-45	Xelpem	T00-11	3,200	300	Cast iron	110	Open	6,238	1.02	15.33	4.79
P-47	T00-11	T00-14	1,500	300	Cast iron	110	Open	12,476	2.04	25.94	17.29
P-49	T-01	T01-02	200	200	Asbestos Cer	110	Open	164	0.06	0.01	0.04
P-50	T01-02	T01-05	1,000	150	Cast iron	110	Open	164	0.11	0.17	0.17
P-52	T-02	T02-04	3,000	200	Cast iron	110	Open	2,573	0.95	20.09	6.7
P-53	T02-04	T02-07	3,000	200	Cast iron	110	Open	2,573	0.95	20.09	6.7
P-58	T03-05	T03-11	6,000	250	Asbestos Cer	110	Open	562	0.13	0.81	0.13
P-61	T07-11	T07-18	2,800	350	Cast iron	110	Open	7410	0.89	8.71	3.11
P-63	T07-18	T07-35	1,650	300	Cast iron	110	Closed	0	0	0	0
P-66	T07-35	Balli Sump	10	300	Cast iron	110	Open	0	0	0	0
P-67	T-06	T06-04	2,700	200	Asbestos Cer	110	Open	1,072	0.4	3.57	1.32
P-68	T06-04	T06-05	500	200	Asbestos Cer	110	Open	249	0.09	0.04	0.09
P-69	T-09	T10-03	1,500	250	Cast iron	110	Open	9,617	2.27	38.93	25.95
P-76	St Jose De A	T12-05	650	300	Asbestos Cer	110	Open	9,827	1.61	7.22	11.11
P-77	T12-05	T12-11	3,200	250	Asbestos Cer	110	Open	4,200	0.99	17.9	5.59
P-79	T-14	T14-02	1,000	300	Cast iron	110	Open	0	0	0	0
P-89	T19-05	T-19	2,100	300	Cast iron	110	Open	-750	0.12	0.2	0.09
P-93	T-21	T21-02	500	400	Cast iron	110	Open	74	0.01	0	0
P-94	T21-02	T21-07	1,000	400	Cast iron	110	Open	74	0.01	0	0
P-101	T14-02	T14-06	2,500	300	Cast iron	110	Open	0	0	0	0
P-106	T-31	T31-12	3,000	600	Cast iron	110	Open	20,612	0.84	4.49	1.5
P-108	T-39	T39-02	1,000	250	Cast iron	110	Open	8,855	2.09	22.28	22.28
P-114	T38-12	T38-06	2,600	500	Cast iron	110	Open	7,569	0.45	1.48	0.57
P-115	T38-06	T38-37	500	500	Cast iron	110	Open	5,941	0.35	0.18	0.36

Table F34.1.4 Pipeline Details at 12:00 for Salaulim Scheme (2/5)

Pipe No.	From Node	To Node	Length (m)	Diameter (mm)	Material	Hazen-Williams C	Control Status	Discharge (m^3/day)	Velocity (m/s)	Pressure Pipe Headloss (m)	Headloss Gradient (m/km)
P-117	T38-43	T38-48	900	400	Cast iron	110	Open	3,422	0.32	0.35	0.39
P-124	T38-54	T38-48	650	150	Cast iron	110	Open	-3,422	2.24	29.96	46.09
P-126	T-44	T44-03	300	300	Cast iron	110	Open	26,516	4.34	20.96	69.86
P-129	T38-48	T38-56	1,000	400	Cast iron	110	Open	0	0	0	0
P-136	Mid-land Sa	Head-land S	1,000	200	Cast iron	110	Closed	0	0	0	0
P-137	Margao MB	T18-07	600	600	Cast iron	110	Open	40,628	1.66	3.16	5.26
P-138	T18-07	T18-09	1,000	600	Cast iron	110	Open	40,628	1.66	5.26	5.26
P-139	Margao MB	Vasant Naga	500	150	Cast iron	110	Closed	0	0	0	0
P-142	T07-59	Khanaguinin	1,800	300	Cast iron	110	Open	0	0	0	0
P-143	T-24	T24-01	500	250	Cast iron	110	Open	8,871	2.09	11.17	22.35
P-144	T24-01	Nuvem	300	200	Cast iron	110	Open	8,871	3.27	19.88	66.26
P-145	T20-13	T20-15	600	500	Cast iron	110	Open	0	0	0	0
P-148	T-14	T15-06	3,000	600	Cast iron	110	Open	0	0	0	0
P-152	T18-10	T18-11	700	400	Cast iron	110	Open	0	0	0	0
P-153	T-21	T18-10	1,000	400	Cast iron	110	Closed	0	0	0	0
P-154	T38-29	T38-25	3,200	750	Cast iron	110	Open	15,995	0.42	1.01	0.32
P-156	T38-21	T38-12	2,300	500	Cast iron	110	Open	7,569	0.45	1.31	0.57
P-162	Salaulim W	FCV-1	10	1,400	Steel	110	Open	146,982	1.11	0.01	0.92
P-163	FCV-1	Salaulim Re	10	1,400	Steel	110	Open	146,982	1.11	0.01	0.92
P-164	Salaulim Re	T-00	10	1,400	Steel	110	Open	187,782	1.41	0.01	1.45
P-166	T21-13	T21-15	400	250	Cast iron	110	Open	0	0	0	0
P-167	T31-12	T31-23	2,500	600	Cast iron	110	Open	20,612	0.84	3.74	1.5
P-168	T31-23	T38-29	800	750	Cast iron	110	Open	20,612	0.54	0.4	0.5
P-169	T21-13	J-104	1,900	400	Cast iron	110	Open	0	0	0	0
P-170	J-104	T31-23	10,100	750	Cast iron	110	Closed	0	0	0	0
P-171	Gogol Sump	PMP-1	10	300	Steel	110	Open	33,203	5.44	1.06	105.95
P-173	Gogol Sump	PMP-2	10	300	Steel	110	Open	0	0	0	0
P-175	Verna Sump	PMP-3	10	500	Steel	110	Open	46,648	2.75	0.17	16.52
P-177	Verna Sump	PMP-4	10	500	Steel	110	Open	46,648	2.75	0.17	16.52
P-179	Verna Sump	PMP-5	10	500	Steel	110	Open	29,357	1.73	0.07	7.01
P-181	Verna Sump	PMP-6	10	500	Steel	110	Open	0	0	0	0
P-183	T38-43	T-40	1,600	250	Cast iron	110	Open	2,520	0.59	3.48	2.17
P-185	T-03	T03-03	1,000	300	Cast iron	110	Closed	0	0	0	0
P-186	T38-37	T38-43	700	500	Cast iron	110	Open	5,941	0.35	0.25	0.36
P-187	T03-03	T03-05	2,600	450	Ductile Iron	110	Open	17,179	1.25	11.28	4.34
P-188	T03-05	T03-12	1,500	300	Asbestos Ce	110	Open	1,435	0.23	0.47	0.32
P-189	T03-12	T03-13	1,500	200	Asbestos Ce	110	Open	1001	0.37	1.75	1.16
P-190	T03-13	T03-14	1,500	150	Asbestos Ce	110	Open	566	0.37	2.47	1.65
P-191	T-06	T07-10	4,400	450	Cast iron	110	Open	7410	0.54	4.02	0.91
P-192	T07-10	T07-11	500	350	Cast iron	110	Open	7410	0.89	1.55	3.11
P-193	T12-05	T12-07	600	300	Asbestos Ce	110	Open	5,628	0.92	2.37	3.96
P-194	T12-07	T12-08	1,100	250	Asbestos Ce	110	Open	0	0	0	0
P-195	PMP-2	T18-03	10	300	Steel	110	Open	0	0	0	0
P-196	PMP-1	T18-03	10	300	Steel	110	Open	33,203	5.44	1.06	105.95
P-197	T18-03	Margao MB	600	600	Cast iron	110	Open	33,203	1.36	2.17	3.62
P-199	T20-10	T20-13	4,000	500	Cast iron	110	Open	10,260	0.6	4	1
P-200	T20-13	T20-16	300	500	Cast iron	110	Open	10,260	0.6	0.3	1
P-201	T20-16	T20-19	600	400	PSC	110	Open	10,260	0.94	1.78	2.96
P-203	T20-38	T20-39	500	200	Cast iron	110	Open	0	0	0	0
P-204	T20-34	T20-38	1,500	300	Cast iron	110	Open	0	0	0	0
P-205	T-38	T38-03	140	700	Cast iron	110	Open	-1,628	0.05	0	0.01
P-206	T38-03	T38-06	1,560	600	Cast iron	110	Open	-1,628	0.07	0.02	0.01
P-207	T38-06	T38-32	500	200	Cast iron	110	Open	0	0	0	0
P-210	T38-56	T38-57	1,500	300	Cast iron	110	Closed	0	0	0	0
P-211	PMP-3	J-117	10	500	Steel	110	Open	46,648	2.75	0.17	16.52
P-214	J-117	Verna MBR	600	900	Steel	110	Open	122,654	2.23	3.39	5.65
P-215	PMP-4	J-117	10	500	Steel	110	Open	46,648	2.75	0.17	16.52
P-216	PMP-5	J-117	10	500	Steel	110	Open	29,357	1.73	0.07	7.01
P-217	PMP-6	J-117	10	500	Steel	110	Open	0	0	0	0
P-218	T00-11	T00-17	2,500	300	Cast iron	110	Closed	0	0	0	0
P-222	T07-36	T07-40	700	300	Cast iron	110	Open	6,790	1.11	3.92	5.6
P-224	T07-40	T07-46	1,800	300	Cast iron	110	Open	957	0.16	0.27	0.15
P-225	T07-46	T07-55	2,300	300	Cast iron	110	Open	405	0.07	0.07	0.03
P-226	T07-55	T07-59	1,200	300	Cast iron	110	Closed	0	0	0	0
P-229	T00-14	T00-51	3,600	250	Ductile Iron	110	Open	342	0.08	0.19	0.05

Table F34.1.4 Pipeline Details at 12:00 for Salaulim Scheme (3/5)

Pipe No.	From Node	To Node	Length (m)	Diameter (mm)	Material	Hazen-Williams C	Control Status	Discharge (m^3/day)	Velocity (m/s)	Pressure Pipe Headloss (m)	Headloss Gradient (m/km)
P-230	T00-51	J-128	8,300	150	Ductile Iron	110	Closed	0	0	0	0
P-231	J-128	NS1	400	150	Ductile Iron	110	Open	0	0	0	0
P-232	T00-51	T00-52	3,500	200	Ductile Iron	110	Open	86	0.03	0.04	0.01
P-235	T00-53	NS4 300GL	100	200	Ductile Iron	110	Open	901	0.33	0.1	0.96
P-237	J-130	NS5	50	250	Ductile Iron	110	Open	3,754	0.89	0.23	4.55
P-239	J-124	NQ4	50	150	Ductile Iron	110	Open	412	0.27	0.05	0.91
P-240	T07-40	J-123	2,500	200	Ductile Iron	110	Open	4919	1.81	55.58	22.23
P-245	T10-03	T10-05	1,500	250	Cast iron	110	Open	4,995	1.18	11.57	7.71
P-247	T21-07	T21-11	1,700	400	Cast iron	110	Open	74	0.01	0	0
P-248	T21-11	T21-13	800	400	Cast iron	110	Open	0	0	0	0
P-249	T20-19	T20-20	1,400	400	PSC	110	Open	10260	0.94	4.15	2.96
P-251	T10-05	T10-06	1,300	250	Cast iron	110	Open	4,454	1.05	8.11	6.24
P-252	T10-06	T10-08	800	250	Cast iron	110	Open	3,203	0.76	2.71	3.39
P-254	T20-25	T20-29	2,300	400	PSC	110	Open	2843	0.26	0.63	0.28
P-256	T07-18	T07-23	2,700	300	Cast iron	110	Open	7,409	1.21	17.79	6.59
P-258	T20-29	T20-30	1,000	400	PSC	110	Open	2078	0.19	0.15	0.15
P-259	T20-30	T20-34	1,500	400	PSC	110	Open	0	0	0	0
P-260	T20-20	T20-22	3,400	400	PSC	110	Open	10092	0.93	9.78	2.88
P-261	T20-22	T20-23	900	400	PSC	110	Open	5,921	0.55	0.96	1.07
P-262	T20-23	T20-25	1,800	400	PSC	110	Open	3,245	0.3	0.63	0.35
P-263	T-00	J-142	400	300	Cast iron	110	Open	25,603	4.19	26.19	65.47
P-264	J-142	Xelpem	10	300	Cast iron	110	Open	25603	4.19	0.65	65.47
P-265	T00-14	J-143	10	300	Cast iron	110	Open	12134	1.99	0.16	16.42
P-266	J-143	Sanguem	10	300	Cast iron	110	Open	12134	1.99	0.16	16.43
P-267	T00-52	J-145	100	200	Ductile Iron	110	Closed	0	0	0	0
P-268	J-144	T00-53	1,900	200	Ductile Iron	110	Open	901	0.33	1.82	0.96
P-269	J-145	NS3	10	200	Ductile Iron	110	Open	0	0	0	0
P-270	NS3	PMP-7	10	200	Steel	110	Open	901	0.33	0.01	0.96
P-271	PMP-7	J-144	100	200	Ductile Iron	110	Open	901	0.33	0.1	0.96
P-278	NS6	PMP-8	10	250	Steel	110	Open	3754	0.89	0.05	4.55
P-281	J-147	NS6	10	300	Ductile Iron	110	Open	0	0	0	0
P-282	T00-20	J-148	500	300	Cast iron	110	Open	5,017	0.82	1.6	3.2
P-284	NS1	PMP-9	10	150	Steel	110	Open	0	0	0	0
P-285	PMP-9	NS2	1,300	150	Ductile Iron	110	Open	0	0	0	0
P-286	T01-02	J-149	200	200	Asbestos Ce	110	Closed	0	0	0	0
P-287	J-149	Malkarnem	10	200	Asbestos Ce	110	Open	0	0	0	0
P-288	T02-07	J-150	200	200	Cast iron	110	Open	1441	0.53	0.46	2.29
P-289	J-150	Rivona	10	200	Cast iron	110	Open	1441	0.53	0.02	2.29
P-290	T02-04	J-151	200	200	Cast iron	110	Closed	0	0	0	0
P-291	J-151	Zambaulim	92	200	Cast iron	110	Open	0	0	0	0
P-292	T-03	J-152	500	200	Cast iron	110	Closed	0	0	0	0
P-293	J-152	Shivoi	10	200	Cast iron	110	Open	0	0	0	0
P-294	T-06	J-153	1,350	200	Ductile Iron	110	Open	4064	1.5	21.07	15.61
P-295	J-153	NQ1	50	200	Ductile Iron	110	Open	4064	1.5	0.78	15.61
P-297	J-154	J-124	3,300	150	Ductile Iron	110	Open	412	0.27	3.01	0.91
P-298	NQ4/S	PMP-10	10	150	Steel	110	Open	412	0.27	0.01	0.91
P-299	PMP-10	J-154	25	150	Ductile Iron	110	Open	412	0.27	0.02	0.91
P-300	T06-05	J-155	25	150	Ductile Iron	110	Closed	0	0	0	0
P-301	J-155	NQ4/S	10	150	Ductile Iron	110	Open	0	0	0	0
P-302	T07-11	J-156	200	350	Cast iron	110	Closed	0	0	0	0
P-303	J-156	Veroda	10	350	Cast iron	110	Open	0	0	0	0
P-304	T07-23	J-157	4,300	300	Cast iron	110	Open	6506	1.07	22.27	5.18
P-305	J-157	Velim	10	300	Cast iron	110	Open	6506	1.07	0.05	5.18
P-306	J-123	J-158	100	200	Ductile Iron	110	Open	4919	1.81	2.22	22.23
P-307	J-158	NQ2	10	200	Ductile Iron	110	Open	4919	1.81	0.22	22.23
P-309	J-159	NQ3	4,700	200	Ductile Iron	110	Open	1362	0.5	9.69	2.06
P-310	NQ2	PMP-11	10	200	Steel	110	Open	1362	0.5	0.02	2.06
P-311	PMP-11	J-159	100	200	Ductile Iron	110	Open	1362	0.5	0.21	2.06
P-312	T10-08	J-160	2,000	150	Cast iron	110	Open	0	0	0	0
P-313	J-160	Deusa	10	150	Cast iron	110	Closed	0	0	0	0
P-314	T10-08	J-161	1,400	200	Cast iron	110	Open	3,203	1.18	14.06	10.04
P-315	J-161	Baida	10	200	Cast iron	110	Open	3,203	1.18	0.1	10.04
P-316	T10-03	J-162	500	200	Cast iron	110	Open	4,622	1.7	9.91	19.81
P-317	J-162	Sarzora	10	200	Cast iron	110	Open	4622	1.7	0.2	19.81
P-318	T-09	J-163	2,800	250	Asbestos Ce	110	Closed	0	0	0	0

Table F34.1.4 Pipeline Details at 12:00 for Salaulim Scheme (4/5)

Pipe No.	From Node	To Node	Length (m)	Diameter (mm)	Material	Hazen-Williams C	Control Status	Discharge (m^3/day)	Velocity (m/s)	Pressure Pipe Headloss (m)	Headloss Gradient (m/km)
P-319	J-163	Chandor	10	250	Asbestos Ce	110	Open	0	0	0	0
P-320	T-12	J-164	50	250	Cast iron	110	Closed	0	0	0	0
P-321	J-164	St Jose De A	10	250	Cast iron	110	Open	0	0	0	0
P-322	T14-02	J-165	3,500	300	Cast iron	110	Closed	0	0	0	0
P-323	J-165	Girdolim	10	300	Cast iron	110	Open	0	0	0	0
P-324	T14-06	J-166	200	300	Cast iron	110	Closed	0	0	0	0
P-325	J-166	Curtorim	10	300	Cast iron	110	Open	0	0	0	0
P-326	T14-06	J-167	3,200	200	Cast iron	110	Closed	0	0	0	0
P-327	J-167	Makazana	10	200	Cast iron	110	Open	0	0	0	0
P-328	T15-06	J-168	500	600	Cast iron	110	Closed	0	0	0	0
P-329	J-168	Borda/Monte	10	600	Cast iron	110	Open	0	0	0	0
P-330	T15-06	J-169	700	600	Cast iron	110	Closed	0	0	0	0
P-331	J-169	Aquem	10	600	Cast iron	110	Open	0	0	0	0
P-332	T-18	J-170	200	600	Steel	110	Closed	0	0	0	0
P-333	J-170	Gogol Sump	10	600	Steel	110	Open	0	0	0	0
P-334	T18-07	J-171	600	300	Cast iron	110	Closed	0	0	0	0
P-335	J-171	Near MBR	10	300	Cast iron	110	Open	0	0	0	0
P-336	T18-09	J-172	2,700	400	Cast iron	110	Open	29994	2.76	58.37	21.62
P-337	J-172	Monte Hill	10	400	Cast iron	110	Open	29994	2.76	0.22	21.62
P-338	T18-11	J-173	950	400	Cast iron	110	Closed	0	0	0	0
P-339	J-173	Dongar Wad	10	400	Cast iron	110	Open	0	0	0	0
P-340	T18-11	J-174	300	400	Cast iron	110	Closed	0	0	0	0
P-341	J-174	Fatorda	10	400	Cast iron	110	Open	0	0	0	0
P-342	T20-15	J-175	10	500	Cast iron	110	Closed	0	0	0	0
P-343	J-175	Colva	10	500	Cast iron	110	Open	0	0	0	0
P-344	T20-15	J-176	3,500	200	Cast iron	110	Closed	0	0	0	0
P-345	J-176	Betalbatim	10	200	Cast iron	110	Open	0	0	0	0
P-346	T21-02	J-177	300	150	Cast iron	110	Closed	0	0	0	0
P-347	J-177	Damon Raia	130	150	Cast iron	110	Open	0	0	0	0
P-348	T21-07	J-178	1,000	150	Cast iron	110	Closed	0	0	0	0
P-349	J-178	Collea Dong	10	150	Cast iron	110	Open	0	0	0	0
P-350	T21-15	J-179	100	250	Cast iron	110	Closed	0	0	0	0
P-351	J-179	Camurlim	10	250	Cast iron	110	Open	0	0	0	0
P-352	T21-15	J-180	1,400	250	Cast iron	110	Closed	0	0	0	0
P-353	J-180	Loutoulim	10	250	Cast iron	110	Open	0	0	0	0
P-354	T-23	J-181	50	250	Cast iron	110	Closed	0	0	0	0
P-355	J-181	Manora Raia	10	250	Cast iron	110	Open	0	0	0	0
P-356	T-28	J-182	1,300	200	Asbestos Ce	110	Open	2872	1.06	10.67	8.21
P-357	J-182	Consua	10	300	Ductile Iron	110	Open	2872	0.47	0.01	1.14
P-358	T-31	J-184	500	200	Cast iron	110	Open	1738	0.64	1.62	3.24
P-359	J-183	Verna Sump	10	1,200	PSC	110	Open	198968	2.04	0.03	3.41
P-360	J-184	Upasnagar, S	10	200	Cast iron	110	Open	6788	2.5	0.4	40.36
P-361	T31-12	J-185	1,600	250	Cast iron	110	Closed	0	0	0	0
P-362	J-185	Nagao	10	250	Cast iron	110	Open	0	0	0	0
P-363	T38-29	J-186	100	100	Cast iron	110	Open	4,617	6.8	57.85	578.47
P-364	J-186	Quelossim	10	100	Cast iron	110	Open	4,617	6.8	5.78	578.47
P-365	T38-25	J-187	500	150	Cast iron	110	Open	4,480	2.93	37.96	75.91
P-366	J-187	Sancole	10	150	Cast iron	110	Open	4480	2.93	0.76	75.91
P-367	T38-21	J-188	500	100	Cast iron	110	Closed	0	0	0	0
P-368	J-188	Rua Escirand	10	100	Cast iron	110	Open	3947	5.82	4.33	432.67
P-369	T38-12	J-189	600	80	Cast iron	110	Closed	0	0	0	0
P-370	J-189	St Jacinto I.	10	80	Cast iron	110	Open	0	0	0	0
P-371	T-37	J-190	150	300	Steel	110	Closed	0	0	0	0
P-372	J-190	Dabolim	10	300	Steel	110	Open	0	0	0	0
P-373	T39-02	J-191	300	250	Cast iron	110	Open	8,855	2.09	6.68	22.28
P-374	J-191	Issorcim	10	250	Cast iron	110	Open	8855	2.09	0.22	22.27
P-375	T39-02	J-192	2,000	250	Cast iron	110	Closed	0	0	0	0
P-376	J-192	Bogmalo	10	250	Cast iron	110	Open	0	0	0	0
P-377	T-47	J-193	400	250	Cast iron	110	Closed	0	0	0	0
P-378	J-193	Mangor	10	250	Cast iron	110	Open	0	0	0	0
P-379	T-48	J-194	70	250	Cast iron	110	Closed	0	0	0	0
P-380	J-194	Gandhi Naga	10	250	Cast iron	110	Open	0	0	0	0
P-381	T44-03	J-195	100	300	Cast iron	110	Open	19,667	3.22	4.02	40.17
P-382	J-195	New Vadden	39	300	Cast iron	110	Open	19,667	3.22	1.57	40.17
P-383	T44-03	J-196	800	250	Cast iron	110	Open	6,849	1.61	11.07	13.84

Table F34.1.4 Pipeline Details at 12:00 for Salaulim Scheme (5/5)

Pipe No.	From Node	To Node	Length (m)	Diameter (mm)	Material	Hazen-Williams C	Control Status	Discharge (m^3/day)	Velocity (m/s)	Pressure Pipe Headloss (m)	Headloss Gradient (m/km)
P-384	J-196	New Vadden	10	250	Cast iron	110	Open	6849	1.61	0.14	13.84
P-385	T38-54	J-197	200	150	Cast iron	110	Open	3422	2.24	9.22	46.09
P-386	J-197	New Vadden	10	150	Cast iron	110	Open	3422	2.24	0.46	46.09
P-387	T38-32	J-198	300	200	Cast iron	110	Closed	0	0	0	0
P-388	J-198	Chicalim	10	200	Cast iron	110	Open	0	0	0	0
P-389	T38-32	J-199	1,000	200	Cast iron	110	Closed	0	0	0	0
P-390	J-199	Chicalim 60	10	200	Cast iron	110	Open	0	0	0	0
P-391	T38-56	J-200	100	300	Cast iron	110	Closed	0	0	0	0
P-392	J-200	INS Gomant	10	300	Cast iron	110	Open	0	0	0	0
P-393	T-49	J-201	2,100	300	Cast iron	110	Closed	0	0	0	0
P-394	J-201	Mid-land Sa	201	300	Cast iron	110	Open	0	0	0	0
P-396	J-202	Head-land S	10	600	Steel	110	Open	39833	1.63	0.05	5.07
P-397	Salaulim WT	FCV-2	10	1,400	Steel	110	Open	90000	0.68	0	0.37
P-398	FCV-2	T-70	10	1,400	Steel	110	Open	90000	0.68	0	0.37
P-399	T-70	J-205	10	1,400	Steel	110	Open	99580	0.75	0	0.45
P-400	J-205	PMP-12	10	1,100	Steel	110	Open	49790	0.61	0	0.4
P-401	PMP-12	J-204	10	1,100	Steel	110	Open	49,790	0.61	0	0.4
P-402	J-205	PMP-13	10	1,100	Steel	110	Open	49,790	0.61	0	0.4
P-403	PMP-13	J-204	10	1,100	Steel	110	Open	49,790	0.61	0	0.4
P-404	J-204	J-203	7,250	1,400	Steel	110	Open	99,580	0.75	3.24	0.45
P-405	J-203	New Sirvoi	250	1,400	Steel	110	Open	99,580	0.75	0.11	0.45
P-406	New Sirvoi	J-206	300	1,400	Steel	110	Open	115,884	0.87	0.18	0.59
P-408	Xelpem	T00-11	3,200	300	Ductile Iron	110	Open	6,238	1.02	15.33	4.79
P-410	T07-18	T07-35	1,650	200	Ductile Iron	110	Closed	0	0	0	0
P-411	T07-10	T07-11	500	200	Ductile Iron	110	Closed	0	0	0	0
P-412	T07-11	T07-18	2,800	200	Ductile Iron	110	Closed	0	0	0	0
P-413	Balli Sump	PMP-14	10	300	Steel	110	Open	3,573	0.59	0.02	1.71
P-414	PMP-14	Balli	450	300	Ductile Iron	110	Open	3,573	0.59	0.77	1.71
P-415	Balli	T07-36	450	300	Cast iron	110	Open	6790	1.11	2.52	5.6
P-416	Verna MBR	T-31	850	900	Ductile Iron	110	Open	59423	1.08	1.25	1.48
P-422	T-37	T-38	300	900	Ductile Iron	110	Open	41077	0.75	0.22	0.75
P-429	T-31	J-184	500	300	Ductile Iron	110	Open	5,049	0.83	1.62	3.24
P-430	T38-21	J-188	500	150	Ductile Iron	110	Open	3,947	2.58	30.02	60.04
P-432	T38-43	J-199	100	200	Cast iron	110	Closed	0	0	0	0
P-433	T38-57	Mid-land Sa	2,500	250	Cast iron	110	Open	0	0	0	0
P-442	J-131	J-215	1,050	250	Ductile Iron	110	Open	0	0	0	0
P-443	J-214	J-130	2,500	250	Ductile Iron	110	Open	3,754	0.89	11.36	4.55
P-445	J-215	J-147	50	250	Ductile Iron	110	Closed	0	0	0	0
P-446	PMP-8	J-214	50	250	Ductile Iron	110	Open	3,754	0.89	0.23	4.55
P-447	J-148	J-131	1,500	250	Ductile Iron	110	Open	0	0	0	0
P-448	J-228	T00-20	500	300	Ductile Iron	110	Open	5,017	0.82	1.6	3.2
P-449	T00-20	J-148	500	300	Ductile Iron	110	Open	5,017	0.82	1.6	3.2
P-450	J-148	J-216	100	300	Cast iron	110	Open	10,033	1.64	1.15	11.55
P-451	J-216	Pentemol(Cu	10	300	Cast iron	110	Open	10,033	1.64	0.12	11.55
P-454	T38-25	J-223	300	500	Cast iron	110	Open	11,515	0.68	0.37	1.24
P-455	J-223	T38-21	2,800	500	Cast iron	110	Open	11,515	0.68	3.47	1.24
P-458	J-225	PBV-1	17,300	1,400	Steel	110	Open	98706	0.74	7.6	0.44
P-459	PBV-1	T-18	10	1,400	Steel	110	Open	98706	0.74	0	0.44
P-468	J-206	J-225	1,600	1,400	Steel	110	Open	115,884	0.87	0.95	0.59
P-470	J-225	T03-03	100	450	Ductile Iron	110	Open	17179	1.25	0.43	4.34
P-471	T03-05	J-226	2,700	150	Cast iron	110	Open	944	0.62	11.45	4.24
P-472	J-226	J-227	1,200	150	Cast iron	110	Open	944	0.62	5.09	4.24
P-473	J-227	T03-15	1,100	150	Cast iron	110	Open	1,739	1.14	14.47	13.16
P-474	T03-05	J-226	2,700	400	Ductile Iron	110	Open	12448	1.15	11.45	4.24
P-475	T00-17	J-228	1,400	300	Cast iron	110	Open	-1620	0.27	0.55	0.39
P-476	J-228	T00-20	500	300	Cast iron	110	Open	5,017	0.82	1.6	3.2
P-477	J-227	J-228	1,400	300	Ductile Iron	110	Open	11,653	1.91	21.33	15.24
P-478	J-226	J-227	1,200	400	Ductile Iron	110	Open	12448	1.15	5.09	4.24
P-479	T-20	T20-06	1,600	600	Cast iron	110	Closed	0	0	0	0
P-480	T20-06	T20-10	1,900	600	Cast iron	110	Open	10,634	0.44	0.84	0.44
P-481	T18-09	T20-06	800	400	Cast iron	110	Open	10,634	0.98	2.53	3.17
P-482	T20-06	T18-10	800	400	Cast iron	110	Open	0	0	0	0

Table F34.1.5 Pipeline Details at 18:00 for Salaulim Scheme (1/5)

Pipe No.	From Node	To Node	Length (m)	Diameter (mm)	Material	Hazen-Williams C	Control Status	Discharge (m^3/day)	Velocity (m/s)	Pressure Pipe Headloss (m)	Headloss Gradient (m/km)
P-1	T-00	T-01	4,974	1,400	Steel	110	Open	162,840	1.22	5.52	1.11
P-2	T-01	J-207	1,352	1,400	Steel	110	Open	162,487	1.22	1.49	1.11
P-2+	J-207	T-02	1,750	1,400	Steel	110	Open	162,487	1.22	1.93	1.11
P-3	T-02	T-03	740	1,400	PSC	110	Open	158,803	1.19	0.78	1.06
P-4	T-03	T-04	1,178	1,400	PSC	110	Open	158,803	1.19	1.25	1.06
P-5	T-04	T-05	1,752	1,400	PSC	110	Open	158,755	1.19	1.86	1.06
P-6	T-05	T-06	791	1,400	PSC	110	Open	157,589	1.18	0.83	1.04
P-7	T-06	T-08	2,989	1,400	PSC	110	Open	142,313	1.07	2.59	0.86
P-8	T-08	T-09	2,965	1,400	PSC	110	Open	141,902	1.07	2.55	0.86
P-9	T-09	T-12	915	1,400	Steel	110	Open	137,955	1.04	0.75	0.82
P-10	T-12	T-13	3,910	1,400	Steel	110	Open	74,763	0.56	1.03	0.26
P-11	T-13	T-14	990	1,400	PSC	110	Open	63,068	0.47	0.19	0.19
P-12	T-14	T-16	10	1,400	PSC	110	Open	1,065	0.01	0	0
P-13	T-16	T-17	750	1,200	PSC	110	Open	675	0.01	0	0
P-14	T-17	T-18	300	1,200	PSC	110	Closed	0	0	0	0
P-15	T-18	T-19	510	1,200	PSC	110	Open	19,918	0.2	0.02	0.05
P-16	T-19	T-20	1,290	1,200	PSC	110	Open	19,243	0.2	0.06	0.05
P-17	T-20	T-21	700	1,200	PSC	110	Open	19,243	0.2	0.03	0.05
P-18	T-21	T-22	700	1,200	PSC	110	Open	14,708	0.15	0.02	0.03
P-19	T-22	T-23	100	1,200	PSC	110	Open	14,436	0.15	0	0.03
P-20	T-23	T-24	2,760	1,200	PSC	110	Open	14,436	0.15	0.07	0.03
P-21	T-24	T-25	2,465	1,200	PSC	110	Open	14,436	0.15	0.07	0.03
P-22	T-25	T-27	1,000	1,200	PSC	110	Open	11,564	0.12	0.02	0.02
P-23	T-27	T-28	1,225	1,200	PSC	110	Open	7,972	0.08	0.01	0.01
P-24	T-28	T-29	250	1,200	PSC	110	Open	733	0.01	0	0
P-25	T-29	J-183	200	1,200	PSC	110	Closed	0	0	0	0
P-26	Verna MBR	T-31	850	900	PSC	110	Open	73,607	1.34	1.87	2.19
P-27	T-31	T-32	1,700	900	PSC	110	Open	123,910	2.25	9.79	5.76
P-28	T-32	T-33	550	900	PSC	110	Open	121,654	2.21	3.06	5.57
P-29	T-33	T-34	550	900	PSC	110	Open	119,399	2.17	2.96	5.38
P-30	T-34	T-35	1,030	900	PSC	110	Open	117,144	2.13	5.34	5.19
P-31	T-35	T-37	1,570	900	PSC	110	Open	114,888	2.09	7.86	5.01
P-32	T-37	T-38	300	900	PSC	110	Open	40,750	0.74	0.22	0.73
P-33	T-38	T-39	500	900	PSC	110	Open	75,703	1.38	1.16	2.31
P-34	T-39	T-40	1,100	900	PSC	110	Open	69,716	1.27	2.18	1.98
P-35	T-40	T-44	1,800	900	PSC	110	Open	68,066	1.24	3.42	1.9
P-36	T-44	T-45	200	900	PSC	110	Open	48,963	0.89	0.21	1.03
P-37	T-45	T-46	500	900	PSC	110	Open	43,587	0.79	0.42	0.83
P-38	T-46	T-47	500	900	PSC	110	Open	38,212	0.7	0.33	0.65
P-39	T-47	T-48	700	600	PSC	110	Open	21,779	0.89	1.16	1.66
P-40	T-48	T-49	1,300	600	PSC	110	Open	21,779	0.89	2.16	1.66
P-41	T-49	J-202	1,360	600	Steel	110	Open	21,779	0.89	2.26	1.66
P-45	Xelpem	T00-11	3,200	300	Cast iron	110	Open	622	0.1	0.21	0.07
P-47	T00-11	T00-14	1,500	300	Cast iron	110	Open	1,244	0.2	0.36	0.24
P-49	T-01	T01-02	200	200	Asbestos Ce	110	Open	147	0.05	0.01	0.03
P-50	T01-02	T01-05	1,000	150	Cast iron	110	Open	147	0.1	0.14	0.14
P-52	T-02	T02-04	3,000	200	Cast iron	110	Open	3,684	1.36	39.04	13.01
P-53	T02-04	T02-07	3,000	200	Cast iron	110	Open	1,013	0.37	3.57	1.19
P-58	T03-05	T03-11	6,000	250	Asbestos Ce	110	Open	503	0.12	0.66	0.11
P-61	T07-11	T07-18	2,800	350	Cast iron	110	Open	14316	1.72	29.48	10.53
P-63	T07-18	T07-35	1,650	300	Cast iron	110	Open	13508	2.21	33.05	20.03
P-66	T07-35	Balli Sump	10	300	Cast iron	110	Open	13508	2.21	0.2	20.03
P-67	T-06	T06-04	2,700	200	Asbestos Ce	110	Open	960	0.35	2.91	1.08
P-68	T06-04	T06-05	500	200	Asbestos Ce	110	Open	223	0.08	0.04	0.07
P-69	T-09	T10-03	1,500	250	Cast iron	110	Open	3,724	0.88	6.72	4.48
P-76	St Jose De A	T12-05	650	300	Asbestos Ce	110	Open	8,795	1.44	5.88	9.05
P-77	T12-05	T12-11	3,200	250	Asbestos Ce	110	Open	3,758	0.89	14.58	4.56
P-79	T-14	T14-02	1,000	300	Cast iron	110	Open	13,664	2.24	20.47	20.47
P-89	T19-05	T-19	2,100	300	Cast iron	110	Open	-675	0.11	0.16	0.08
P-93	T-21	T21-02	500	400	Cast iron	110	Open	4,535	0.42	0.33	0.65
P-94	T21-02	T21-07	1,000	400	Cast iron	110	Open	4535	0.42	0.65	0.65
P-101	T14-02	T14-06	2,500	300	Cast iron	110	Open	13,664	2.24	51.16	20.47
P-106	T-31	T31-12	3,000	600	Cast iron	110	Open	19,143	0.78	3.92	1.31
P-108	T-39	T39-02	1,000	250	Cast iron	110	Open	5,987	1.41	10.79	10.79
P-114	T38-12	T38-06	2,600	500	Cast iron	110	Open	15,629	0.92	5.67	2.18
P-115	T38-06	T38-37	500	500	Cast iron	110	Open	21,426	1.26	1.96	3.91

Table F34.1.5 Pipeline Details at 18:00 for Salaulim Scheme (2/5)

Pipe No.	From Node	To Node	Length (m)	Diameter (mm)	Material	Hazen-Williams C	Control Status	Discharge (m^3/day)	Velocity (m/s)	Pressure Pipe Headloss (m)	Headloss Gradient (m/km)
P-117	T38-43	T38-48	900	400	Cast iron	110	Open	23,076	2.13	11.97	13.3
P-124	T38-54	T38-48	650	150	Cast iron	110	Open	-1,715	1.12	8.34	12.83
P-126	T-44	T44-03	300	300	Cast iron	110	Open	19,103	3.13	11.42	38.06
P-129	T38-48	T38-56	1,000	400	Cast iron	110	Open	21361	1.97	11.53	11.53
P-136	Mid-land Sa	Head-land S	1,000	200	Cast iron	110	Closed	0	0	0	0
P-137	Margao MB	T18-07	600	600	Cast iron	110	Open	56,913	2.33	5.89	9.82
P-138	T18-07	T18-09	1,000	600	Cast iron	110	Open	56,913	2.33	9.82	9.82
P-139	Margao MB	Vasant Naga	500	150	Cast iron	110	Closed	0	0	0	0
P-142	T07-59	Khanaguinin	1,800	300	Cast iron	110	Open	0	0	0	0
P-143	T-24	T24-01	500	250	Cast iron	110	Closed	0	0	0	0
P-144	T24-01	Nuvem	300	200	Cast iron	110	Open	0	0	0	0
P-145	T20-13	T20-15	600	500	Cast iron	110	Open	0	0	0	0
P-148	T-14	T15-06	3,000	600	Cast iron	110	Open	48339	1.98	21.78	7.26
P-152	T18-10	T18-11	700	400	Cast iron	110	Open	20680	1.9	7.6	10.86
P-153	T-21	T18-10	1,000	400	Cast iron	110	Closed	0	0	0	0
P-154	T38-29	T38-25	3,200	750	Cast iron	110	Open	19,143	0.5	1.41	0.44
P-156	T38-21	T38-12	2,300	500	Cast iron	110	Open	15,629	0.92	5.01	2.18
P-162	Salaulim WT	FCV-1	10	1,400	Steel	110	Open	146,982	1.11	0.01	0.92
P-163	FCV-1	Salaulim Res	10	1,400	Steel	110	Open	146,982	1.11	0.01	0.92
P-164	Salaulim Res	T-00	10	1,400	Steel	110	Open	162,965	1.23	0.01	1.11
P-166	T21-13	T21-15	400	250	Cast iron	110	Open	0	0	0	0
P-167	T31-12	T31-23	2,500	600	Cast iron	110	Open	19,143	0.78	3.26	1.31
P-168	T31-23	T38-29	800	750	Cast iron	110	Open	19,143	0.5	0.35	0.44
P-169	T21-13	J-104	1,900	400	Cast iron	110	Open	0	0	0	0
P-170	J-104	T31-23	10,100	750	Cast iron	110	Closed	0	0	0	0
P-171	Gogol Sump	PMP-1	10	300	Steel	110	Open	33,593	5.5	1.08	108.27
P-173	Gogol Sump	PMP-2	10	300	Steel	110	Open	0	0	0	0
P-175	Verna Sump	PMP-3	10	500	Steel	110	Open	46,794	2.76	0.17	16.61
P-177	Verna Sump	PMP-4	10	500	Steel	110	Open	46,794	2.76	0.17	16.61
P-179	Verna Sump	PMP-5	10	500	Steel	110	Open	29,448	1.74	0.07	7.05
P-181	Verna Sump	PMP-6	10	500	Steel	110	Open	0	0	0	0
P-183	T38-43	T-40	1,600	250	Cast iron	110	Open	-1,649	0.39	1.59	0.99
P-185	T-03	T03-03	1,000	300	Cast iron	110	Closed	0	0	0	0
P-186	T38-37	T38-43	700	500	Cast iron	110	Open	21,426	1.26	2.74	3.91
P-187	T03-03	T03-05	2,600	450	Ductile Iron	110	Open	6,423	0.47	1.82	0.7
P-188	T03-05	T03-12	1,500	300	Asbestos Ce	110	Open	1,284	0.21	0.38	0.26
P-189	T03-12	T03-13	1,500	200	Asbestos Ce	110	Open	896	0.33	1.42	0.95
P-190	T03-13	T03-14	1,500	150	Asbestos Ce	110	Open	507	0.33	2.01	1.34
P-191	T-06	T07-10	4,400	450	Cast iron	110	Open	14316	1.04	13.62	3.1
P-192	T07-10	T07-11	500	350	Cast iron	110	Open	14316	1.72	5.26	10.53
P-193	T12-05	T12-07	600	300	Asbestos Ce	110	Open	5,036	0.82	1.93	3.22
P-194	T12-07	T12-08	1,100	250	Asbestos Ce	110	Open	0	0	0	0
P-195	PMP-2	T18-03	10	300	Steel	110	Open	0	0	0	0
P-196	PMP-1	T18-03	10	300	Steel	110	Open	33,593	5.5	1.08	108.27
P-197	T18-03	Margao MB	600	600	Cast iron	110	Open	33,593	1.38	2.22	3.7
P-199	T20-10	T20-13	4,000	500	Cast iron	110	Open	9,182	0.54	3.26	0.81
P-200	T20-13	T20-16	300	500	Cast iron	110	Open	9,182	0.54	0.24	0.81
P-201	T20-16	T20-19	600	400	PSC	110	Open	9,182	0.85	1.45	2.41
P-203	T20-38	T20-39	500	200	Cast iron	110	Open	0	0	0	0
P-204	T20-34	T20-38	1,500	300	Cast iron	110	Open	0	0	0	0
P-205	T-38	T38-03	140	700	Cast iron	110	Open	5,797	0.17	0.01	0.07
P-206	T38-03	T38-06	1,560	600	Cast iron	110	Open	5,797	0.24	0.22	0.14
P-207	T38-06	T38-32	500	200	Cast iron	110	Open	0	0	0	0
P-210	T38-56	T38-57	1,500	300	Cast iron	110	Closed	0	0	0	0
P-211	PMP-3	J-117	10	500	Steel	110	Open	46,794	2.76	0.17	16.61
P-214	J-117	Verna MBR	600	900	Steel	110	Open	123,035	2.24	3.41	5.68
P-215	PMP-4	J-117	10	500	Steel	110	Open	46,794	2.76	0.17	16.61
P-216	PMP-5	J-117	10	500	Steel	110	Open	29,448	1.74	0.07	7.05
P-217	PMP-6	J-117	10	500	Steel	110	Open	0	0	0	0
P-218	T00-11	T00-17	2,500	300	Cast iron	110	Closed	0	0	0	0
P-222	T07-36	T07-40	700	300	Cast iron	110	Open	1,674	0.27	0.29	0.42
P-224	T07-40	T07-46	1,800	300	Cast iron	110	Open	856	0.14	0.22	0.12
P-225	T07-46	T07-55	2,300	300	Cast iron	110	Open	362	0.06	0.06	0.02
P-226	T07-55	T07-59	1,200	300	Cast iron	110	Closed	0	0	0	0
P-229	T00-14	T00-51	3,600	250	Ductile Iron	110	Open	1,244	0.29	2.12	0.59

Table F34.1.5 Pipeline Details at 18:00 for Salaulim Scheme (3/5)

Pipe No.	From Node	To Node	Length (m)	Diameter (mm)	Material	Hazen-Williams C	Control Status	Discharge (m^3/day)	Velocity (m/s)	Pressure Pipe Headloss (m)	Headloss Gradient (m/km)
P-230	T00-51	J-128	8,300	150	Ductile Iron	110	Open	938	0.61	34.84	4.2
P-231	J-128	NS1	400	150	Ductile Iron	110	Open	938	0.61	1.68	4.2
P-232	T00-51	T00-52	3,500	200	Ductile Iron	110	Open	77	0.03	0.04	0.01
P-235	T00-53	NS4 300GL	100	200	Ductile Iron	110	Open	892	0.33	0.09	0.94
P-237	J-130	NS5	50	250	Ductile Iron	110	Open	3,671	0.87	0.22	4.36
P-239	J-124	NQ4	50	150	Ductile Iron	110	Open	398	0.26	0.04	0.86
P-240	T07-40	J-123	2,500	200	Ductile Iron	110	Open	0	0	0	0
P-245	T10-03	T10-05	1,500	250	Cast iron	110	Open	3,724	0.88	6.72	4.48
P-247	T21-07	T21-11	1,700	400	Cast iron	110	Open	66	0.01	0	0
P-248	T21-11	T21-13	800	400	Cast iron	110	Open	0	0	0	0
P-249	T20-19	T20-20	1,400	400	PSC	110	Open	9182	0.85	3.38	2.41
P-251	T10-05	T10-06	1,300	250	Cast iron	110	Open	3,239	0.76	4.5	3.46
P-252	T10-06	T10-08	800	250	Cast iron	110	Open	2,120	0.5	1.26	1.58
P-254	T20-25	T20-29	2,300	400	PSC	110	Open	2544	0.23	0.52	0.22
P-256	T07-18	T07-23	2,700	300	Cast iron	110	Open	808	0.13	0.29	0.11
P-258	T20-29	T20-30	1,000	400	PSC	110	Open	1859	0.17	0.13	0.13
P-259	T20-30	T20-34	1,500	400	PSC	110	Open	0	0	0	0
P-260	T20-20	T20-22	3,400	400	PSC	110	Open	9032	0.83	7.96	2.34
P-261	T20-22	T20-23	900	400	PSC	110	Open	5,299	0.49	0.78	0.87
P-262	T20-23	T20-25	1,800	400	PSC	110	Open	2,904	0.27	0.52	0.29
P-263	T-00	J-142	400	300	Cast iron	110	Closed	0	0	0	0
P-264	J-142	Xelpem	10	300	Cast iron	110	Open	0	0	0	0
P-265	T00-14	J-143	10	300	Cast iron	110	Closed	0	0	0	0
P-266	J-143	Sanguem	10	300	Cast iron	110	Open	0	0	0	0
P-267	T00-52	J-145	100	200	Ductile Iron	110	Closed	0	0	0	0
P-268	J-144	T00-53	1,900	200	Ductile Iron	110	Open	892	0.33	1.79	0.94
P-269	J-145	NS3	10	200	Ductile Iron	110	Open	0	0	0	0
P-270	NS3	PMP-7	10	200	Steel	110	Open	892	0.33	0.01	0.94
P-271	PMP-7	J-144	100	200	Ductile Iron	110	Open	892	0.33	0.09	0.94
P-278	NS6	PMP-8	10	250	Steel	110	Open	3671	0.87	0.04	4.36
P-281	J-147	NS6	10	300	Ductile Iron	110	Open	0	0	0	0
P-282	T00-20	J-148	500	300	Cast iron	110	Open	0	0	0	0
P-284	NS1	PMP-9	10	150	Steel	110	Open	590	0.39	0.02	1.78
P-285	PMP-9	NS2	1,300	150	Ductile Iron	110	Open	590	0.39	2.31	1.78
P-286	T01-02	J-149	200	200	Asbestos Ce	110	Closed	0	0	0	0
P-287	J-149	Malkarnem	10	200	Asbestos Ce	110	Open	0	0	0	0
P-288	T02-07	J-150	200	200	Cast iron	110	Closed	0	0	0	0
P-289	J-150	Rivona	10	200	Cast iron	110	Open	0	0	0	0
P-290	T02-04	J-151	200	200	Cast iron	110	Open	2671	0.98	1.44	7.18
P-291	J-151	Zambaulim	92	200	Cast iron	110	Open	2671	0.98	0.66	7.18
P-292	T-03	J-152	500	200	Cast iron	110	Closed	0	0	0	0
P-293	J-152	Shivoi	10	200	Cast iron	110	Open	0	0	0	0
P-294	T-06	J-153	1,350	200	Ductile Iron	110	Closed	0	0	0	0
P-295	J-153	NQ1	50	200	Ductile Iron	110	Open	0	0	0	0
P-297	J-154	J-124	3,300	150	Ductile Iron	110	Open	398	0.26	2.83	0.86
P-298	NQ4/S	PMP-10	10	150	Steel	110	Open	398	0.26	0.01	0.86
P-299	PMP-10	J-154	25	150	Ductile Iron	110	Open	398	0.26	0.02	0.86
P-300	T06-05	J-155	25	150	Ductile Iron	110	Closed	0	0	0	0
P-301	J-155	NQ4/S	10	150	Ductile Iron	110	Open	0	0	0	0
P-302	T07-11	J-156	200	350	Cast iron	110	Closed	0	0	0	0
P-303	J-156	Veroda	10	350	Cast iron	110	Open	0	0	0	0
P-304	T07-23	J-157	4,300	300	Cast iron	110	Closed	0	0	0	0
P-305	J-157	Velim	10	300	Cast iron	110	Open	0	0	0	0
P-306	J-123	J-158	100	200	Ductile Iron	110	Closed	0	0	0	0
P-307	J-158	NQ2	10	200	Ductile Iron	110	Open	0	0	0	0
P-309	J-159	NQ3	4,700	200	Ductile Iron	110	Open	1344	0.5	9.45	2.01
P-310	NQ2	PMP-11	10	200	Steel	110	Open	1344	0.5	0.02	2.01
P-311	PMP-11	J-159	100	200	Ductile Iron	110	Open	1344	0.5	0.2	2.01
P-312	T10-08	J-160	2,000	150	Cast iron	110	Open	2120	1.39	37.98	18.99
P-313	J-160	Deusa	10	150	Cast iron	110	Open	2120	1.39	0.19	18.99
P-314	T10-08	J-161	1,400	200	Cast iron	110	Closed	0	0	0	0
P-315	J-161	Baida	10	200	Cast iron	110	Open	0	0	0	0
P-316	T10-03	J-162	500	200	Cast iron	110	Closed	0	0	0	0
P-317	J-162	Sarzora	10	200	Cast iron	110	Open	0	0	0	0
P-318	T-09	J-163	2,800	250	Asbestos Ce	110	Closed	0	0	0	0

Table F34.1.5 Pipeline Details at 18:00 for Salaulim Scheme (4/5)

Pipe No.	From Node	To Node	Length (m)	Diameter (mm)	Material	Hazen-Williams C	Control Status	Discharge (m^3/day)	Velocity (m/s)	Pressure Pipe Headloss (m)	Headloss Gradient (m/km)
P-319	J-163	Chandor	10	250	Asbestos Ce	110	Open	0	0	0	0
P-320	T-12	J-164	50	250	Cast iron	110	Open	63192	14.9	42.4	848.02
P-321	J-164	St Jose De A	10	250	Cast iron	110	Open	63,192	14.9	8.48	848.02
P-322	T14-02	J-165	3,500	300	Cast iron	110	Closed	0	0	0	0
P-323	J-165	Girdolim	10	300	Cast iron	110	Open	0	0	0	0
P-324	T14-06	J-166	200	300	Cast iron	110	Open	13664	2.24	4.09	20.47
P-325	J-166	Curtorim	10	300	Cast iron	110	Open	13,664	2.24	0.2	20.47
P-326	T14-06	J-167	3,200	200	Cast iron	110	Open	0	0	0	0
P-327	J-167	Makazana	10	200	Cast iron	110	Closed	0	0	0	0
P-328	T15-06	J-168	500	600	Cast iron	110	Closed	0	0	0	0
P-329	J-168	Borda/Monte	10	600	Cast iron	110	Open	0	0	0	0
P-330	T15-06	J-169	700	600	Cast iron	110	Open	48339	1.98	5.08	7.26
P-331	J-169	Aquem	10	600	Cast iron	110	Open	48,339	1.98	0.07	7.26
P-332	T-18	J-170	200	600	Steel	110	Closed	0	0	0	0
P-333	J-170	Gogol Sump	10	600	Steel	110	Open	0	0	0	0
P-334	T18-07	J-171	600	300	Cast iron	110	Closed	0	0	0	0
P-335	J-171	Near MBR	10	300	Cast iron	110	Open	0	0	0	0
P-336	T18-09	J-172	2,700	400	Cast iron	110	Open	26715	2.46	47.1	17.44
P-337	J-172	Monte Hill	10	400	Cast iron	110	Open	26715	2.46	0.17	17.44
P-338	T18-11	J-173	950	400	Cast iron	110	Closed	0	0	0	0
P-339	J-173	Dongar Wad	10	400	Cast iron	110	Open	0	0	0	0
P-340	T18-11	J-174	300	400	Cast iron	110	Open	20680	1.9	3.26	10.86
P-341	J-174	Fatorda	10	400	Cast iron	110	Open	20680	1.9	0.11	10.86
P-342	T20-15	J-175	10	500	Cast iron	110	Closed	0	0	0	0
P-343	J-175	Colva	10	500	Cast iron	110	Open	0	0	0	0
P-344	T20-15	J-176	3,500	200	Cast iron	110	Closed	0	0	0	0
P-345	J-176	Betalbatim	10	200	Cast iron	110	Open	0	0	0	0
P-346	T21-02	J-177	300	150	Cast iron	110	Closed	0	0	0	0
P-347	J-177	Damon Raia	130	150	Cast iron	110	Open	0	0	0	0
P-348	T21-07	J-178	1,000	150	Cast iron	110	Open	4469	2.93	75.59	75.59
P-349	J-178	Collea Dong	10	150	Cast iron	110	Open	4469	2.93	0.76	75.59
P-350	T21-15	J-179	100	250	Cast iron	110	Closed	0	0	0	0
P-351	J-179	Camurlim	10	250	Cast iron	110	Open	0	0	0	0
P-352	T21-15	J-180	1,400	250	Cast iron	110	Closed	0	0	0	0
P-353	J-180	Loutoulim	10	250	Cast iron	110	Open	0	0	0	0
P-354	T-23	J-181	50	250	Cast iron	110	Closed	0	0	0	0
P-355	J-181	Manora Raia	10	250	Cast iron	110	Open	0	0	0	0
P-356	T-28	J-182	1,300	200	Asbestos Ce	110	Open	7239	2.67	59.12	45.48
P-357	J-182	Consua	10	300	Ductile Iron	110	Open	7239	1.19	0.06	6.31
P-358	T-31	J-184	500	200	Cast iron	110	Open	1065	0.39	0.65	1.31
P-359	J-183	Verna Sump	10	1,200	PSC	110	Open	0	0	0	0
P-360	J-184	Upasnagar, S	10	200	Cast iron	110	Open	4161	1.53	0.16	16.31
P-361	T31-12	J-185	1,600	250	Cast iron	110	Closed	0	0	0	0
P-362	J-185	Nagao	10	250	Cast iron	110	Open	0	0	0	0
P-363	T38-29	J-186	100	100	Cast iron	110	Closed	0	0	0	0
P-364	J-186	Quelossim	10	100	Cast iron	110	Open	0	0	0	0
P-365	T38-25	J-187	500	150	Cast iron	110	Closed	0	0	0	0
P-366	J-187	Sancole	10	150	Cast iron	110	Open	0	0	0	0
P-367	T38-21	J-188	500	100	Cast iron	110	Closed	0	0	0	0
P-368	J-188	Rua Escirand	10	100	Cast iron	110	Open	3513	5.18	3.49	348.84
P-369	T38-12	J-189	600	80	Cast iron	110	Closed	0	0	0	0
P-370	J-189	St Jacinto I.	10	80	Cast iron	110	Open	0	0	0	0
P-371	T-37	J-190	150	300	Steel	110	Open	33,388	5.47	16.06	107.05
P-372	J-190	Dabolim	10	300	Steel	110	Open	33388	5.47	1.07	107.05
P-373	T39-02	J-191	300	250	Cast iron	110	Open	5,987	1.41	3.24	10.79
P-374	J-191	Issorcim	10	250	Cast iron	110	Open	5987	1.41	0.11	10.79
P-375	T39-02	J-192	2,000	250	Cast iron	110	Closed	0	0	0	0
P-376	J-192	Bogmalo	10	250	Cast iron	110	Open	0	0	0	0
P-377	T-47	J-193	400	250	Cast iron	110	Open	16432	3.87	28	70
P-378	J-193	Mangor	10	250	Cast iron	110	Open	16432	3.87	0.7	70
P-379	T-48	J-194	70	250	Cast iron	110	Closed	0	0	0	0
P-380	J-194	Gandhi Naga	10	250	Cast iron	110	Open	0	0	0	0
P-381	T44-03	J-195	100	300	Cast iron	110	Open	12,752	2.09	1.8	18.01
P-382	J-195	New Vadden	39	300	Cast iron	110	Open	12,752	2.09	0.7	18.01
P-383	T44-03	J-196	800	250	Cast iron	110	Open	6,351	1.5	9.63	12.04

Table F34.1.5 Pipeline Details at 18:00 for Salaulim Scheme (5/5)

Pipe No.	From Node	To Node	Length (m)	Diameter (mm)	Material	Hazen-Williams C	Control Status	Discharge (m^3/day)	Velocity (m/s)	Pressure Pipe Headloss (m)	Headloss Gradient (m/km)
P-384	J-196	New Vadden	10	250	Cast iron	110	Open	6351	1.5	0.12	12.04
P-385	T38-54	J-197	200	150	Cast iron	110	Open	1715	1.12	2.57	12.83
P-386	J-197	New Vadden	10	150	Cast iron	110	Open	1715	1.12	0.13	12.83
P-387	T38-32	J-198	300	200	Cast iron	110	Closed	0	0	0	0
P-388	J-198	Chicalim	10	200	Cast iron	110	Open	0	0	0	0
P-389	T38-32	J-199	1,000	200	Cast iron	110	Closed	0	0	0	0
P-390	J-199	Chicalim 60	10	200	Cast iron	110	Open	0	0	0	0
P-391	T38-56	J-200	100	300	Cast iron	110	Open	21,361	3.5	4.68	46.81
P-392	J-200	INS Gomant	10	300	Cast iron	110	Open	21361	3.5	0.47	46.81
P-393	T-49	J-201	2,100	300	Cast iron	110	Closed	0	0	0	0
P-394	J-201	Mid-land Sa	201	300	Cast iron	110	Open	0	0	0	0
P-396	J-202	Head-land S	10	600	Steel	110	Open	21779	0.89	0.02	1.66
P-397	Salaulim WT	FCV-2	10	1,400	Steel	110	Open	90000	0.68	0	0.37
P-398	FCV-2	T-70	10	1,400	Steel	110	Open	90000	0.68	0	0.37
P-399	T-70	J-205	10	1,400	Steel	110	Open	100883	0.76	0	0.46
P-400	J-205	PMP-12	10	1,100	Steel	110	Open	50441	0.61	0	0.41
P-401	PMP-12	J-204	10	1,100	Steel	110	Open	50,441	0.61	0	0.41
P-402	J-205	PMP-13	10	1,100	Steel	110	Open	50,441	0.61	0	0.41
P-403	PMP-13	J-204	10	1,100	Steel	110	Open	50,441	0.61	0	0.41
P-404	J-204	J-203	7,250	1,400	Steel	110	Open	100,883	0.76	3.32	0.46
P-405	J-203	New Sirvoi	250	1,400	Steel	110	Open	100,883	0.76	0.11	0.46
P-406	New Sirvoi	J-206	300	1,400	Steel	110	Open	26,342	0.2	0.01	0.04
P-408	Xelpem	T00-11	3,200	300	Ductile Iron	110	Open	622	0.1	0.21	0.07
P-410	T07-18	T07-35	1,650	200	Ductile Iron	110	Closed	0	0	0	0
P-411	T07-10	T07-11	500	200	Ductile Iron	110	Closed	0	0	0	0
P-412	T07-11	T07-18	2,800	200	Ductile Iron	110	Closed	0	0	0	0
P-413	Balli Sump	PMP-14	10	300	Steel	110	Open	3,572	0.58	0.02	1.71
P-414	PMP-14	Balli	450	300	Ductile Iron	110	Open	3,572	0.58	0.77	1.71
P-415	Balli	T07-36	450	300	Cast iron	110	Open	1674	0.27	0.19	0.42
P-416	Verna MBR	T-31	850	900	Ductile Iron	110	Open	73607	1.34	1.87	2.19
P-422	T-37	T-38	300	900	Ductile Iron	110	Open	40750	0.74	0.22	0.73
P-429	T-31	J-184	500	300	Ductile Iron	110	Open	3,095	0.51	0.65	1.31
P-430	T38-21	J-188	500	150	Ductile Iron	110	Open	3,513	2.3	24.2	48.4
P-432	T38-43	J-199	100	200	Cast iron	110	Closed	0	0	0	0
P-433	T38-57	Mid-land Sa	2,500	250	Cast iron	110	Open	0	0	0	0
P-442	J-131	J-215	1,050	250	Ductile Iron	110	Open	0	0	0	0
P-443	J-214	J-130	2,500	250	Ductile Iron	110	Open	3,671	0.87	10.9	4.36
P-445	J-215	J-147	50	250	Ductile Iron	110	Closed	0	0	0	0
P-446	PMP-8	J-214	50	250	Ductile Iron	110	Open	3,671	0.87	0.22	4.36
P-447	J-148	J-131	1,500	250	Ductile Iron	110	Open	0	0	0	0
P-448	J-228	T00-20	500	300	Ductile Iron	110	Open	0	0	0	0
P-449	T00-20	J-148	500	300	Ductile Iron	110	Open	0	0	0	0
P-450	J-148	J-216	100	300	Cast iron	110	Closed	0	0	0	0
P-451	J-216	Pentemol(Cu	10	300	Cast iron	110	Open	0	0	0	0
P-454	T38-25	J-223	300	500	Cast iron	110	Open	19,143	1.13	0.95	3.17
P-455	J-223	T38-21	2,800	500	Cast iron	110	Open	19,143	1.13	8.89	3.17
P-458	J-225	PBV-1	17,300	1,400	Steel	110	Open	19918	0.15	0.39	0.02
P-459	PBV-1	T-18	10	1,400	Steel	110	Open	19918	0.15	0	0.02
P-468	J-206	J-225	1,600	1,400	Steel	110	Open	26,342	0.2	0.06	0.04
P-470	J-225	T03-03	100	450	Ductile Iron	110	Open	6423	0.47	0.07	0.7
P-471	T03-05	J-226	2,700	150	Cast iron	110	Open	214	0.14	0.73	0.27
P-472	J-226	J-227	1,200	150	Cast iron	110	Open	214	0.14	0.33	0.27
P-473	J-227	T03-15	1,100	150	Cast iron	110	Open	1,571	1.03	11.99	10.9
P-474	T03-05	J-226	2,700	400	Ductile Iron	110	Open	2821	0.26	0.73	0.27
P-475	T00-17	J-228	1,400	300	Cast iron	110	Open	-1464	0.24	0.46	0.33
P-476	J-228	T00-20	500	300	Cast iron	110	Open	0	0	0	0
P-477	J-227	J-228	1,400	300	Ductile Iron	110	Open	1,464	0.24	0.46	0.33
P-478	J-226	J-227	1,200	400	Ductile Iron	110	Open	2821	0.26	0.33	0.27
P-479	T-20	T20-06	1,600	600	Cast iron	110	Closed	0	0	0	0
P-480	T20-06	T20-10	1,900	600	Cast iron	110	Open	9,519	0.39	0.68	0.36
P-481	T18-09	T20-06	800	400	Cast iron	110	Open	30,199	2.78	17.51	21.89
P-482	T20-06	T18-10	800	400	Cast iron	110	Open	20,680	1.9	8.69	10.86

Table F34.1.6 Pipeline Details at 24:00 for Salaulim Scheme (1/5)

Pipe No.	From Node	To Node	Length (m)	Diameter (mm)	Material	Hazen-Williams C	Control Status	Discharge (m^3/day)	Velocity (m/s)	Pressure Pipe Headloss (m)	Headloss Gradient (m/km)
P-1	T-00	T-01	4,974	1,400	Steel	110	Open	156,666	1.18	5.14	1.03
P-2	T-01	J-207	1,352	1,400	Steel	110	Open	156,488	1.18	1.39	1.03
P-2+	J-207	T-02	1,750	1,400	Steel	110	Open	156,488	1.18	1.8	1.03
P-3	T-02	T-03	740	1,400	PSC	110	Open	155,979	1.17	0.76	1.03
P-4	T-03	T-04	1,178	1,400	PSC	110	Open	155,979	1.17	1.21	1.03
P-5	T-04	T-05	1,752	1,400	PSC	110	Open	155,955	1.17	1.8	1.02
P-6	T-05	T-06	791	1,400	PSC	110	Open	155,370	1.17	0.8	1.02
P-7	T-06	T-08	2,989	1,400	PSC	110	Open	139,884	1.05	2.5	0.84
P-8	T-08	T-09	2,965	1,400	PSC	110	Open	139,678	1.05	2.48	0.84
P-9	T-09	T-12	915	1,400	Steel	110	Open	138,760	1.04	0.76	0.83
P-10	T-12	T-13	3,910	1,400	Steel	110	Open	138,760	1.04	3.23	0.83
P-11	T-13	T-14	990	1,400	PSC	110	Open	132,885	1	0.75	0.76
P-12	T-14	T-16	10	1,400	PSC	110	Open	132,885	1	0.01	0.76
P-13	T-16	T-17	750	1,200	PSC	110	Open	132,689	1.36	1.21	1.61
P-14	T-17	T-18	300	1,200	PSC	110	Open	132,332	1.35	0.48	1.6
P-15	T-18	T-19	510	1,200	PSC	110	Open	219,241	2.24	2.08	4.08
P-16	T-19	T-20	1,290	1,200	PSC	110	Open	218,883	2.24	5.25	4.07
P-17	T-20	T-21	700	1,200	PSC	110	Open	218,883	2.24	2.85	4.07
P-18	T-21	T-22	700	1,200	PSC	110	Open	218,850	2.24	2.85	4.07
P-19	T-22	T-23	100	1,200	PSC	110	Open	218,714	2.24	0.41	4.06
P-20	T-23	T-24	2,760	1,200	PSC	110	Open	218,714	2.24	11.21	4.06
P-21	T-24	T-25	2,465	1,200	PSC	110	Open	218,714	2.24	10.01	4.06
P-22	T-25	T-27	1,000	1,200	PSC	110	Open	216,172	2.21	3.97	3.97
P-23	T-27	T-28	1,225	1,200	PSC	110	Open	212,994	2.18	4.74	3.87
P-24	T-28	T-29	250	1,200	PSC	110	Open	212,994	2.18	0.97	3.87
P-25	T-29	J-183	200	1,200	PSC	110	Open	212,626	2.18	0.77	3.85
P-26	Verna MBR	T-31	850	900	PSC	110	Open	58,926	1.07	1.24	1.45
P-27	T-31	T-32	1,700	900	PSC	110	Open	91,015	1.66	5.53	3.25
P-28	T-32	T-33	550	900	PSC	110	Open	89,048	1.62	1.72	3.12
P-29	T-33	T-34	550	900	PSC	110	Open	87,082	1.58	1.65	3
P-30	T-34	T-35	1,030	900	PSC	110	Open	85,115	1.55	2.96	2.87
P-31	T-35	T-37	1,570	900	PSC	110	Open	83,149	1.51	4.32	2.75
P-32	T-37	T-38	300	900	PSC	110	Open	41,574	0.76	0.23	0.76
P-33	T-38	T-39	500	900	PSC	110	Open	60,293	1.1	0.76	1.52
P-34	T-39	T-40	1,100	900	PSC	110	Open	51,367	0.93	1.24	1.13
P-35	T-40	T-44	1,800	900	PSC	110	Open	46,411	0.84	1.68	0.93
P-36	T-44	T-45	200	900	PSC	110	Open	19,953	0.36	0.04	0.2
P-37	T-45	T-46	500	900	PSC	110	Open	15,308	0.28	0.06	0.12
P-38	T-46	T-47	500	900	PSC	110	Open	10,663	0.19	0.03	0.06
P-39	T-47	T-48	700	600	PSC	110	Open	10,663	0.44	0.31	0.44
P-40	T-48	T-49	1,300	600	PSC	110	Open	10,663	0.44	0.57	0.44
P-41	T-49	J-202	1,360	600	Steel	110	Closed	0	0	0	0
P-45	Xelpem	T00-11	3,200	300	Cast iron	110	Open	6,225	1.02	15.27	4.77
P-47	T00-11	T00-14	1,500	300	Cast iron	110	Open	12,449	2.04	25.83	17.22
P-49	T-01	T01-02	200	200	Asbestos Ce	110	Open	74	0.03	0	0.01
P-50	T01-02	T01-05	1,000	150	Cast iron	110	Open	74	0.05	0.04	0.04
P-52	T-02	T02-04	3,000	200	Cast iron	110	Open	509	0.19	1	0.33
P-53	T02-04	T02-07	3,000	200	Cast iron	110	Open	509	0.19	1	0.33
P-58	T03-05	T03-11	6,000	250	Asbestos Ce	110	Open	253	0.06	0.18	0.03
P-61	T07-11	T07-18	2,800	350	Cast iron	110	Open	15003	1.8	32.15	11.48
P-63	T07-18	T07-35	1,650	300	Cast iron	110	Open	13026	2.13	30.9	18.73
P-66	T07-35	Balli Sump	10	300	Cast iron	110	Open	13026	2.13	0.19	18.73
P-67	T-06	T06-04	2,700	200	Asbestos Ce	110	Open	482	0.18	0.81	0.3
P-68	T06-04	T06-05	500	200	Asbestos Ce	110	Open	112	0.04	0.01	0.02
P-69	T-09	T10-03	1,500	250	Cast iron	110	Open	806	0.19	0.39	0.26
P-76	St Jose De A	T12-05	650	300	Asbestos Ce	110	Open	4,418	0.72	1.64	2.53
P-77	T12-05	T12-11	3,200	250	Asbestos Ce	110	Open	1,888	0.45	4.07	1.27
P-79	T-14	T14-02	1,000	300	Cast iron	110	Open	0	0	0	0
P-89	T19-05	T-19	2,100	300	Cast iron	110	Open	-357	0.06	0.05	0.02
P-93	T-21	T21-02	500	400	Cast iron	110	Open	33	0	0	0
P-94	T21-02	T21-07	1,000	400	Cast iron	110	Open	33	0	0	0
P-101	T14-02	T14-06	2,500	300	Cast iron	110	Open	0	0	0	0
P-106	T-31	T31-12	3,000	600	Cast iron	110	Open	20,488	0.84	4.44	1.48
P-108	T-39	T39-02	1,000	250	Cast iron	110	Open	8,925	2.1	22.6	22.6
P-114	T38-12	T38-06	2,600	500	Cast iron	110	Open	11,449	0.67	3.18	1.22
P-115	T38-06	T38-37	500	500	Cast iron	110	Open	34,305	2.02	4.67	9.35

Table F34.1.6 Pipeline Details at 24:00 for Salaulim Scheme (2/5)

Pipe No.	From Node	To Node	Length (m)	Diameter (mm)	Material	Hazen-Williams C	Control Status	Discharge (m^3/day)	Velocity (m/s)	Pressure Pipe Headloss (m)	Headloss Gradient (m/km)
P-117	T38-43	T38-48	900	400	Cast iron	110	Open	23,276	2.14	12.16	13.52
P-124	T38-54	T38-48	650	150	Cast iron	110	Open	0	0	0	0
P-126	T-44	T44-03	300	300	Cast iron	110	Open	26,458	4.33	20.87	69.58
P-129	T38-48	T38-56	1,000	400	Cast iron	110	Open	23276	2.14	13.52	13.52
P-136	Mid-land Sa	Head-land S	1,000	200	Cast iron	110	Closed	0	0	0	0
P-137	Margao MB	T18-07	600	600	Cast iron	110	Open	4,791	0.2	0.06	0.1
P-138	T18-07	T18-09	1,000	600	Cast iron	110	Open	4,791	0.2	0.1	0.1
P-139	Margao MB	Vasant Naga	500	150	Cast iron	110	Closed	0	0	0	0
P-142	T07-59	Khanaguinin	1,800	300	Cast iron	110	Open	0	0	0	0
P-143	T-24	T24-01	500	250	Cast iron	110	Closed	0	0	0	0
P-144	T24-01	Nuvem	300	200	Cast iron	110	Open	0	0	0	0
P-145	T20-13	T20-15	600	500	Cast iron	110	Open	0	0	0	0
P-148	T-14	T15-06	3,000	600	Cast iron	110	Open	0	0	0	0
P-152	T18-10	T18-11	700	400	Cast iron	110	Open	0	0	0	0
P-153	T-21	T18-10	1,000	400	Cast iron	110	Closed	0	0	0	0
P-154	T38-29	T38-25	3,200	750	Cast iron	110	Open	15,941	0.42	1	0.31
P-156	T38-21	T38-12	2,300	500	Cast iron	110	Open	11,449	0.67	2.82	1.22
P-162	Salaulim WT	FCV-1	10	1,400	Steel	110	Open	146,982	1.11	0.01	0.92
P-163	FCV-1	Salaulim Res	10	1,400	Steel	110	Open	146,982	1.11	0.01	0.92
P-164	Salaulim Res	T-00	10	1,400	Steel	110	Open	183,186	1.38	0.01	1.38
P-166	T21-13	T21-15	400	250	Cast iron	110	Open	0	0	0	0
P-167	T31-12	T31-23	2,500	600	Cast iron	110	Open	20,488	0.84	3.7	1.48
P-168	T31-23	T38-29	800	750	Cast iron	110	Open	20,488	0.54	0.4	0.5
P-169	T21-13	J-104	1,900	400	Cast iron	110	Open	0	0	0	0
P-170	J-104	T31-23	10,100	750	Cast iron	110	Closed	0	0	0	0
P-171	Gogol Sump	PMP-1	10	300	Steel	110	Open	33,257	5.45	1.06	106.27
P-173	Gogol Sump	PMP-2	10	300	Steel	110	Open	0	0	0	0
P-175	Verna Sump	PMP-3	10	500	Steel	110	Open	46,594	2.75	0.16	16.48
P-177	Verna Sump	PMP-4	10	500	Steel	110	Open	46,594	2.75	0.16	16.48
P-179	Verna Sump	PMP-5	10	500	Steel	110	Open	29,326	1.73	0.07	6.99
P-181	Verna Sump	PMP-6	10	500	Steel	110	Open	0	0	0	0
P-183	T38-43	T-40	1,600	250	Cast iron	110	Open	-4,957	1.17	12.17	7.61
P-185	T-03	T03-03	1,000	300	Cast iron	110	Closed	0	0	0	0
P-186	T38-37	T38-43	700	500	Cast iron	110	Open	34,305	2.02	6.54	9.35
P-187	T03-03	T03-05	2,600	450	Ductile Iron	110	Open	3,362	0.24	0.55	0.21
P-188	T03-05	T03-12	1,500	300	Asbestos Ce	110	Open	645	0.11	0.11	0.07
P-189	T03-12	T03-13	1,500	200	Asbestos Ce	110	Open	450	0.17	0.4	0.27
P-190	T03-13	T03-14	1,500	150	Asbestos Ce	110	Open	255	0.17	0.56	0.38
P-191	T-06	T07-10	4,400	450	Cast iron	110	Open	15003	1.09	14.86	3.38
P-192	T07-10	T07-11	500	350	Cast iron	110	Open	15003	1.8	5.74	11.48
P-193	T12-05	T12-07	600	300	Asbestos Ce	110	Open	2,530	0.41	0.54	0.9
P-194	T12-07	T12-08	1,100	250	Asbestos Ce	110	Open	0	0	0	0
P-195	PMP-2	T18-03	10	300	Steel	110	Open	0	0	0	0
P-196	PMP-1	T18-03	10	300	Steel	110	Open	33,257	5.45	1.06	106.27
P-197	T18-03	Margao MB	600	600	Cast iron	110	Open	33,257	1.36	2.18	3.63
P-199	T20-10	T20-13	4,000	500	Cast iron	110	Open	4,613	0.27	0.91	0.23
P-200	T20-13	T20-16	300	500	Cast iron	110	Open	4,613	0.27	0.07	0.23
P-201	T20-16	T20-19	600	400	PSC	110	Open	4,613	0.42	0.4	0.67
P-203	T20-38	T20-39	500	200	Cast iron	110	Open	0	0	0	0
P-204	T20-34	T20-38	1,500	300	Cast iron	110	Open	0	0	0	0
P-205	T-38	T38-03	140	700	Cast iron	110	Open	22,856	0.69	0.12	0.86
P-206	T38-03	T38-06	1,560	600	Cast iron	110	Open	22,856	0.94	2.83	1.81
P-207	T38-06	T38-32	500	200	Cast iron	110	Open	0	0	0	0
P-210	T38-56	T38-57	1,500	300	Cast iron	110	Closed	0	0	0	0
P-211	PMP-3	J-117	10	500	Steel	110	Open	46,594	2.75	0.16	16.48
P-214	J-117	Verna MBR	600	900	Steel	110	Open	122,513	2.23	3.38	5.64
P-215	PMP-4	J-117	10	500	Steel	110	Open	46,594	2.75	0.16	16.48
P-216	PMP-5	J-117	10	500	Steel	110	Open	29,326	1.73	0.07	6.99
P-217	PMP-6	J-117	10	500	Steel	110	Open	0	0	0	0
P-218	T00-11	T00-17	2,500	300	Cast iron	110	Closed	0	0	0	0
P-222	T07-36	T07-40	700	300	Cast iron	110	Open	841	0.14	0.08	0.12
P-224	T07-40	T07-46	1,800	300	Cast iron	110	Open	430	0.07	0.06	0.03
P-225	T07-46	T07-55	2,300	300	Cast iron	110	Open	182	0.03	0.02	0.01
P-226	T07-55	T07-59	1,200	300	Cast iron	110	Closed	0	0	0	0
P-229	T00-14	T00-51	3,600	250	Ductile Iron	110	Open	154	0.04	0.04	0.01

Table F34.1.6 Pipeline Details at 24:00 for Salaulim Scheme (3/5)

Pipe No.	From Node	To Node	Length (m)	Diameter (mm)	Material	Hazen-Williams C	Control Status	Discharge (m^3/day)	Velocity (m/s)	Pressure Pipe Headloss (m)	Headloss Gradient (m/km)
P-230	T00-51	J-128	8,300	150	Ductile Iron	110	Open	0	0	0	0
P-231	J-128	NS1	400	150	Ductile Iron	110	Closed	0	0	0	0
P-232	T00-51	T00-52	3,500	200	Ductile Iron	110	Open	39	0.01	0.01	0
P-235	T00-53	NS4 300GL	100	200	Ductile Iron	110	Open	856	0.32	0.09	0.87
P-237	J-130	NS5	50	250	Ductile Iron	110	Open	0	0	0	0
P-239	J-124	NQ4	50	150	Ductile Iron	110	Open	380	0.25	0.04	0.79
P-240	T07-40	J-123	2,500	200	Ductile Iron	110	Open	0	0	0	0
P-245	T10-03	T10-05	1,500	250	Cast iron	110	Open	806	0.19	0.39	0.26
P-247	T21-07	T21-11	1,700	400	Cast iron	110	Open	33	0	0	0
P-248	T21-11	T21-13	800	400	Cast iron	110	Open	0	0	0	0
P-249	T20-19	T20-20	1,400	400	PSC	110	Open	4613	0.42	0.94	0.67
P-251	T10-05	T10-06	1,300	250	Cast iron	110	Open	562	0.13	0.18	0.14
P-252	T10-06	T10-08	800	250	Cast iron	110	Open	0	0	0	0
P-254	T20-25	T20-29	2,300	400	PSC	110	Open	1278	0.12	0.14	0.06
P-256	T07-18	T07-23	2,700	300	Cast iron	110	Open	1,977	0.32	1.54	0.57
P-258	T20-29	T20-30	1,000	400	PSC	110	Open	934	0.09	0.04	0.04
P-259	T20-30	T20-34	1,500	400	PSC	110	Open	0	0	0	0
P-260	T20-20	T20-22	3,400	400	PSC	110	Open	4537	0.42	2.22	0.65
P-261	T20-22	T20-23	900	400	PSC	110	Open	2,662	0.25	0.22	0.24
P-262	T20-23	T20-25	1,800	400	PSC	110	Open	1,459	0.13	0.14	0.08
P-263	T-00	J-142	400	300	Cast iron	110	Open	26,457	4.33	27.83	69.57
P-264	J-142	Xelpem	10	300	Cast iron	110	Open	26457	4.33	0.7	69.57
P-265	T00-14	J-143	10	300	Cast iron	110	Open	12296	2.01	0.17	16.83
P-266	J-143	Sanguem	10	300	Cast iron	110	Open	12296	2.01	0.17	16.83
P-267	T00-52	J-145	100	200	Ductile Iron	110	Closed	0	0	0	0
P-268	J-144	T00-53	1,900	200	Ductile Iron	110	Open	856	0.32	1.66	0.87
P-269	J-145	NS3	10	200	Ductile Iron	110	Open	0	0	0	0
P-270	NS3	PMP-7	10	200	Steel	110	Open	856	0.32	0.01	0.87
P-271	PMP-7	J-144	100	200	Ductile Iron	110	Open	856	0.32	0.09	0.87
P-278	NS6	PMP-8	10	250	Steel	110	Open	0	0	0	0
P-281	J-147	NS6	10	300	Ductile Iron	110	Open	0	0	0	0
P-282	T00-20	J-148	500	300	Cast iron	110	Open	0	0	0	0
P-284	NS1	PMP-9	10	150	Steel	110	Open	583	0.38	0.02	1.74
P-285	PMP-9	NS2	1,300	150	Ductile Iron	110	Open	583	0.38	2.26	1.74
P-286	T01-02	J-149	200	200	Asbestos Ce	110	Closed	0	0	0	0
P-287	J-149	Malkarnem	10	200	Asbestos Ce	110	Open	0	0	0	0
P-288	T02-07	J-150	200	200	Cast iron	110	Closed	0	0	0	0
P-289	J-150	Rivona	10	200	Cast iron	110	Open	0	0	0	0
P-290	T02-04	J-151	200	200	Cast iron	110	Closed	0	0	0	0
P-291	J-151	Zambaulim	92	200	Cast iron	110	Open	0	0	0	0
P-292	T-03	J-152	500	200	Cast iron	110	Closed	0	0	0	0
P-293	J-152	Shivoi	10	200	Cast iron	110	Open	0	0	0	0
P-294	T-06	J-153	1,350	200	Ductile Iron	110	Closed	0	0	0	0
P-295	J-153	NQ1	50	200	Ductile Iron	110	Open	0	0	0	0
P-297	J-154	J-124	3,300	150	Ductile Iron	110	Open	380	0.25	2.6	0.79
P-298	NQ4/S	PMP-10	10	150	Steel	110	Open	380	0.25	0.01	0.79
P-299	PMP-10	J-154	25	150	Ductile Iron	110	Open	380	0.25	0.02	0.79
P-300	T06-05	J-155	25	150	Ductile Iron	110	Closed	0	0	0	0
P-301	J-155	NQ4/S	10	150	Ductile Iron	110	Open	0	0	0	0
P-302	T07-11	J-156	200	350	Cast iron	110	Closed	0	0	0	0
P-303	J-156	Veroda	10	350	Cast iron	110	Open	0	0	0	0
P-304	T07-23	J-157	4,300	300	Cast iron	110	Open	1571	0.26	1.6	0.37
P-305	J-157	Velim	10	300	Cast iron	110	Open	1571	0.26	0	0.37
P-306	J-123	J-158	100	200	Ductile Iron	110	Closed	0	0	0	0
P-307	J-158	NQ2	10	200	Ductile Iron	110	Open	0	0	0	0
P-309	J-159	NQ3	4,700	200	Ductile Iron	110	Closed	0	0	0	0
P-310	NQ2	PMP-11	10	200	Steel	110	Open	0	0	0	0
P-311	PMP-11	J-159	100	200	Ductile Iron	110	Open	0	0	0	0
P-312	T10-08	J-160	2,000	150	Cast iron	110	Closed	0	0	0	0
P-313	J-160	Deusa	10	150	Cast iron	110	Open	0	0	0	0
P-314	T10-08	J-161	1,400	200	Cast iron	110	Closed	0	0	0	0
P-315	J-161	Baida	10	200	Cast iron	110	Open	0	0	0	0
P-316	T10-03	J-162	500	200	Cast iron	110	Closed	0	0	0	0
P-317	J-162	Sarzora	10	200	Cast iron	110	Open	0	0	0	0
P-318	T-09	J-163	2,800	250	Asbestos Ce	110	Closed	0	0	0	0

Table F34.1.6 Pipeline Details at 24:00 for Salaulim Scheme (4/5)

Pipe No.	From Node	To Node	Length (m)	Diameter (mm)	Material	Hazen-Williams C	Control Status	Discharge (m^3/day)	Velocity (m/s)	Pressure Pipe Headloss (m)	Headloss Gradient (m/km)
P-319	J-163	Chandor	10	250	Asbestos Ce	110	Open	0	0	0	0
P-320	T-12	J-164	50	250	Cast iron	110	Closed	0	0	0	0
P-321	J-164	St Jose De A	10	250	Cast iron	110	Open	0	0	0	0
P-322	T14-02	J-165	3,500	300	Cast iron	110	Closed	0	0	0	0
P-323	J-165	Girdolim	10	300	Cast iron	110	Open	0	0	0	0
P-324	T14-06	J-166	200	300	Cast iron	110	Closed	0	0	0	0
P-325	J-166	Curtorim	10	300	Cast iron	110	Open	0	0	0	0
P-326	T14-06	J-167	3,200	200	Cast iron	110	Closed	0	0	0	0
P-327	J-167	Makazana	10	200	Cast iron	110	Open	0	0	0	0
P-328	T15-06	J-168	500	600	Cast iron	110	Closed	0	0	0	0
P-329	J-168	Borda/Monte	10	600	Cast iron	110	Open	0	0	0	0
P-330	T15-06	J-169	700	600	Cast iron	110	Closed	0	0	0	0
P-331	J-169	Aquem	10	600	Cast iron	110	Open	0	0	0	0
P-332	T-18	J-170	200	600	Steel	110	Closed	0	0	0	0
P-333	J-170	Gogol Sump	10	600	Steel	110	Open	0	0	0	0
P-334	T18-07	J-171	600	300	Cast iron	110	Closed	0	0	0	0
P-335	J-171	Near MBR	10	300	Cast iron	110	Open	0	0	0	0
P-336	T18-09	J-172	2,700	400	Cast iron	110	Closed	0	0	0	0
P-337	J-172	Monte Hill	10	400	Cast iron	110	Open	0	0	0	0
P-338	T18-11	J-173	950	400	Cast iron	110	Closed	0	0	0	0
P-339	J-173	Dongar Wad	10	400	Cast iron	110	Open	0	0	0	0
P-340	T18-11	J-174	300	400	Cast iron	110	Closed	0	0	0	0
P-341	J-174	Fatorda	10	400	Cast iron	110	Open	0	0	0	0
P-342	T20-15	J-175	10	500	Cast iron	110	Closed	0	0	0	0
P-343	J-175	Colva	10	500	Cast iron	110	Open	0	0	0	0
P-344	T20-15	J-176	3,500	200	Cast iron	110	Closed	0	0	0	0
P-345	J-176	Betalbatim	10	200	Cast iron	110	Open	0	0	0	0
P-346	T21-02	J-177	300	150	Cast iron	110	Closed	0	0	0	0
P-347	J-177	Damon Raia	130	150	Cast iron	110	Open	0	0	0	0
P-348	T21-07	J-178	1,000	150	Cast iron	110	Closed	0	0	0	0
P-349	J-178	Collea Dong	10	150	Cast iron	110	Open	0	0	0	0
P-350	T21-15	J-179	100	250	Cast iron	110	Closed	0	0	0	0
P-351	J-179	Camurlim	10	250	Cast iron	110	Open	0	0	0	0
P-352	T21-15	J-180	1,400	250	Cast iron	110	Closed	0	0	0	0
P-353	J-180	Loutoulim	10	250	Cast iron	110	Open	0	0	0	0
P-354	T-23	J-181	50	250	Cast iron	110	Closed	0	0	0	0
P-355	J-181	Manora Raia	10	250	Cast iron	110	Open	0	0	0	0
P-356	T-28	J-182	1,300	200	Asbestos Ce	110	Open	0	0	0	0
P-357	J-182	Consua	10	300	Ductile Iron	110	Closed	0	0	0	0
P-358	T-31	J-184	500	200	Cast iron	110	Open	1626	0.6	1.43	2.86
P-359	J-183	Verna Sump	10	1,200	PSC	110	Open	212626	2.18	0.04	3.85
P-360	J-184	Upasnagar, S	10	200	Cast iron	110	Open	6349	2.34	0.36	35.67
P-361	T31-12	J-185	1,600	250	Cast iron	110	Closed	0	0	0	0
P-362	J-185	Nagao	10	250	Cast iron	110	Open	0	0	0	0
P-363	T38-29	J-186	100	100	Cast iron	110	Open	4,548	6.7	56.26	562.59
P-364	J-186	Quelossim	10	100	Cast iron	110	Open	4,548	6.7	5.63	562.59
P-365	T38-25	J-187	500	150	Cast iron	110	Open	4,492	2.94	38.15	76.3
P-366	J-187	Sancole	10	150	Cast iron	110	Open	4492	2.94	0.76	76.3
P-367	T38-21	J-188	500	100	Cast iron	110	Closed	0	0	0	0
P-368	J-188	Rua Escirand	10	100	Cast iron	110	Open	0	0	0	0
P-369	T38-12	J-189	600	80	Cast iron	110	Closed	0	0	0	0
P-370	J-189	St Jacinto I.	10	80	Cast iron	110	Open	0	0	0	0
P-371	T-37	J-190	150	300	Steel	110	Closed	0	0	0	0
P-372	J-190	Dabolim	10	300	Steel	110	Open	0	0	0	0
P-373	T39-02	J-191	300	250	Cast iron	110	Open	8,925	2.1	6.78	22.6
P-374	J-191	Issorcim	10	250	Cast iron	110	Open	8925	2.1	0.23	22.6
P-375	T39-02	J-192	2,000	250	Cast iron	110	Closed	0	0	0	0
P-376	J-192	Bogmalo	10	250	Cast iron	110	Open	0	0	0	0
P-377	T-47	J-193	400	250	Cast iron	110	Closed	0	0	0	0
P-378	J-193	Mangor	10	250	Cast iron	110	Open	0	0	0	0
P-379	T-48	J-194	70	250	Cast iron	110	Closed	0	0	0	0
P-380	J-194	Gandhi Naga	10	250	Cast iron	110	Open	0	0	0	0
P-381	T44-03	J-195	100	300	Cast iron	110	Open	26,458	4.33	6.96	69.58
P-382	J-195	New Vadden	39	300	Cast iron	110	Open	26,458	4.33	2.71	69.58
P-383	T44-03	J-196	800	250	Cast iron	110	Closed	0	0	0	0

Table F34.1.6 Pipeline Details at 24:00 for Salaulim Scheme (5/5)

Pipe No.	From Node	To Node	Length (m)	Diameter (mm)	Material	Hazen-Williams C	Control Status	Discharge (m^3/day)	Velocity (m/s)	Pressure Pipe Headloss (m)	Headloss Gradient (m/km)
P-384	J-196	New Vadden	10	250	Cast iron	110	Open	0	0	0	0
P-385	T38-54	J-197	200	150	Cast iron	110	Closed	0	0	0	0
P-386	J-197	New Vadden	10	150	Cast iron	110	Open	0	0	0	0
P-387	T38-32	J-198	300	200	Cast iron	110	Closed	0	0	0	0
P-388	J-198	Chicalim	10	200	Cast iron	110	Open	0	0	0	0
P-389	T38-32	J-199	1,000	200	Cast iron	110	Closed	0	0	0	0
P-390	J-199	Chicalim 60	10	200	Cast iron	110	Open	15,986	5.89	1.97	197.22
P-391	T38-56	J-200	100	300	Cast iron	110	Open	23,276	3.81	5.49	54.88
P-392	J-200	INS Gomant	10	300	Cast iron	110	Open	23276	3.81	0.55	54.88
P-393	T-49	J-201	2,100	300	Cast iron	110	Open	10663	1.75	27.15	12.93
P-394	J-201	Mid-land Sa	201	300	Cast iron	110	Open	10663	1.75	2.6	12.93
P-396	J-202	Head-land S	10	600	Steel	110	Open	0	0	0	0
P-397	Salaulim WT	FCV-2	10	1,400	Steel	110	Open	90000	0.68	0	0.37
P-398	FCV-2	T-70	10	1,400	Steel	110	Open	90000	0.68	0	0.37
P-399	T-70	J-205	10	1,400	Steel	110	Open	101991	0.77	0	0.47
P-400	J-205	PMP-12	10	1,100	Steel	110	Open	50996	0.62	0	0.42
P-401	PMP-12	J-204	10	1,100	Steel	110	Open	50,996	0.62	0	0.42
P-402	J-205	PMP-13	10	1,100	Steel	110	Open	50,996	0.62	0	0.42
P-403	PMP-13	J-204	10	1,100	Steel	110	Open	50,996	0.62	0	0.42
P-404	J-204	J-203	7,250	1,400	Steel	110	Open	101,991	0.77	3.38	0.47
P-405	J-203	New Sirvoi	250	1,400	Steel	110	Open	101,991	0.77	0.12	0.47
P-406	New Sirvoi	J-206	300	1,400	Steel	110	Open	90,271	0.68	0.11	0.37
P-408	Xelpem	T00-11	3,200	300	Ductile Iron	110	Open	6,225	1.02	15.27	4.77
P-410	T07-18	T07-35	1,650	200	Ductile Iron	110	Closed	0	0	0	0
P-411	T07-10	T07-11	500	200	Ductile Iron	110	Closed	0	0	0	0
P-412	T07-11	T07-18	2,800	200	Ductile Iron	110	Closed	0	0	0	0
P-413	Balli Sump	PMP-14	10	300	Steel	110	Open	3,515	0.58	0.02	1.66
P-414	PMP-14	Balli	450	300	Ductile Iron	110	Open	3,515	0.58	0.75	1.66
P-415	Balli	T07-36	450	300	Cast iron	110	Open	841	0.14	0.05	0.12
P-416	Verna MBR	T-31	850	900	Ductile Iron	110	Open	58926	1.07	1.24	1.45
P-422	T-37	T-38	300	900	Ductile Iron	110	Open	41574	0.76	0.23	0.76
P-429	T-31	J-184	500	300	Ductile Iron	110	Open	4,723	0.77	1.43	2.86
P-430	T38-21	J-188	500	150	Ductile Iron	110	Closed	0	0	0	0
P-432	T38-43	J-199	100	200	Cast iron	110	Open	15,986	5.89	19.72	197.22
P-433	T38-57	Mid-land Sa	2,500	250	Cast iron	110	Open	0	0	0	0
P-442	J-131	J-215	1,050	250	Ductile Iron	110	Open	0	0	0	0
P-443	J-214	J-130	2,500	250	Ductile Iron	110	Open	0	0	0	0
P-445	J-215	J-147	50	250	Ductile Iron	110	Closed	0	0	0	0
P-446	PMP-8	J-214	50	250	Ductile Iron	110	Open	0	0	0	0
P-447	J-148	J-131	1,500	250	Ductile Iron	110	Open	0	0	0	0
P-448	J-228	T00-20	500	300	Ductile Iron	110	Open	0	0	0	0
P-449	T00-20	J-148	500	300	Ductile Iron	110	Open	0	0	0	0
P-450	J-148	J-216	100	300	Cast iron	110	Closed	0	0	0	0
P-451	J-216	Pentemol(Cu	10	300	Cast iron	110	Open	0	0	0	0
P-454	T38-25	J-223	300	500	Cast iron	110	Open	11,449	0.67	0.37	1.22
P-455	J-223	T38-21	2,800	500	Cast iron	110	Open	11,449	0.67	3.43	1.22
P-458	J-225	PBV-1	17,300	1,400	Steel	110	Open	86909	0.65	6	0.35
P-459	PBV-1	T-18	10	1,400	Steel	110	Open	86909	0.65	0	0.35
P-468	J-206	J-225	1,600	1,400	Steel	110	Open	90,271	0.68	0.6	0.37
P-470	J-225	T03-03	100	450	Ductile Iron	110	Open	3362	0.24	0.02	0.21
P-471	T03-05	J-226	2,700	150	Cast iron	110	Open	117	0.08	0.24	0.09
P-472	J-226	J-227	1,200	150	Cast iron	110	Open	117	0.08	0.11	0.09
P-473	J-227	T03-15	1,100	150	Cast iron	110	Open	857	0.56	3.9	3.55
P-474	T03-05	J-226	2,700	400	Ductile Iron	110	Open	1543	0.14	0.24	0.09
P-475	T00-17	J-228	1,400	300	Cast iron	110	Open	-803	0.13	0.15	0.11
P-476	J-228	T00-20	500	300	Cast iron	110	Open	0	0	0	0
P-477	J-227	J-228	1,400	300	Ductile Iron	110	Open	803	0.13	0.15	0.11
P-478	J-226	J-227	1,200	400	Ductile Iron	110	Open	1543	0.14	0.11	0.09
P-479	T-20	T20-06	1,600	600	Cast iron	110	Closed	0	0	0	0
P-480	T20-06	T20-10	1,900	600	Cast iron	110	Open	4,791	0.2	0.19	0.1
P-481	T18-09	T20-06	800	400	Cast iron	110	Open	4,791	0.44	0.58	0.72
P-482	T20-06	T18-10	800	400	Cast iron	110	Open	0	0	0	0

Table F34.1.7 Reservoir Details at 06:00 for Salaulim Scheme

Label	Base Elevation (m)	Base Flow (m^3/day)	Minimum Elevation (m)	Initial HGL (m)	Maximum Elevation (m)	Total Volume (m^3)	Tank Diameter (m)	Inflow (m^3/day)	Current Status	Calculated Hydraulic Grade (m)	Calculated Percent Full (%)
Salaulim Reservoir	110.5	0	110.5	111.6	115	6,740	46	-27,314	Draining	114.5	99.9
Gogol Sump	53	0	53	55.5	56	1,500	25	-32,923	Draining	55.9	96.6
Margao MBR	110	0	110	112	114	10,000	56	18,766	Filling	113.41	85.1
Verna Sump	40	0	40	43.5	44	1,500	22	115,491	Filling	43.46	86.5
Head-land Sada	55	16,613	55	58.4	59	2,700	29	22,335	Filling	58.09	77.2
Xelpem	83	165	83	86.5	87	200	8	-716	Draining	86.23	80.7
Pentemol(Cuchorem)	61	4,148	61	64.4	65	800	16	-6,336	Draining	61.89	22.2
Malkarnem	76	138	76	76.7	80	100	6	-219	Draining	78.86	71.6
Zambaulim	58	341	58	59.5	62	300	10	-540	Draining	61.08	77.1
Rivona	60	228	60	62.7	64	200	7.98	-361	Draining	63.15	78.7
Veroda	46	4,686	46	47.9	50	800	16	15,256	Filling	48.22	55.6
Velim	42	1,948	42	43.5	46	800	16	-3,088	Draining	44.86	71.6
Chandor	53	571	53	54.5	57	150	7	-905	Draining	54.78	44.6
St Jose De Areal	40	0	40	43.4	44	800	16	-13,089	Draining	41.68	42
Sarzora	41	2,082	41	41.9	45	300	10	3,392	Filling	42.12	28.1
Deusa	32	222	32	35.1	36	100	5.64	-352	Draining	34.78	69.4
Baida	16	2,138	16	18.4	20	600	14	-3,389	Draining	18.34	58.4
Girdolim	58	921	58	59.6	62	300	9.77	-1,460	Draining	60.41	60.2
Curtorim	14	2,536	14	15.6	18	1,050	18	-4,020	Draining	16.58	64.5
Makazana	40	348	40	43.5	44	100	5.64	-552	Draining	43.46	86.4
Colva	42	3,753	42	44.3	46	300	10	-5,948	Draining	42.89	22.3
Monte Hill	44	14,622	44	46.2	48	5,800	43	-22,681	Draining	46.75	68.7
Aquem	63	3,815	63	64	67	1,600	23	-5,917	Draining	65.5	65.8
Fatorda	55	2,225	55	58.2	59	800	16	-3,451	Draining	57.22	58.5
Dongar Wada	26.5	2,861	26.5	28.7	29	1,200	24	-4,438	Draining	28.2	63.1
Damon Raia	62	649	62	64	66	800	16.37	-1,029	Draining	65.34	87.9
Collea Dongor	15	827	15	17.6	19	700	15	-1,311	Draining	18.07	76.6
Camurlim	36	1,381	36	38.1	40	1,200	20	-2,189	Draining	39.07	76.8
Loutoulim	36	652	36	37.7	40	1,500	22	-1,033	Draining	39.4	85
Consua	32	3,440	32	35.1	36	600	14	-5,129	Draining	35.42	85.6
Nagao	54	420	54	55.3	58	800	16	-666	Draining	57.31	82.7
Upasnagar, Sancole	95	4,810	95	98.4	99	300	10	-5,501	Draining	98.38	84.4
Quelossim	27	2,765	27	30	31	600	14	-4,383	Draining	28.56	39
Bogmalo	45	1,125	45	46.6	49	150	7	4,723	Filling	47.26	56.5
Issorcim	52	2,924	52	55.3	56	300	10	-4,635	Draining	54.94	73.4
Dabolim	52	893	52	52.5	56	450	12	-1415	Draining	54.6	65
St Jacinto I.	22	173	22	23	24	25	3.99	-274	Draining	23.61	80.6
Mid-land Sada	47	2,266	47	49.8	51	300	10	-2,612	Draining	48.15	28.7
New Vaddem	40	8,306	40	43.4	44	1,250	20	1,325	Filling	42.13	53.2
Chicalim	45	953	45	48.5	49	300	9.77	-1511	Draining	46.98	49.4
Chicalim 600GLR	45	2,893	45	46.7	49	900	17	-4,585	Draining	47.13	53.2
INS Gomantak	35	10,572	35	38.4	39	1,600	23	-12,184	Draining	37.32	58
New Vaddem B N	47	9,061	47	47.6	51	1,450	21	10,108	Filling	48.64	41
Mangor	31	12,837	31	33.2	35	2,050	25.54	-14,795	Draining	33.99	74.8
Gandhi Nagar	34	5,286	34	34.9	38	800	16	-6,092	Draining	35.57	39.2
Sanguem	40	1,827	40	41.7	44	200	8	-2,874	Draining	42.33	58.2
Balli Sump	15	0	15	18.2	19	400	11	0	Filling	18.5	87.5
Manora Raia	55	371	55	57.7	59	450	12	-588	Draining	58.11	77.8
Vasant Nagar	70	317	70	73.5	74	150	7.09	-492	Draining	73.46	91.1
Near MBR	55	2,225	55	56.8	59	800	16	-3,451	Draining	57.24	58.9
Shivoi	70	90	70	73	74	800	16	-143	Draining	73.45	86.2
Khanaguinim	40	270	40	41	42	25	4	-428	Draining	40.54	27.2
Nuvem	28	3,513	28	31	32	1,200	20	-5,568	Draining	30.22	55.6
Betalbatim	16	303	16	17.6	20	150	7	-480	Draining	18.62	65.4
Borda/Monte Hill	55	4,132	55	58.5	59	1,750	24	-6,409	Draining	57.36	62
Sancole	50	2,405	50	52.6	54	150	6.91	-2,751	Draining	50.9	22.4
Rua Escirano De Maria	50	2,405	50	51.9	54	150	7	-2,751	Draining	52.74	68.6
Verna MBR	100	5,143	100	101.3	104	10,000	56	-17,110	Draining	102.98	74.6
NQ1	75	1,825	75	76.3	79	800	16	-2,893	Draining	78.04	76.1
NQ3	120	996	120	121.2	124	300	9.77	-1579	Draining	122.41	60.2
NQ2	50	117	50	53.1	54	100	6	-185	Draining	52.98	74.4
NQ4	100	315	100	101.8	104	100	5.64	-499	Draining	103.01	75.2
NS4 300GLR	83	539	83	85	87	300	9.77	-854	Draining	86.23	80.8
NS3	30	0	30	31.7	34	100	5.64	0	Filling	32.31	57.7
NS2	92	334	92	94	96	200	7.98	-529	Draining	95.23	80.8
NS1	45	0	45	48.4	49	100	5.64	0	Filling	45.72	18
NS6	25	0	25	25.8	29	300	10	0	Filling	28.5	87.5
NS5	105	2,412	105	106.8	109	800	16	-3,823	Draining	107.91	72.7
NQ4/S	60	0	60	63.1	64	100	6	0	Filling	60.86	21.6
New Sirvoi MBR	115	0	115	117.5	120	20,000	75	-14,139	Draining	118.74	83
T-70	45	0	45	48.1	50	5,000	35.68	-6334	Draining	46.12	22.4
Balli	115	0	115	116.3	119	650	14	-2,492	Draining	118.2	79.9

Table F34.1.8 Reservoir Details at 12:00 for Salaulim Scheme

Label	Base Elevation (m)	Base Flow (m^3/day)	Minimum Elevation (m)	Initial HGL (m)	Maximum Elevation (m)	Total Volume (m^3)	Tank Diameter (m)	Inflow (m^3/day)	Current Status	Calculated Hydraulic Grade (m)	Calculated Percent Full (%)
Salaulim Reservoir	110.5	0	110.5	111.6	115	6,740	46	-40,800	Draining	111.61	27.7
Gogol Sump	53	0	53	55.5	56	1,500	25	-33,203	Draining	55.89	96.4
Margao MBR	110	0	110	112	114	10,000	56	-7,426	Draining	112.11	52.8
Verna Sump	40	0	40	43.5	44	1,500	22	76,314	Filling	43.5	87.4
Head-land Sada	55	16,613	55	58.4	59	2,700	29	22,397	Filling	57.44	60.9
Xelpem	83	165	83	86.5	87	200	8	12,931	Filling	84.75	43.8
Pentemol(Cuchorem)	61	4,148	61	64.4	65	800	16	5,174	Filling	62.41	35.2
Malkarnem	76	138	76	76.7	80	100	6	-164	Draining	76.67	16.7
Zambaulim	58	341	58	59.5	62	300	10	-406	Draining	59.28	31.9
Rivona	60	228	60	62.7	64	200	7.98	1170	Filling	62.07	51.8
Veroda	46	4,686	46	47.9	50	800	16	-5,321	Draining	47.18	29.5
Velim	42	1,948	42	43.5	46	800	16	4,188	Filling	43.61	40.3
Chandor	53	571	53	54.5	57	150	7	-679	Draining	55.7	67.6
St Jose De Areal	40	0	40	43.4	44	800	16	-9,827	Draining	40.8	20
Sarzora	41	2,082	41	41.9	45	300	10	2,239	Filling	43.64	66
Deusa	32	222	32	35.1	36	100	5.64	-264	Draining	33.06	26.5
Baida	16	2,138	16	18.4	20	600	14	659	Filling	17.19	29.7
Girdolim	58	921	58	59.6	62	300	9.77	-1,096	Draining	60.97	74.1
Curtorim	14	2,536	14	15.6	18	1,050	18	-3,018	Draining	17.04	75.9
Makazana	40	348	40	43.5	44	100	5.64	-414	Draining	43.46	86.4
Colva	42	3,753	42	44.3	46	300	10	-4,466	Draining	42.97	24.2
Monte Hill	44	14,622	44	46.2	48	5,800	43	12,755	Filling	45.11	27.8
Aquem	63	3,815	63	64	67	1,600	23	-4,498	Draining	65.88	75.9
Fatorda	55	2,225	55	58.2	59	800	16	-2,623	Draining	57.94	77.2
Dongar Wada	26.5	2,861	26.5	28.7	29	1,200	24	-3,373	Draining	28.19	62.5
Damon Raia	62	649	62	64	66	800	16.37	-772	Draining	64.11	55.6
Collea Dongor	15	827	15	17.6	19	700	15	-984	Draining	16.19	29.7
Camurlim	36	1,381	36	38.1	40	1,200	20	-1,643	Draining	37.24	31.1
Loutoulim	36	652	36	37.7	40	1,500	22	-776	Draining	38.71	67.7
Consua	32	3,440	32	35.1	36	600	14	-1,117	Draining	34.39	59.8
Nagao	54	420	54	55.3	58	800	16	-500	Draining	56.47	61.8
Upasnagar, Sancole	95	4,810	95	98.4	99	300	10	1,753	Filling	98.06	76.5
Quelossim	27	2,765	27	30	31	600	14	1,326	Filling	27.81	20.3
Bogmalo	45	1,125	45	46.6	49	150	7	-1,339	Draining	47.41	60.3
Issorcim	52	2,924	52	55.3	56	300	10	5,376	Filling	53.21	30.2
Dabolim	52	893	52	52.5	56	450	12	-1063	Draining	54.59	64.7
St Jacinto I.	22	173	22	23	24	25	3.99	-206	Draining	23.39	69.6
Mid-land Sada	47	2,266	47	49.8	51	300	10	-2,378	Draining	49.14	53.6
New Vaddem	40	8,306	40	43.4	44	1,250	20	1,553	Filling	43.38	84.6
Chicalim	45	953	45	48.5	49	300	9.77	-1134	Draining	45.92	23
Chicalim 600GLR	45	2,893	45	46.7	49	900	17	-3,443	Draining	47.6	65
INS Gomantak	35	10,572	35	38.4	39	1,600	23	-11,096	Draining	36.14	28.5
New Vaddem B N	47	9,061	47	47.6	51	1,450	21	10,157	Filling	49.01	50.3
Mangor	31	12,837	31	33.2	35	2,050	25.54	-13,473	Draining	34.24	81
Gandhi Nagar	34	5,286	34	34.9	38	800	16	-5,548	Draining	35.27	31.8
Sanguem	40	1,827	40	41.7	44	200	8	9,968	Filling	43.16	79
Balli Sump	15	0	15	18.2	19	400	11	-3,573	Draining	15.71	17.6
Manora Raia	55	371	55	57.7	59	450	12	-441	Draining	56.8	45
Vasant Nagar	70	317	70	73.5	74	150	7.09	-374	Draining	73.5	92.1
Near MBR	55	2,225	55	56.8	59	800	16	-2,623	Draining	56.59	42
Shivoi	70	90	70	73	74	800	16	-107	Draining	73.27	81.8
Khanaguinim	40	270	40	41	42	25	4	-321	Draining	41.6	80
Nuvem	28	3,513	28	31	32	1,200	20	4,690	Filling	31.22	80.4
Betalbatim	16	303	16	17.6	20	150	7	-361	Draining	18.98	74.6
Borda/Monte Hill	55	4,132	55	58.5	59	1,750	24	-4,872	Draining	57.34	61.7
Sancole	50	2,405	50	52.6	54	150	6.91	1,962	Filling	51.72	42.9
Rua Escirano De Maria	50	2,405	50	51.9	54	150	7	1,429	Filling	52.25	56.2
Verna MBR	100	5,143	100	101.3	104	10,000	56	-2,313	Draining	101.34	33.4
NQ1	75	1,825	75	76.3	79	800	16	1,892	Filling	76.15	28.7
NQ3	120	996	120	121.2	124	300	9.77	177	Filling	120.51	12.9
NQ2	50	117	50	53.1	54	100	6	3,418	Filling	52.13	53.2
NQ4	100	315	100	101.8	104	100	5.64	37	Filling	100.23	5.8
NS4 300GLR	83	539	83	85	87	300	9.77	259	Filling	83.53	13.3
NS3	30	0	30	31.7	34	100	5.64	-901	Draining	31.83	45.6
NS2	92	334	92	94	96	200	7.98	-397	Draining	92.58	14.4
NS1	45	0	45	48.4	49	100	5.64	0	Filling	45.72	18
NS6	25	0	25	25.8	29	300	10	-3,754	Draining	28.32	82.9
NS5	105	2,412	105	106.8	109	800	16	884	Filling	105.63	15.9
NQ4/S	60	0	60	63.1	64	100	6	-412	Draining	62.39	59.6
New Sirvoi MBR	115	0	115	117.5	120	20,000	75	-16,305	Draining	117.59	57.6
T-70	45	0	45	48.1	50	5,000	35.68	-9580	Draining	46.74	34.9
Balli	115	0	115	116.3	119	650	14	-3,216	Draining	116.6	40

Table F34.1.9 Reservoir Details at 18:00 for Salaulim Scheme

Label	Base Elevation (m)	Base Flow (m^3/day)	Minimum Elevation (m)	Initial HGL (m)	Maximum Elevation (m)	Total Volume (m^3)	Tank Diameter (m)	Inflow (m^3/day)	Current Status	Calculated Hydraulic Grade (m)	Calculated Percent Full (%)
Salaulim Reservoir	110.5	0	110.5	111.6	115	6,740	46	-15,983	Draining	111.3	20.1
Gogol Sump	53	0	53	55.5	56	1,500	25	-33,593	Draining	55.9	96.6
Margao MBR	110	0	110	112	114	10,000	56	-23,321	Draining	110.31	7.6
Verna Sump	40	0	40	43.5	44	1,500	22	-123,035	Draining	43.46	86.4
Head-land Sada	55	16,613	55	58.4	59	2,700	29	4,885	Filling	56.7	42.4
Xelpem	83	165	83	86.5	87	200	8	-1,420	Draining	85.87	71.8
Pentemol(Cuchorem)	61	4,148	61	64.4	65	800	16	-4,391	Draining	62.31	32.8
Malkarnem	76	138	76	76.7	80	100	6	-147	Draining	78.26	56.5
Zambaulim	58	341	58	59.5	62	300	10	2,308	Filling	61.2	80.1
Rivona	60	228	60	62.7	64	200	7.98	-243	Draining	62.61	65.2
Veroda	46	4,686	46	47.9	50	800	16	-4,903	Draining	49.21	80.3
Velim	42	1,948	42	43.5	46	800	16	-2,075	Draining	44.95	73.8
Chandor	53	571	53	54.5	57	150	7	-608	Draining	54.91	47.6
St Jose De Areal	40	0	40	43.4	44	800	16	54,397	Filling	40.86	21.5
Sarzora	41	2,082	41	41.9	45	300	10	-2,185	Draining	43.5	62.5
Deusa	32	222	32	35.1	36	100	5.64	1883	Filling	35.13	78.2
Baida	16	2,138	16	18.4	20	600	14	-2,277	Draining	19.47	86.7
Girdolim	58	921	58	59.6	62	300	9.77	-981	Draining	61.24	81
Curtorim	14	2,536	14	15.6	18	1,050	18	10,964	Filling	14.6	15
Makazana	40	348	40	43.5	44	100	5.64	-371	Draining	43.44	86.1
Colva	42	3,753	42	44.3	46	300	10	-3,997	Draining	45.26	81.6
Monte Hill	44	14,622	44	46.2	48	5,800	43	11,197	Filling	47.32	82.9
Aquem	63	3,815	63	64	67	1,600	23	44,291	Filling	63.59	15.6
Fatorda	55	2,225	55	58.2	59	800	16	18,319	Filling	57.43	63.8
Dongar Wada	26.5	2,861	26.5	28.7	29	1,200	24	-3,036	Draining	28.76	83.8
Damon Raia	62	649	62	64	66	800	16.37	-691	Draining	63.3	34.1
Collea Dongor	15	827	15	17.6	19	700	15	3,589	Filling	17.47	61.9
Camurlim	36	1,381	36	38.1	40	1,200	20	-1,471	Draining	39.41	85.3
Loutoulim	36	652	36	37.7	40	1,500	22	-694	Draining	38.25	56.2
Consua	32	3,440	32	35.1	36	600	14	3,611	Filling	35.43	85.9
Nagao	54	420	54	55.3	58	800	16	-447	Draining	55.91	47.9
Upasnagar, Sancole	95	4,810	95	98.4	99	300	10	-726	Draining	98.4	85.1
Quelossim	27	2,765	27	30	31	600	14	-2,945	Draining	30.18	79.5
Bogmalo	45	1,125	45	46.6	49	150	7	-1,198	Draining	46.9	47.5
Issorcim	52	2,924	52	55.3	56	300	10	2,873	Filling	54.7	67.5
Dabolim	52	893	52	52.5	56	450	12	32437	Filling	53.08	27
St Jacinto I.	22	173	22	23	24	25	3.99	-184	Draining	22.79	39.3
Mid-land Sada	47	2,266	47	49.8	51	300	10	-2,304	Draining	50.09	77.3
New Vaddem	40	8,306	40	43.4	44	1,250	20	-380	Draining	42.06	51.6
Chicalim	45	953	45	48.5	49	300	9.77	-1015	Draining	46.13	28.2
Chicalim 600GLR	45	2,893	45	46.7	49	900	17	-3,081	Draining	46.59	39.7
INS Gomantak	35	10,572	35	38.4	39	1,600	23	10,610	Filling	36.42	35.4
New Vaddem B N	47	9,061	47	47.6	51	1,450	21	3,538	Filling	49.31	57.8
Mangor	31	12,837	31	33.2	35	2,050	25.54	3,378	Filling	33.59	64.7
Gandhi Nagar	34	5,286	34	34.9	38	800	16	-5,376	Draining	35.48	37.1
Sanguem	40	1,827	40	41.7	44	200	8	-1,943	Draining	41.16	29
Balli Sump	15	0	15	18.2	19	400	11	9,936	Filling	16.01	25.2
Manora Raia	55	371	55	57.7	59	450	12	-395	Draining	55.93	23.2
Vasant Nagar	70	317	70	73.5	74	150	7.09	-336	Draining	73.47	91.4
Near MBR	55	2,225	55	56.8	59	800	16	-2,361	Draining	57.05	53.9
Shivoi	70	90	70	73	74	800	16	-96	Draining	73.15	78.8
Khanaguinim	40	270	40	41	42	25	4	-288	Draining	41.26	63
Nuvem	28	3,513	28	31	32	1,200	20	-3,741	Draining	28.6	14.9
Betalbatim	16	303	16	17.6	20	150	7	-323	Draining	16.84	21
Borda/Monte Hill	55	4,132	55	58.5	59	1,750	24	-4,385	Draining	58.27	86.1
Sancole	50	2,405	50	52.6	54	150	6.91	-2,443	Draining	52.5	62.6
Rua Escirano De Maria	50	2,405	50	51.9	54	150	7	1,070	Filling	52.75	68.7
Verna MBR	100	5,143	100	101.3	104	10,000	56	-29,655	Draining	101.09	27.1
NQ1	75	1,825	75	76.3	79	800	16	-1,944	Draining	78.23	80.8
NQ3	120	996	120	121.2	124	300	9.77	283	Filling	121.5	37.5
NQ2	50	117	50	53.1	54	100	6	-1,469	Draining	52.19	54.8
NQ4	100	315	100	101.8	104	100	5.64	63	Filling	100.93	23.3
NS4 300GLR	83	539	83	85	87	300	9.77	318	Filling	84.6	40
NS3	30	0	30	31.7	34	100	5.64	-892	Draining	32.53	63.2
NS2	92	334	92	94	96	200	7.98	234	Filling	93.64	40.9
NS1	45	0	45	48.4	49	100	5.64	348	Filling	46.66	41.4
NS6	25	0	25	25.8	29	300	10	-3,671	Draining	27.86	71.5
NS5	105	2,412	105	106.8	109	800	16	1,102	Filling	107.02	50.4
NQ4/S	60	0	60	63.1	64	100	6	-398	Draining	61.85	46.3
New Sirvoi MBR	115	0	115	117.5	120	20,000	75	74,541	Filling	117.43	53.9
T-70	45	0	45	48.1	50	5,000	35.68	-10883	Draining	47.31	46.2
Balli	115	0	115	116.3	119	650	14	1,898	Filling	116.93	48.2

Table F34.1.10 Reservoir Details at 24:00 for Salaulim Scheme

Label	Base Elevation (m)	Base Flow (m^3/day)	Minimum Elevation (m)	Initial HGL (m)	Maximum Elevation (m)	Total Volume (m^3)	Tank Diameter (m)	Inflow (m^3/day)	Current Status	Calculated Hydraulic Grade (m)	Calculated Percent Full (%)
Salaulim Reservoir	110.5	0	110.5	111.6	115	6,740	46	-36,204	Draining	112.93	60.9
Gogol Sump	53	0	53	55.5	56	1,500	25	-33,257	Draining	55.89	96.5
Margao MBR	110	0	110	112	114	10,000	56	28,466	Filling	111.86	46.6
Verna Sump	40	0	40	43.5	44	1,500	22	90,113	Filling	43.46	86.6
Head-land Sada	55	16,613	55	58.4	59	2,700	29	-14,599	Draining	55.68	17
Xelpem	83	165	83	86.5	87	200	8	13,920	Filling	84.4	34.9
Pentemol(Cuchorem)	61	4,148	61	64.4	65	800	16	-2,408	Draining	64.38	84.4
Malkarnem	76	138	76	76.7	80	100	6	-74	Draining	77.06	26.5
Zambaulim	58	341	58	59.5	62	300	10	-182	Draining	60.56	64.1
Rivona	60	228	60	62.7	64	200	7.98	-122	Draining	61.62	40.4
Veroda	46	4,686	46	47.9	50	800	16	-3,132	Draining	48.26	56.5
Velim	42	1,948	42	43.5	46	800	16	529	Filling	44.12	53
Chandor	53	571	53	54.5	57	150	7	-305	Draining	54.9	47.6
St Jose De Areal	40	0	40	43.4	44	800	16	-4,418	Draining	41.89	47.2
Sarzora	41	2,082	41	41.9	45	300	10	-1,345	Draining	41.74	18.5
Deusa	32	222	32	35.1	36	100	5.64	-119	Draining	34.78	69.5
Baida	16	2,138	16	18.4	20	600	14	-1,144	Draining	19.34	83.5
Girdolim	58	921	58	59.6	62	300	9.77	-493	Draining	58.57	14.3
Curtorim	14	2,536	14	15.6	18	1,050	18	-1,357	Draining	16.13	53.2
Makazana	40	348	40	43.5	44	100	5.64	-186	Draining	43.49	87.2
Colva	42	3,753	42	44.3	46	300	10	-2,008	Draining	44.87	71.7
Monte Hill	44	14,622	44	46.2	48	5,800	43	-8,216	Draining	45.52	38.1
Aquem	63	3,815	63	64	67	1,600	23	-2,144	Draining	64.86	48.9
Fatorda	55	2,225	55	58.2	59	800	16	-1,250	Draining	56.32	34.8
Dongar Wada	26.5	2,861	26.5	28.7	29	1,200	24	-1,608	Draining	27.35	31.6
Damon Raia	62	649	62	64	66	800	16.37	-347	Draining	62.63	16.5
Collea Dongor	15	827	15	17.6	19	700	15	-442	Draining	17.76	69.1
Camurlim	36	1,381	36	38.1	40	1,200	20	-739	Draining	38.41	60.3
Loutoulim	36	652	36	37.7	40	1,500	22	-349	Draining	37.87	46.8
Consua	32	3,440	32	35.1	36	600	14	-2,097	Draining	35.46	86.6
Nagao	54	420	54	55.3	58	800	16	-225	Draining	55.46	36.5
Upasnagar, Sancole	95	4,810	95	98.4	99	300	10	2,088	Filling	98.36	84
Quelossim	27	2,765	27	30	31	600	14	3,068	Filling	29.72	68
Bogmalo	45	1,125	45	46.6	49	150	7	-602	Draining	47.55	63.7
Issorcim	52	2,924	52	55.3	56	300	10	7,361	Filling	53.38	34.6
Dabolim	52	893	52	52.5	56	450	12	-478	Draining	53.85	46.2
St Jacinto I.	22	173	22	23	24	25	3.99	-93	Draining	22.82	40.8
Mid-land Sada	47	2,266	47	49.8	51	300	10	8,671	Filling	49.31	57.8
New Vaddem	40	8,306	40	43.4	44	1,250	20	-7,299	Draining	40.93	23.1
Chicalim	45	953	45	48.5	49	300	9.77	-510	Draining	46.92	48
Chicalim 600GLR	45	2,893	45	46.7	49	900	17	14,438	Filling	47.89	72.2
INS Gomantak	35	10,572	35	38.4	39	1,600	23	13,985	Filling	37.87	71.7
New Vaddem B N	47	9,061	47	47.6	51	1,450	21	18,495	Filling	49.53	63.1
Mangor	31	12,837	31	33.2	35	2,050	25.54	-11,281	Draining	34.15	78.7
Gandhi Nagar	34	5,286	34	34.9	38	800	16	-4,645	Draining	36.01	50.2
Sanguem	40	1,827	40	41.7	44	200	8	11,301	Filling	42.96	73.9
Balli Sump	15	0	15	18.2	19	400	11	9,511	Filling	16.17	29.3
Manora Raia	55	371	55	57.7	59	450	12	-198	Draining	58.24	81.1
Vasant Nagar	70	317	70	73.5	74	150	7.09	-178	Draining	73.47	91.4
Near MBR	55	2,225	55	56.8	59	800	16	-1,250	Draining	57.98	78.4
Shivoi	70	90	70	73	74	800	16	-48	Draining	73.05	76.3
Khanaguinim	40	270	40	41	42	25	4	-144	Draining	40.6	30.1
Nuvem	28	3,513	28	31	32	1,200	20	-1,879	Draining	30.7	67.4
Betalbatim	16	303	16	17.6	20	150	7	-162	Draining	18.34	58.5
Borda/Monte Hill	55	4,132	55	58.5	59	1,750	24	-2,322	Draining	56.3	34.3
Sancole	50	2,405	50	52.6	54	150	6.91	2,362	Filling	51.69	42.2
Rua Escirano De Maria	50	2,405	50	51.9	54	150	7	-2,130	Draining	53.44	86.1
Verna MBR	100	5,143	100	101.3	104	10,000	56	1,909	Filling	101.38	34.6
NQ1	75	1,825	75	76.3	79	800	16	-976	Draining	76.25	31.2
NQ3	120	996	120	121.2	124	300	9.77	-533	Draining	122.98	74.5
NQ2	50	117	50	53.1	54	100	6	-63	Draining	50.75	18.9
NQ4	100	315	100	101.8	104	100	5.64	212	Filling	102.14	53.6
NS4 300GLR	83	539	83	85	87	300	9.77	568	Filling	85.92	73.1
NS3	30	0	30	31.7	34	100	5.64	-856	Draining	32.39	59.7
NS2	92	334	92	94	96	200	7.98	404	Filling	95.13	78.2
NS1	45	0	45	48.4	49	100	5.64	-583	Draining	47.7	67.6
NS6	25	0	25	25.8	29	300	10	0	Filling	28.5	87.5
NS5	105	2,412	105	106.8	109	800	16	-1,290	Draining	108.35	83.7
NQ4/S	60	0	60	63.1	64	100	6	-380	Draining	61.47	36.8
New Sirvoi MBR	115	0	115	117.5	120	20,000	75	11,720	Filling	117.36	52.5
T-70	45	0	45	48.1	50	5,000	35.68	-11991	Draining	47.87	57.3
Balli	115	0	115	116.3	119	650	14	2,674	Filling	118.11	77.9

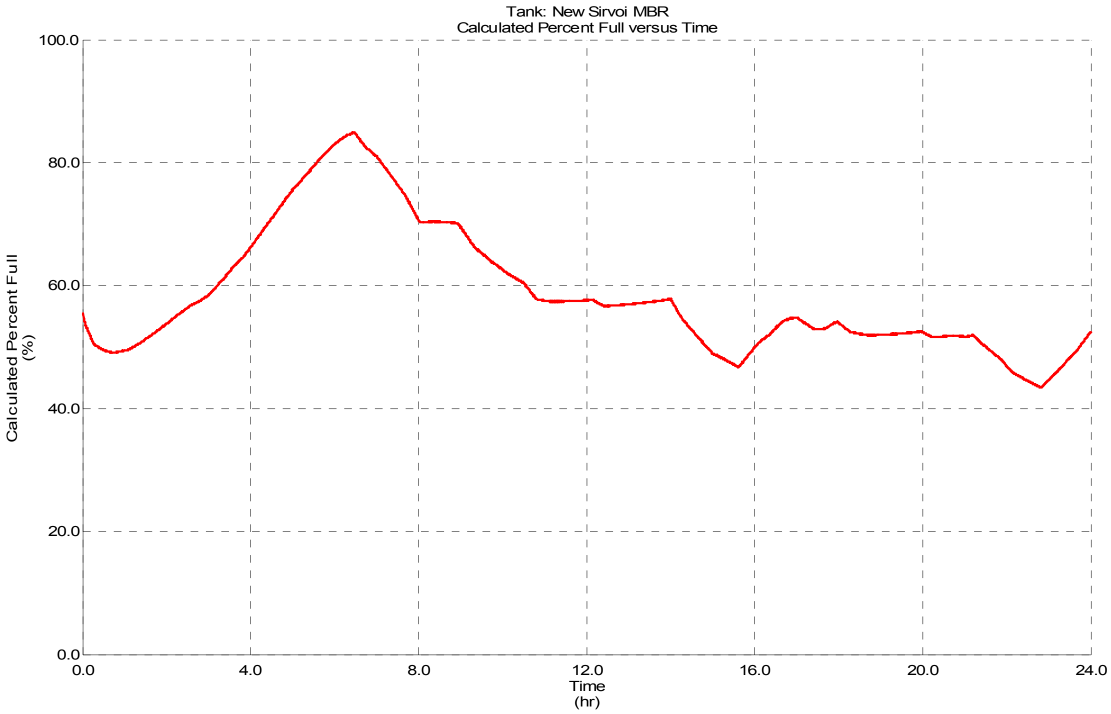


Figure F34.1.2 Water Level Fluctuation of Sirvoi MBR

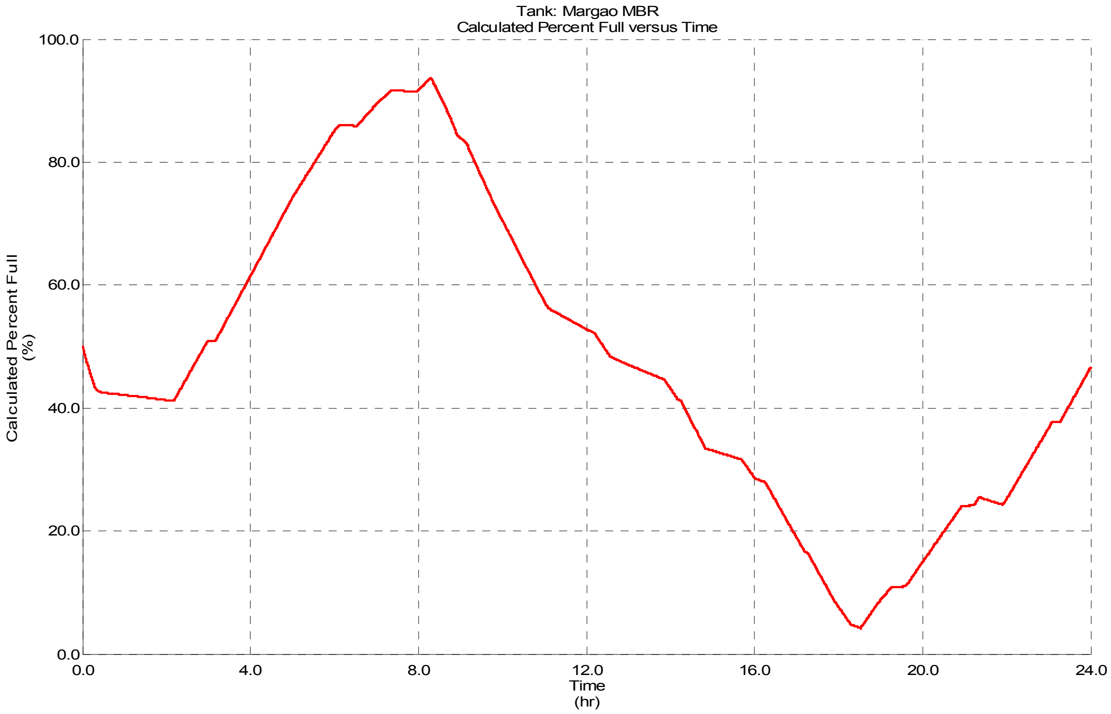


Figure F34.1.3 Water Level Fluctuation of Margao MBR

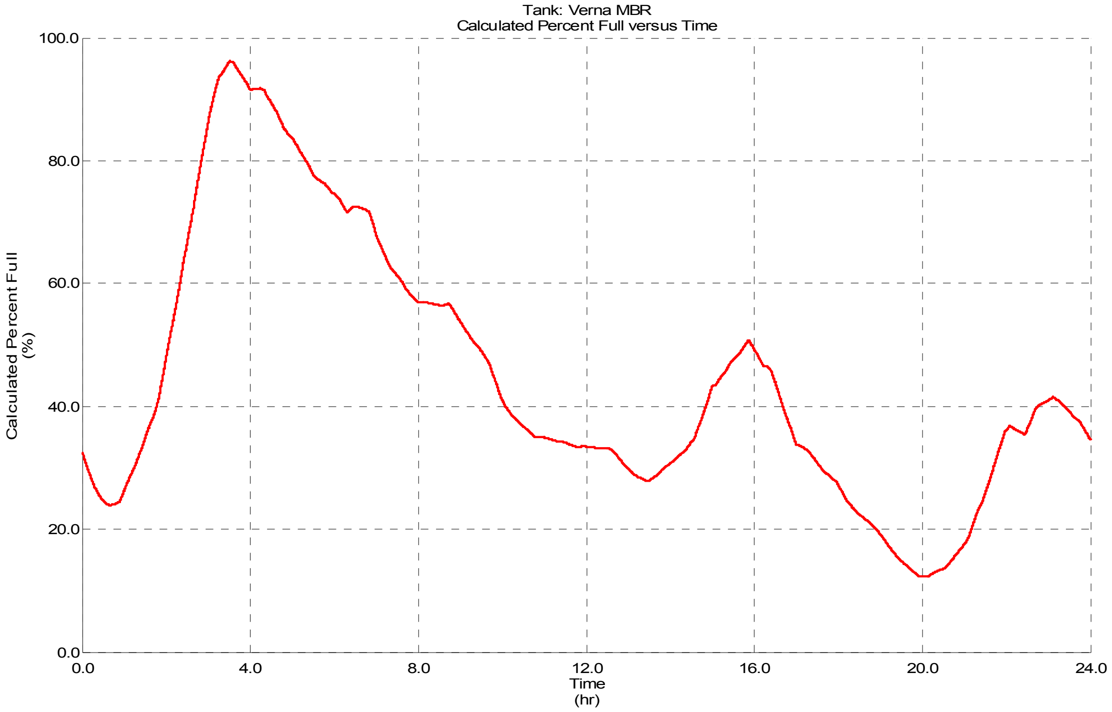


Figure F34.1.4 Water Level Fluctuation of Verna MBR

Appendix F35

Drinking Water Quality Parameters and Frequency of Analysis to be conducted by the Central Laboratory

Contents for Appendix F35

F35.1 Drinking Water Quality Parameters and Frequency of Analysis to be conducted by the Central Laboratory

Parameter		Recommended Guidelines* (mg/L)		WHO Guidelines**** (mg/L)	Frequency of analysis			
		Acceptable**	Cause for Rejection***		Recommended	Present	Short Term	Long Term
Health Significance Aspects	**1. Microbial aspects**							
	E.coli or Thermotolerant coliform bacteria	0 in 100ml sample		Must not be detectable in any 100ml sample	Monthly	Monthly	Monthly	Monthly
	2. Naturally occurring chemicals							
	Arsenic (As)	0.01	0.05	0.01	Monthly		Monthly	Monthly
	Barium (Ba)	-	-	0.7				
	Boron (B)	-	-	0.5				
	Chromium (Cr^{6+})	0.05	0.05	0.05	Monthly		Monthly	Monthly
	Fluoride (F)	1	1.5	1.5	Monthly	Monthly	Monthly	Monthly
	Manganese (Mn)	0.05	0.5	0.4	Monthly	Monthly	Monthly	Monthly
	Molybdenum (Mo)	-	-	0.07				
	Selenium (Se)	0.01	0.01	0.01	Monthly		Monthly	Monthly
	Uranium (U)	-	-	0.009				
	3. Chemicals from industrial sources and human dwellings							
	Inorganics							
	Cadmium (Cd)	0.01	0.05	0.003	Monthly		Monthly	Monthly
	Cyanide (CN)	0.05	0.05	0.07	Monthly		Monthly	Monthly
	Mercury (Hg)	0.001	0.001	0.001	Monthly		Monthly	Monthly
	Organics							
	Benzene	-	-	0.01				
	Carbon tetrachloride	-	-	0.004				
	Di(2-ethylhexyl)phthalate	-	-	0.008				
	Dichlorobenzene, 1,2-	-	-	1				
	Dichlorobenzene, 1,4-	-	-	0.3				
	Dichloroethane, 1,2-	-	-	0.03				
	Dichloroethene, 1,1-	-	-	0.03				
	Dichloroethene, 1,2-	-	-	0.05				
	Dichloromethane	-	-	0.02				
	Edetic acid (EDTA)	-	-	0.6				
	Ethylbenzene	-	-	0.3				
	Hexachlorobutadiene	-	-	0.0006				
	Nitrilotriacetic acid (NTA)	-	-	0.2				
	Pentachlorophenol	-	-	0.009				
	Styrene	-	-	0.02				
	Tetrachloroethene	-	-	0.04				
	Toluene	-	-	0.7				
	Trichloroethene	-	-	0.07				
	Xylenes	-	-	0.5				

*Source: The Government of India, Manual on Water Supply and Treatment Third Edition.

**The figures indicated under the column ‘Acceptable’ are the limits up to which water is generally acceptable to consumers.

***The figures which exceed 'Acceptable' but are less than 'Cause for Rejection' may be tolerated in the absence of an alternative and better source.

****Source: Guidelines for Drinking-water Quality Third Edition, WHO 2004

Parameter		Recommended Guidelines* (mg/L)		WHO Guidelines**** (mg/L)	Frequency of analysis			
		Acceptable**	Cause for Rejection***		Recommended	Present	Short Term	Long Term
Health Significance Aspects	**4. Chemicals from agricultural activities**							
	Non-pesticides							
	Nitrate (NO3)	45	45	50	Monthly	Monthly	Monthly	Monthly
	Nitrite (NO2) (long term)	-	-	3				
	Nitrite (NO2) (short term)	-	-	0.2				
	Pesticides used in agriculture							
	Alachlor	-	-	0.02				
	Aldicarb	-	-	0.01				
	Aldrin and dieldrin	-	-	0.00003				
	Atrazine	-	-	0.002				
	Carbofuran	-	-	0.007				
	Chlordane	-	-	0.0002				
	Chlorotoluron	-	-	0.03				
	Cyanazine	-	-	0.0006				
	2,4-D (2,4-dichlorophenoxyacetic acid)	-	-	0.03				
	2,4-DB	-	-	0.09				
	1,2-Dibromo-3-chloropropane	-	-	0.001				
	1,2-Dibromoethane	-	-	0.0004				
	1,2-Dichloropropane (1,2-DCP)	-	-	0.04				
	1,3-Dichloropropene	-	-	0.02				
	Dichlorprop	-	-	0.1				
	Dimethoate	-	-	0.006				
	Endrin	-	-	0.0006				
	Fenoprop	-	-	0.009				
	Isoproturon	-	-	0.009				
	Lindane	-	-	0.002				
	MCPA	-	-	0.002				
	Mecoprop	-	-	0.01				
	Methoxychlor	-	-	0.02				
	Metolachlor	-	-	0.01				
	Molinate	-	-	0.006				
	Pendimethalin	-	-	0.02				
	Simazine	-	-	0.002				
	2,4,5-T	-	-	0.009				
	Terbuthylazine	-	-	0.007				
	Trifluralin	-	-	0.02				

Parameter		Recommended Guidelines* (mg/L)		WHO Guidelines**** (mg/L)	Frequency of analysis			
		Acceptable**	Cause for Rejection***		Recommended	Present	Short Term	Long Term
Health Significance Aspects	**5. Chemicals used in water treatment or materials in contact with drinking-water**							
	Disinfectants							
	Chlorine (as OCL^-)	-	-	5				
	Monochloramine	-	-	3				
	Disinfection by-products							
	Bromate	-	-	0.01				
	Bromodichloromethane	-	-	0.06				
	Bromoform	-	-	0.1				
	Chloral hydrate (trichloroacetaldehyde)	-	-	0.01				
	Chlorate	-	-	0.7				
	Chlorite	-	-	0.7				
	Chloroform	-	-	0.2				
	Cyanogen chloride	-	-	0.07				
	Dibromoacetonitrile	-	-	0.07				
	Dibromochloromethane	-	-	0.1				
	Dichloroacetate	-	-	0.05				
	Dichloroacetonitrile	-	-	0.02				
	Formaldehyde	-	-	0.9				
	Monochloroacetate	-	-	0.02				
	Trichloroacetate	-	-	0.2				
	Trichlorophenol, 2,4,6-	-	-	0.2				
	Trihalomethanes	-	-	0.001				
	Contaminants from treatment chemicals							
	Acrylamide	-	-	0.0005				
	Epichlorohydrin	-	-	0.0004				
	Contaminants from pipes and fittings							
	Antimony (Sb)	-	-	0.02				
	Benzo[a]pyrene	-	-	0.0007				
	Copper (Cu)	0.05	1.5	2	Monthly		Monthly	Monthly
	Lead (Pb)	0.05	0.05	0.01	Monthly		Monthly	Monthly
	Nickel (Ni)	-	-	0.02				
	Vinyl chloride	-	-	0.0003				
	6. Cyanotoxins							
	Microcystin-LR	-	-	0.001				

Parameter		Recommended Guidelines* (mg/L)		WHO Guidelines**** (mg/L)	Frequency of analysis			
		Acceptable**	Cause for Rejection***		Recommended	Present	Short Term	Long Term
Acceptability Aspects	**7. Acceptability aspects**							
	Alkalinity	200	600		Monthly	Monthly	Monthly	Monthly
	Aluminium (Al)	0.03	0.2	0.1	Monthly	Monthly	Monthly	Monthly
	Ammonia	-	-	1.5				
	Anionic detergent	0.2	1	-	Monthly			Monthly
	Calcium (Ca)	75	200	-	Monthly	Monthly	Monthly	Monthly
	Chloride (Cl)	200	1000	200-300	Monthly	Monthly	Monthly	Monthly
	Chlorine (as OCL^-)	-	-	0.6 - 1.0				
	Chlorophenols	-	-	0.0001-0.002				
	Color	5 Pt/Co Scale	25 Pt/Co	15 TCU	Monthly	Monthly	Monthly	Monthly
	Copper (Cu)	0.05	1.5	5	Monthly		Monthly	Monthly
	Dichlorobenzenes	-	-	0.002-0.03				
	Ethylbenzene	-	-	0.002-0.13				
	Gross Alpha activity (Bq/L)	0.1	0.1	-				
	Gross Beta activity (Bq/L)	1	1	-				
	Hardness	200	600	100-300	Monthly	Monthly	Monthly	Monthly
	Hydrogen sulfide (H_2S)	200	400	0.05-0.1				
	Iron (Fe)	0.1	1	0.3	Monthly	Monthly	Monthly	Monthly
	Magnesium (Mg)	30	150	-				
	Manganese (Mn)	0.05	0.5	0.1	Monthly	Monthly	Monthly	Monthly
	Mineral Oil	0.01	0.03	-	Monthly			Monthly
	Monochloramine	-	-	0.3				
	Monochlorobenzene	-	-	0.01-0.02				
	Odor	Objectable	Objectable	acceptable	Monthly	Monthly	Monthly	Monthly
	Petroleum oils	-	-	-				
	pH	7.0 to 8.5	<6.5 or >9.2	6.5 - 8.5	Monthly	Monthly	Monthly	Monthly
	Phenol	0.001	0.002	-				
	Polynuclear aromatic hydrocarbon (PAH)	0.0002	0.0002	-				
	Sodium (Na)	-	-	200				
	Styrene	-	-	0.004-2.6				
	Sulfate (SO4)	200	400	250	Monthly	Monthly	Monthly	Monthly
	Synthetic detergents	-	-	-				
	Taste	Objectable	Objectable	acceptable	Monthly	Monthly	Monthly	Monthly
	Toluene	-	-	0.04-0.17				
	Total dissolved solid (TDS)	500	2000	600-1000	Monthly	Monthly	Monthly	Monthly
	Trichlorobenzenes	-	-	0.005-0.05				
	Turbidity	1NTU	10NTU	5 NTU	Monthly	Monthly	Monthly	Monthly
	Xylenes	-	-	0.3				
	Zinc (Zn)	5	15	3-5	Monthly			Monthly

Appendix F36

Lengths and Longitudinal Sections of Proposed Transmission Mains

Contents for Appendix F36

F36.1 Transmission Main from Proposed WTP to Margao via Sirvoi MBR: TM1 & TM2

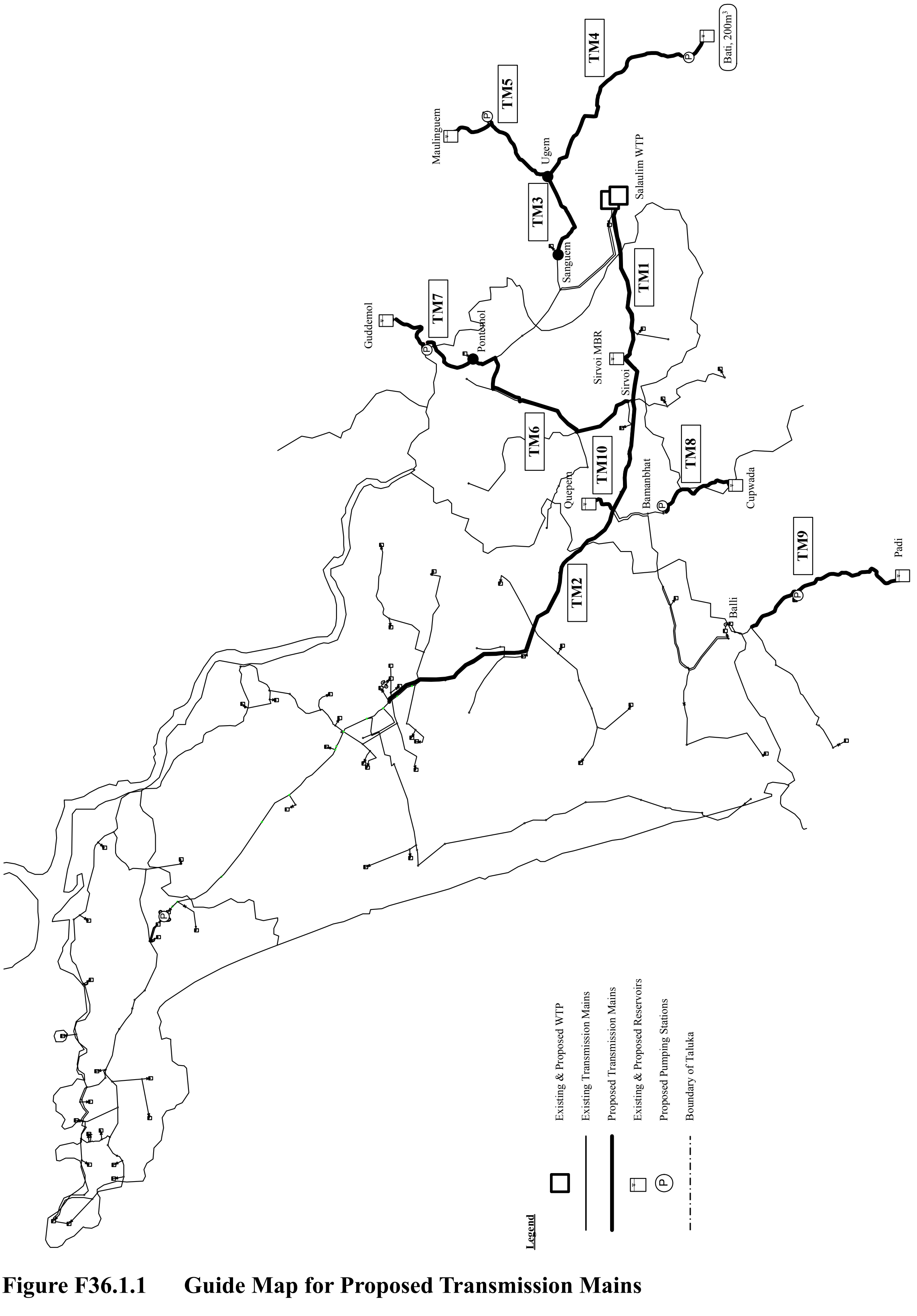


Figure F36.1.1 Guide Map for Proposed Transmission Mains

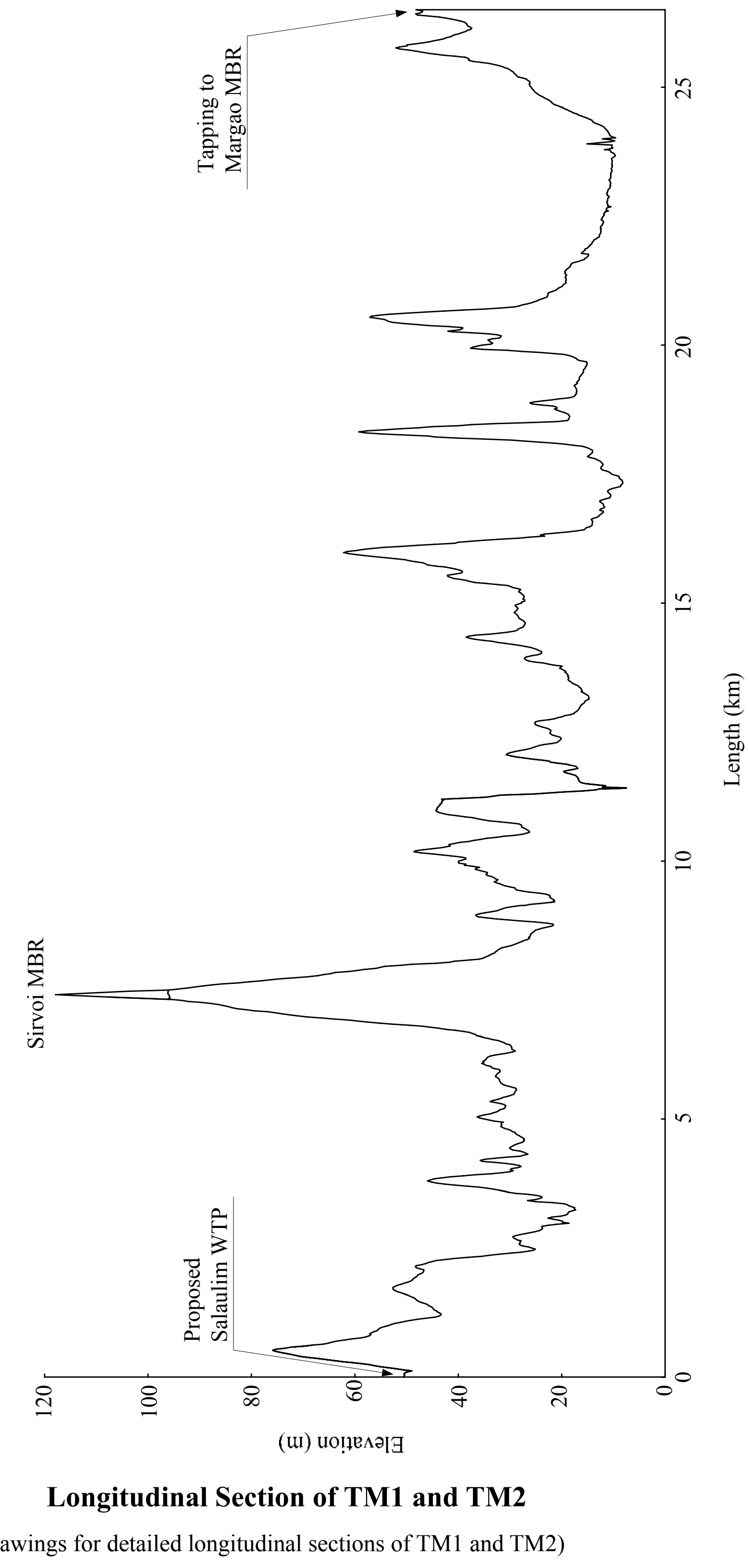


Figure F36.1.2 Longitudinal Section of TM1 and TM2

(see Valume VI Drawings for detailed longitudinal sections of TM1 and TM2)

F36.2 Transmission Main from Sanguem to Ugem: TM3

Table F36.1.1 Details of Pipeline Route of TM3

Point	Latidude			Longitude			Calculated Length *1	Total Length	Measured Length *2	Elevation *3
	deg.	min.	sec.	deg.	min.	sec.				
1	15°	13	36.7	74°	9	20.0		0	0	38
2	15°	13	30.9	74°	9	31.7	404	404	400	25
3	15°	13	29.6	74°	9	35.4	119	524	500	22
4	15°	13	21.6	74°	9	40.8	300	824	800	23
5	15°	13	13.8	74°	9	52.4	431	1,255	1250	25
6	15°	13	19.9	74°	10	9.0	545	1,799	1800	24
7	15°	13	23.8	74°	10	17.4	286	2,085	2100	20
8	15°	13	29.0	74°	10	21.7	210	2,296	2300	13
9	15°	13	36.6	74°	10	40.0	612	2,907	2900	13
10	15°	13	44.9	74°	10	59.6	656	3,563	3600	15

*1: Calculated length is based on GPS coordinates.
*2: Measured length shows the readings of GPS.
*3: Elevations are measued by GPS.

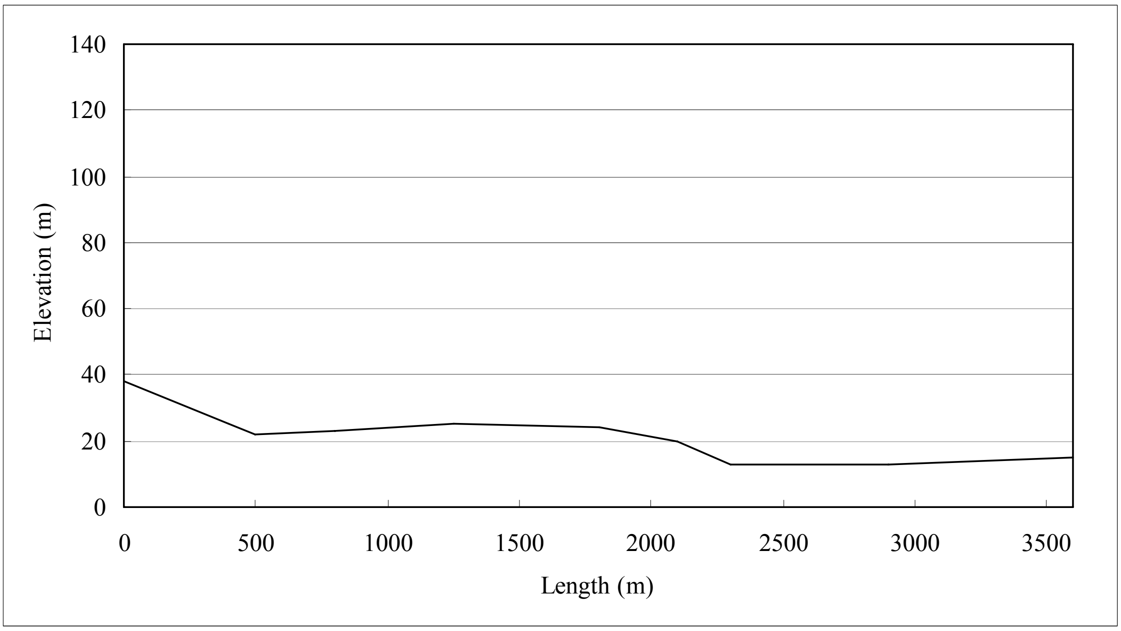


Figure F36.1.3 Longitudinal Section of TM3

F36.3 Transmission Main from Ugem to Bati: TM4

Table F36.1.2 Details of Pipeline Route of TM4

Point	Latidude			Longitude			Calculated Length *1	Total Length	Measured Length *2	Elevation *3
	deg.	min.	sec.	deg.	min.	sec.				
1	15°	13	44.9	74°	10	59.6		0	0	15
2	15°	13	38.4	74°	11	7.9	326	326	300	16
3	15°	13	34.0	74°	11	16.0	285	611	600	27
4	15°	13	25.8	74°	11	22.9	331	942	900	28
5	15°	13	18.0	74°	11	32.4	379	1,321	1300	29
6	15°	13	13.2	74°	11	44.6	403	1,725	1700	32
7	15°	13	4.0	74°	11	58.9	527	2,251	2300	38
8	15°	12	57.6	74°	12	12.7	467	2,718	2700	65
9	15°	12	47.4	74°	12	18.7	366	3,085	3100	67
10	15°	12	41.4	74°	12	21.6	205	3,290	3300	59
11	15°	12	41.1	74°	12	31.6	309	3,599	3600	55
12	15°	12	41.4	74°	12	47.1	478	4,077	4100	33
13	15°	12	37.8	74°	12	51.9	184	4,261	4300	23
14	15°	12	32.1	74°	13	2.6	375	4,636	4700	31
15	15°	12	26.1	74°	13	9.3	277	4,913	5000	30
16	15°	12	16.6	74°	13	18.9	416	5,329	5400	36
17	15°	12	4.3	74°	13	23.7	409	5,738	5800	43
18	15°	12	-0.5	74°	13	35.1	383	6,120	6200	43
19	15°	11	48.6	74°	13	39.2	360	6,480	6600	39
20	15°	11	33.6	74°	13	43.2	481	6,961	7100	50
21	15°	11	18.1	74°	13	40.8	482	7,443	7600	47
22	15°	11	10.4	74°	13	37.1	264	7,707	7800	43
23	15°	10	55.0	74°	13	41.0	491	**8,198**	8300	45
24	15°	10	50.6	74°	13	38.4	158	8,356	8500	51
25	15°	10	47.9	74°	13	39.2	87	8,444	8600	51
26	15°	10	35.5	74°	13	41.3	387	8,830	9000	67
27	15°	10	23.8	74°	13	58.2	635	9,466	9600	92

*1: Calculated length is based on GPS coordinates.
*2: Measured length shows the readings of GPS.
*3: Elevations are measued by GPS.

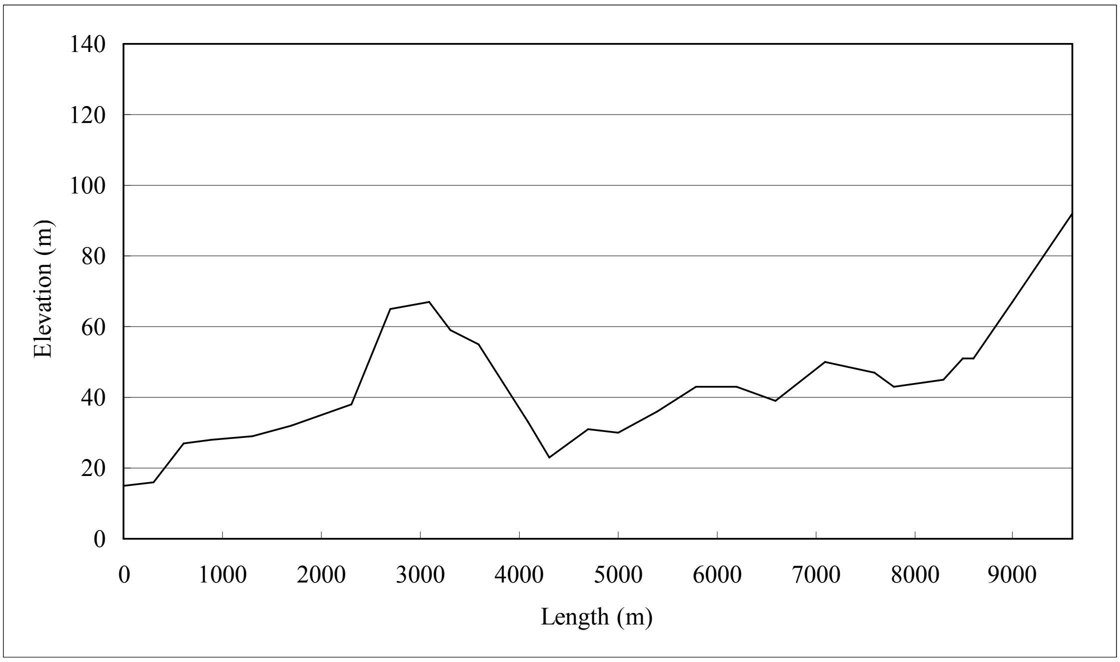


Figure F36.1.4 Longitudinal Section of TM4

F36.4 Transmission Main from Ugem to Maulinguem: TM5

Table F36.1.3 Details of Pipeline Route of TM5

Point	Latidude			Longitude			Calculated Length *1	Total Length	Measured Length *2	Elevation *3
	deg.	min.	sec.	deg.	min.	sec.				
1	15°	13	44.9	74°	10	59.6		0	0	15
2	15°	13	45.6	74°	10	59.5	22	22	50	16
3	15°	14	-0.5	74°	11	4.3	454	476	450	11
4	15°	14	4.2	74°	11	7.1	167	643	650	12
5	15°	14	19.1	74°	11	20.8	625	1,268	1250	17
6	15°	14	30.1	74°	11	38.8	653	1,922	1950	25
7	15°	14	42.9	74°	11	56.2	665	2,587	2600	27
8	15°	15	-3.8	74°	12	4.2	479	3,065	3100	29
9	15°	15	2.1	74°	12	15.8	401	**3,466**	3600	30
10	15°	15	15.9	74°	12	2.9	583	4,049	4200	46
11	15°	15	34.4	74°	12	5.7	579	4,628	4800	60
12	15°	15	46.4	74°	12	2.2	386	5,014	5200	70
13	15°	16	-1.1	74°	11	57.0	418	**5,431**	**5700**	83
14	15°	16	6.7	74°	11	50.7	309	5,740	6000	76
15	15°	16	13.4	74°	11	45.4	265	6,005	6300	72
16	15°	16	23.9	74°	11	31.3	541	6,547	6800	68
17	15°	16	36.4	74°	11	26.4	416	6,962	7300	68
18	15°	16	45.8	74°	11	9.0	610	7,572	7900	64
19	15°	17	-0.5	74°	10	58.8	527	8,099	8500	51

*1: Calculated length is based on GPS coordinates.
*2: Measured length shows the readings of GPS.
*3: Elevations are measued by GPS.

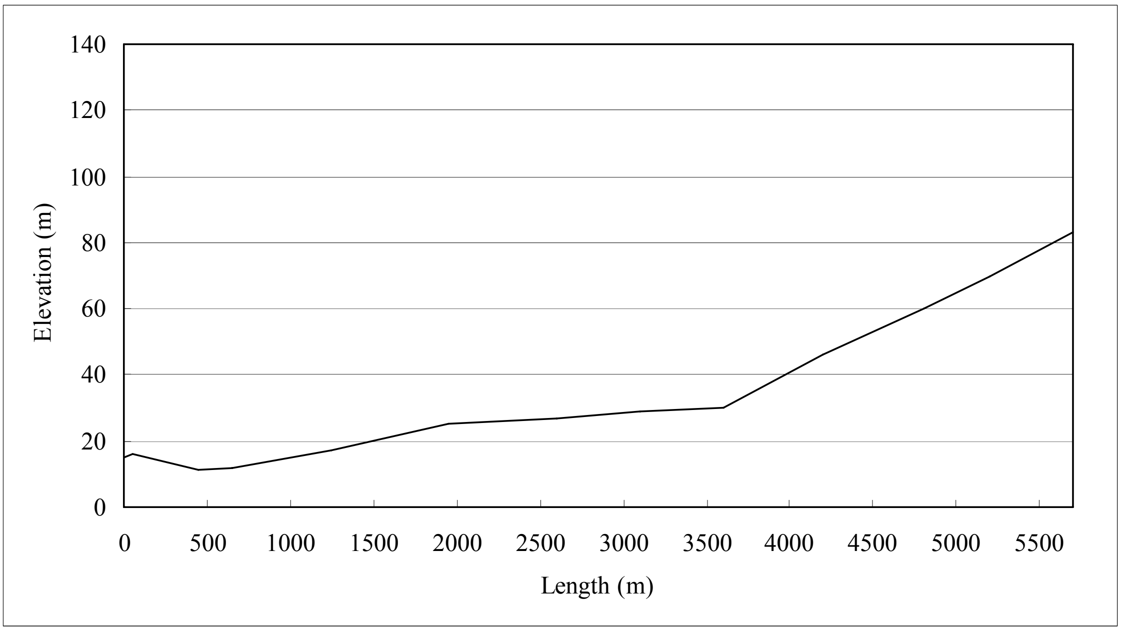


Figure F36.1.5 Longitudinal Section of TM5

F36.5 Transmission Main from Sirvoi to Pontemol: TM6

Table F36.1.4 Details of Pipeline Route of TM6

Point	Latidude			Longitude			Calculated Length *1	Total Length	Measured Length *2	Elevation *3
	deg.	min.	sec.	deg.	min.	sec.				
1	15°	12	-1.9	74°	5	55.0		0	0	20
2	15°	12	4.6	74°	5	56.5	207	207	200	20
3	15°	12	16.5	74°	5	48.3	444	651	700	27
4	15°	12	26.5	74°	5	32.5	578	1,230	1200	25
5	15°	12	37.7	74°	5	22.8	458	1,688	1700	18
6	15°	12	55.7	74°	5	17.8	576	2,265	2300	15
7	15°	13	9.7	74°	5	15.7	437	**2,702**	2700	16
8	15°	13	13.6	74°	5	18.6	148	2,850	2900	14
9	15°	13	22.6	74°	5	27.1	381	3,231	3300	14
10	15°	13	25.4	74°	5	29.6	118	3,349	3400	12
11	15°	13	33.5	74°	5	40.6	420	3,769	3800	13
12	15°	13	38.7	74°	5	43.6	186	3,955	4000	12
13	15°	13	42.4	74°	5	45.2	124	4,079	4100	13
14	15°	13	51.4	74°	5	46.5	280	4,359	4400	11
15	15°	13	55.9	74°	5	47.5	142	4,502	4600	8
16	15°	13	59.3	74°	5	48.7	112	4,614	4700	8
17	15°	14	6.9	74°	5	51.2	248	4,862	4900	9
18	15°	14	9.8	74°	5	51.9	91	4,953	5000	9
19	15°	14	18.5	74°	5	53.8	277	5,230	5300	7
20	15°	14	24.1	74°	5	55.1	175	5,404	5500	9
21	15°	14	29.3	74°	5	56.2	167	5,571	5600	8
22	15°	14	36.7	74°	5	59.9	255	5,826	5900	8
23	15°	14	41.5	74°	6	2.5	167	5,994	6100	8
24	15°	14	45.7	74°	6	4.7	147	6,141	6200	10
25	15°	14	51.4	74°	6	7.3	193	6,334	6400	8
26	15°	14	58.6	74°	6	10.4	240	**6,574**	6600	5
27	15°	14	55.1	74°	6	30.7	636	7,210	7200	9
28	15°	14	53.8	74°	6	42.1	356	7,566	7600	11
29	15°	14	55.6	74°	6	52.2	316	**7,882**	8000	10
30	15°	15	12.2	74°	6	45.4	553	8,435	8500	6
31	15°	15	14.7	74°	6	45.2	76	8,511	8600	6
32	15°	15	15.5	74°	6	47.2	66	8,577	8700	6
33	15°	15	23.9	74°	6	51.4	290	8,867	8900	10
34	15°	15	24.4	74°	6	50.6	28	**8,896**	9000	10

*1: Calculated length is based on GPS coordinates.
*2: Measured length shows the readings of GPS.
*3: Elevations are measued by GPS.

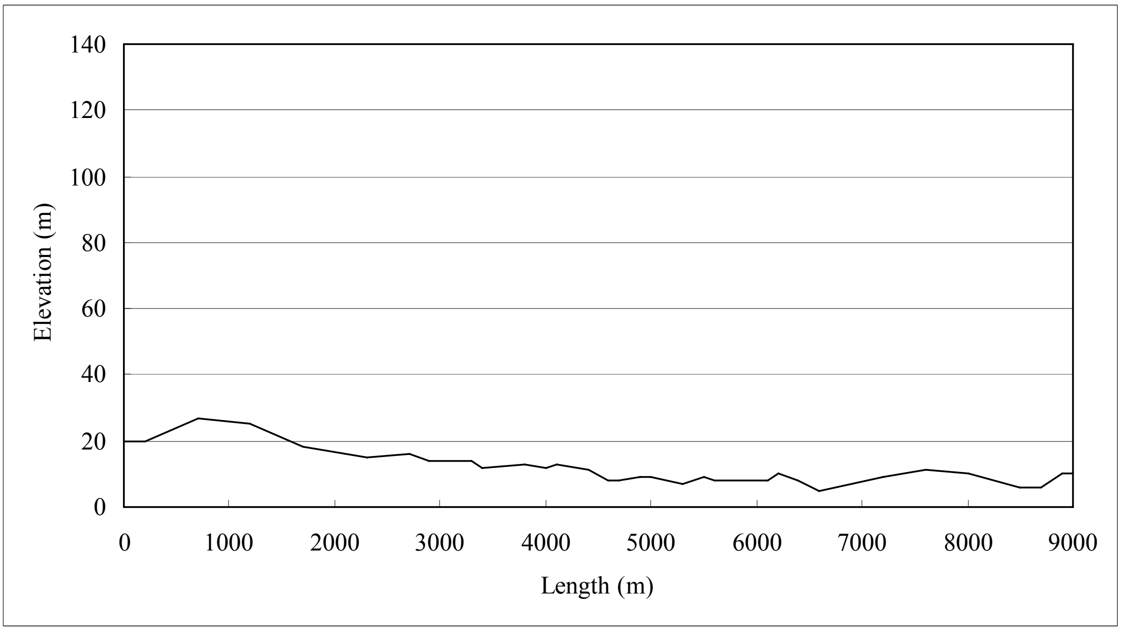


Figure F36.1.6 Longitudinal Section of TM6

F36.6 Transmission Main from Pontemol to Guddemol: TM7

Table F36.1.5 Details of Pipeline Route of TM7

Point	Latidude			Longitude			Calculated Length *1	Total Length	Measured Length *2	Elevation *3
	deg.	min.	sec.	deg.	min.	sec.				
1	15°	15	24.4	74°	6	50.6		0	0	10
2	15°	15	26.0	74°	6	42.9	244	244	300	11
3	15°	15	36.4	74°	6	46.2	338	582	600	11
4	15°	15	46.8	74°	6	42.6	337	919	900	17
5	15°	16	1.5	74°	6	44.1	458	1,377	1300	7
6	15°	16	4.1	74°	6	47.5	132	**1,509**	1500	7
7	15°	16	3.0	74°	6	52.4	154	1,663	1600	7
8	15°	16	9.0	74°	7	2.4	358	2,020	2100	6
9	15°	16	18.5	74°	7	15.7	507	**2,528**	2600	25
10	15°	16	32.4	74°	7	14.1	431	2,958	3100	10
11	15°	16	39.9	74°	7	29.0	514	3,473	3600	35
12	15°	16	35.0	74°	7	37.3	298	3,771	3900	58
13	15°	16	43.6	74°	7	36.0	268	4,039	4200	71
14	15°	17	-0.6	74°	7	42.9	532	4,570	4800	99
15	15°	17	8.5	74°	7	51.9	395	4,966	5200	105

*1: Calculated length is based on GPS coordinates.
*2: Measured length shows the readings of GPS.
*3: Elevations are measued by GPS.

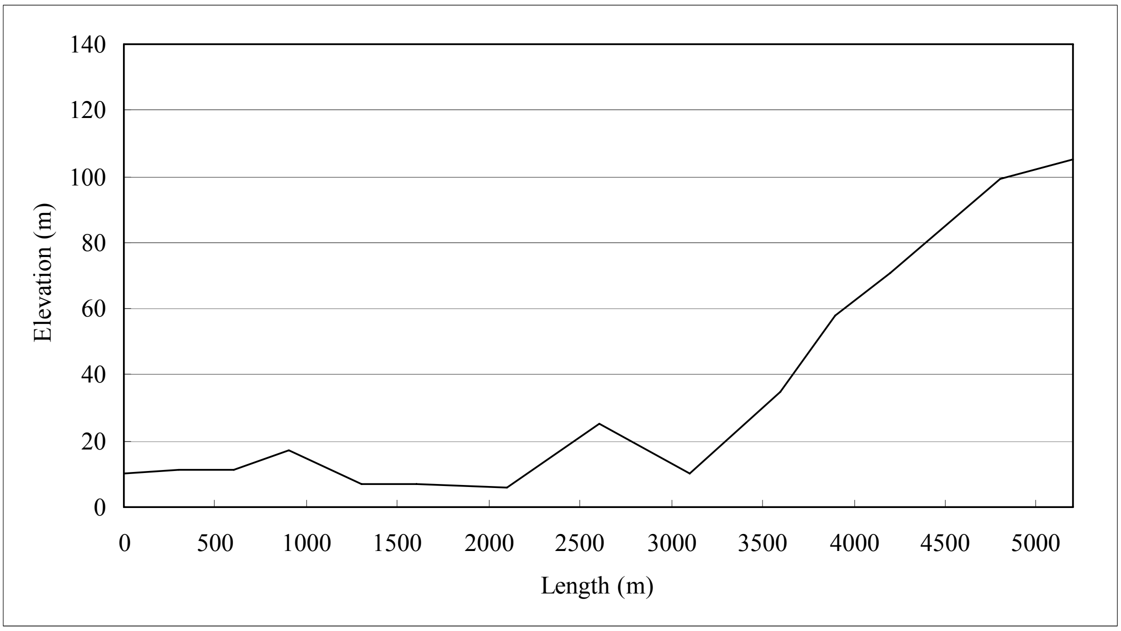


Figure F36.1.7 Longitudinal Section of TM7

F36.7 Transmission Main from Bamanbhat to Cupwada: TM8

Table F36.1.6 Details of Pipeline Route of TM8

Point	Latidude			Longitude			Calculated Length *1	Total Length	Measured Length *2	Elevation *3
	deg.	min.	sec.	deg.	min.	sec.				
1	15°	11	14.6	74°	3	22.7		0	0	56
2	15°	11	9.3	74°	3	35.7	432	432	500	62
3	15°	11	-1.4	74°	3	51.4	589	1,021	1100	85
4	15°	10	43.3	74°	3	55.7	490	1,511	1600	72
5	15°	10	24.1	74°	3	60.6	611	2,123	2200	65
6	15°	10	5.5	74°	4	7.8	614	2,736	2800	76
7	15°	10	-0.8	74°	4	8.1	197	2,933	3000	96
8	15°	9	49.1	74°	4	4.3	333	3,266	3400	98

*1: Calculated length is based on GPS coordinates.

*2: Measured length shows the readings of GPS.

*3: Elevations are measued by GPS.

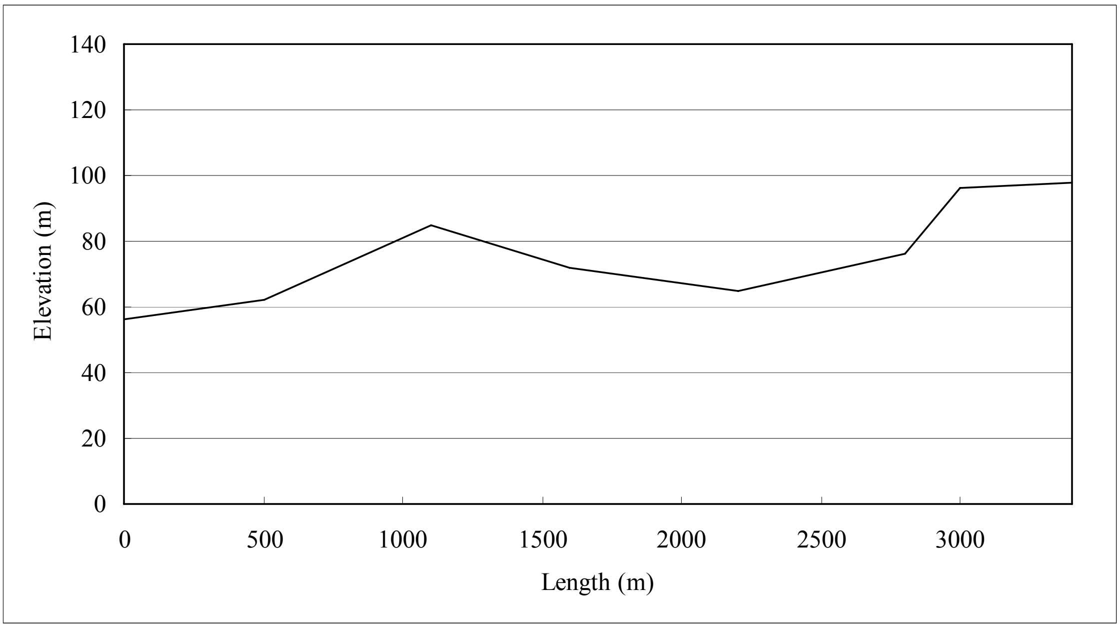


Figure F36.1.8 Longitudinal Section of TM8

F36.8 Transmission Main from Balli to Padi: TM9

Table F36.1.7 Details of Pipeline Route of TM9

Point	Latidude			Longitude			Calculated Length *1	Total Length	Measured Length *2	Elevation *3
	deg.	min.	sec.	deg.	min.	sec.				
1	15°	9	20.2	74°	0	53.9		0	0	17
2	15°	9	5.5	74°	1	6.6	600	600	600	31
3	15°	8	52.7	74°	1	12.9	441	1,041	1100	31
4	15°	8	38.8	74°	1	29.0	658	1,698	1800	34
5	15°	8	29.3	74°	1	35.5	354	2,053	2100	34
6	15°	8	23.8	74°	1	41.2	245	**2,298**	2400	50
7	15°	8	3.5	74°	1	50.5	689	2,986	3100	62
8	15°	7	42.3	74°	1	61.6	741	3,727	3800	67
9	15°	7	35.8	74°	2	4.2	214	3,940	4000	59
10	15°	7	21.4	74°	2	6.3	449	4,389	4500	61
11	15°	7	13.1	74°	2	6.7	258	4,647	4800	54
12	15°	7	3.7	74°	2	4.1	300	4,947	5100	58
13	15°	6	43.6	74°	2	10.1	649	5,596	5800	84
14	15°	6	33.8	74°	2	2.3	386	5,983	6200	105
15	15°	6	25.8	74°	1	53.9	358	6,340	6600	110
16	15°	6	5.3	74°	1	57.0	641	6,981	7200	120

*1: Calculated length is based on GPS coordinates.
*2: Measured length shows the readings of GPS.
*3: Elevations are measued by GPS.

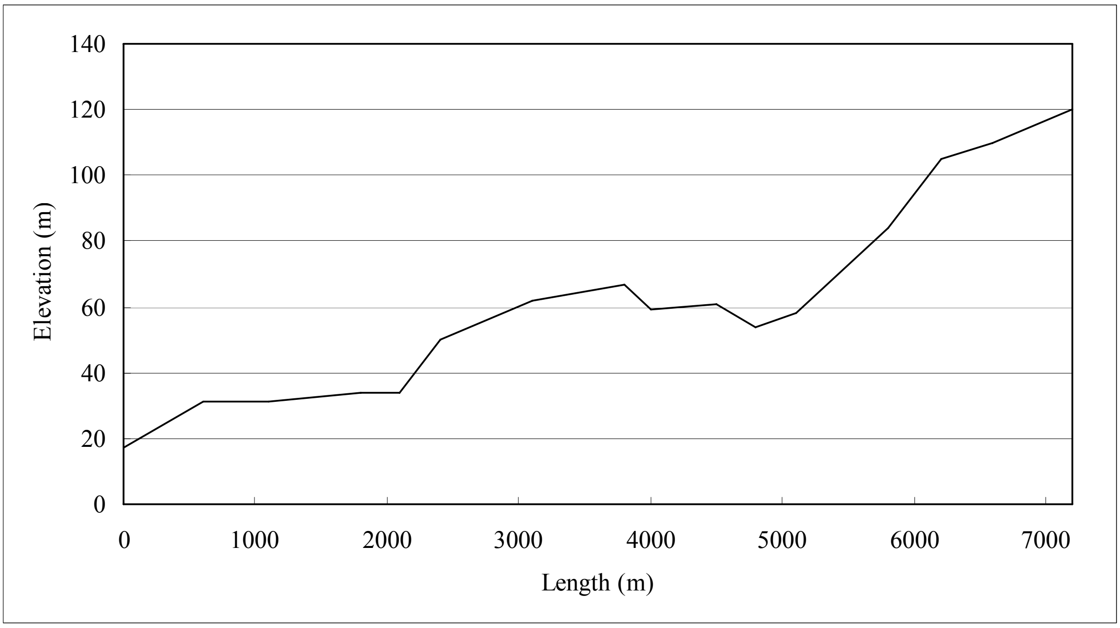


Figure F36.1.9 Longitudinal Section of TM9

F36.9 Transmission Main for Quepem Reservoir: TM10

Table F36.1.8 Details of Pipeline Route of TM10

Point	Measured Length *	Elevation *
1	0	15
2	300	12
3	500	10
4	800	10
5	1000	10
6	1150	20
7	1200	30
8	1250	40
9	1300	50
10	1350	60
11	1400	75

*: estimated from maps

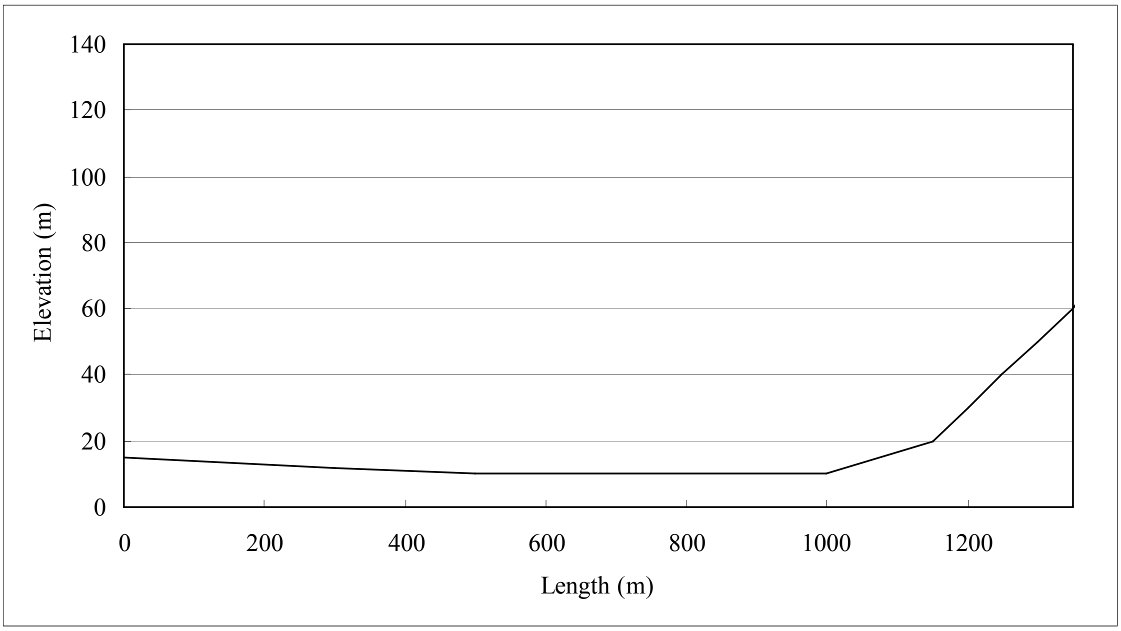


Figure F36.1.10 Longitudinal Section of TM10

APPENDIX F5

This appendix is reference to and supporting data of

Volume 3 Main Report – Feasibility Study

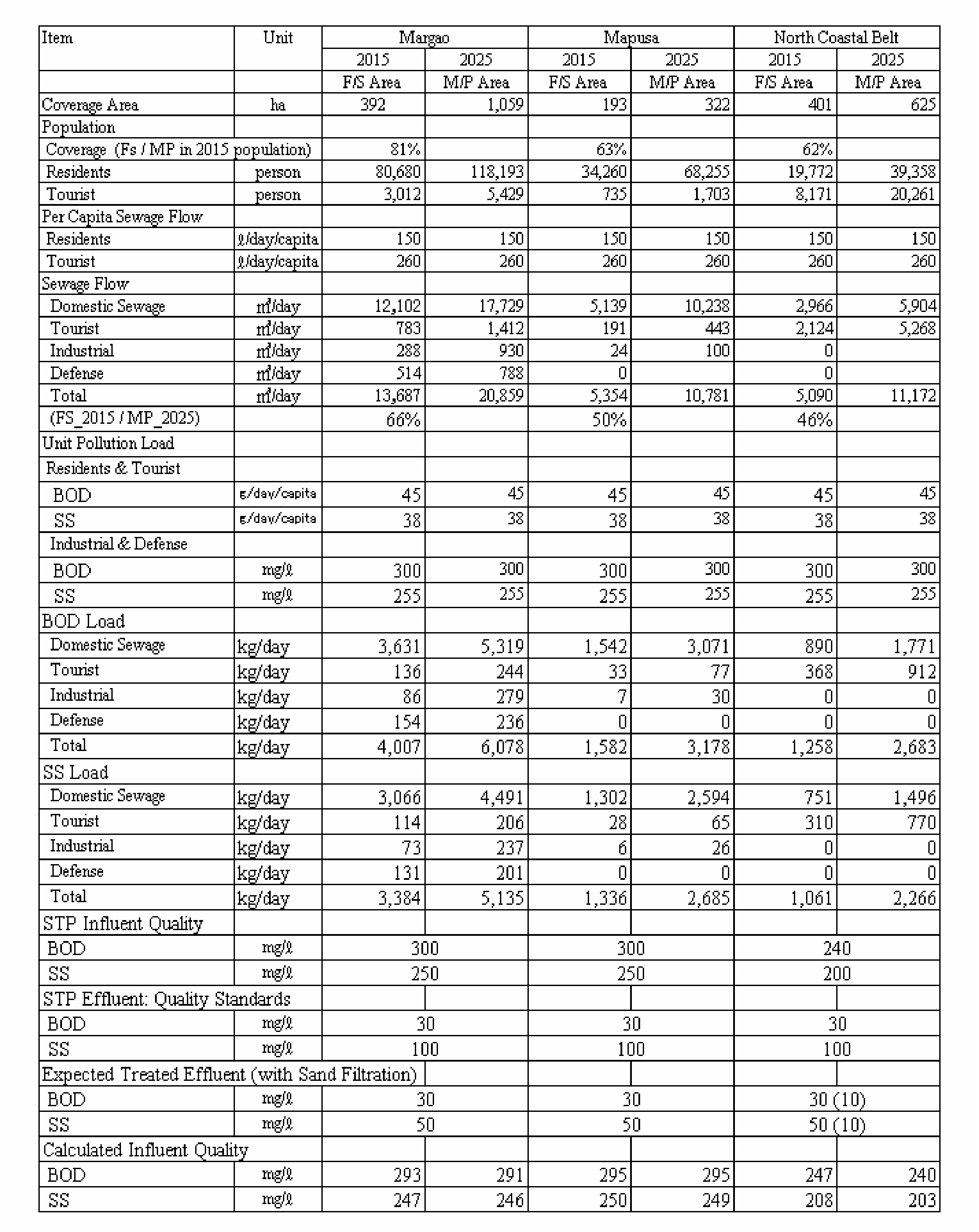
Chapter 5 Sewerage System

Appendix F51

Population and Sewage flow in the Master Plan Area for F/S Target Cities / Flow Calculation Sheet

Contents for Appendix F51

Appendix F 51.1 Population and Sewage flow in the Master Plan Area for F/S Target Cities



Item	Unit	Margao		Mapusa		North Coastal Belt	
		2015	2025	2015	2025	2015	2025
		F/S Area	M/P Area	F/S Area	M/P Area	F/S Area	M/P Area
Coverage Area	ha	392	1,059	193	322	401	625
Population							
Coverage (Fs / MP in 2015 population)		81%		63%		62%	
Residents	person	80,680	118,193	34,260	68,255	19,772	39,358
Tourist	person	3,012	5,429	735	1,703	8,171	20,261
Per Capita Sewage Flow							
Residents	ℓ/day/capita	150	150	150	150	150	150
Tourist	ℓ/day/capita	260	260	260	260	260	260
Sewage Flow							
Domestic Sewage	㎥/day	12,102	17,729	5,139	10,238	2,966	5,904
Tourist	㎥/day	783	1,412	191	443	2,124	5,268
Industrial	㎥/day	288	930	24	100	0	
Defense	㎥/day	514	788	0		0	
Total	㎥/day	13,687	20,859	5,354	10,781	5,090	11,172
(FS_2015 / MP_2025)		66%		50%		46%	
Unit Pollution Load							
Residents & Tourist							
BOD	g/day/capita	45	45	45	45	45	45
SS	g/day/capita	38	38	38	38	38	38
Industrial & Defense							
BOD	mg/ℓ	300	300	300	300	300	300
SS	mg/ℓ	255	255	255	255	255	255
BOD Load							
Domestic Sewage	kg/day	3,631	5,319	1,542	3,071	890	1,771
Tourist	kg/day	136	244	33	77	368	912
Industrial	kg/day	86	279	7	30	0	0
Defense	kg/day	154	236	0	0	0	0
Total	kg/day	4,007	6,078	1,582	3,178	1,258	2,683
SS Load							
Domestic Sewage	kg/day	3,066	4,491	1,302	2,594	751	1,496
Tourist	kg/day	114	206	28	65	310	770
Industrial	kg/day	73	237	6	26	0	0
Defense	kg/day	131	201	0	0	0	0
Total	kg/day	3,384	5,135	1,336	2,685	1,061	2,266
STP Influent Quality							
BOD	mg/ℓ	300		300		240	
SS	mg/ℓ	250		250		200	
STP Effluent: Quality Standards							
BOD	mg/ℓ	30		30		30	
SS	mg/ℓ	100		100		100	
Expected Treated Effluent (with Sand Filtration)							
BOD	mg/ℓ	30		30		30 (10)	
SS	mg/ℓ	50		50		50 (10)	
Calculated Influent Quality							
BOD	mg/ℓ	293	291	295	295	247	240
SS	mg/ℓ	247	246	250	249	208	203

Appendix F 51.2 Flow Calculation Sheet

(1) Flow Calculation Sheet for Margao (F/S)

Node		Area (ha) (2025)		Population (2025)		Average Flow (lps) (2025)		Peak Factor	Peak Flow (2025) (lps)	Diameter (mm)	Length (m)	Gradient (1/x)	Ground level (m)		Invert level (m)		Covering (m)		Velocity at 80% depth (m/sec)	Flow Capacity at 80% depth (lps)	Remarks
From	To	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative						Upstream	Downstream	Upstream	Downstream	Upstream	Downstream			
from Part I, II		119.20		13,262		27.1															
1	2	27.68	146.9	3,606	16,868	7.4	34.5	3.00	103.4	450	259	490	15.26	13.06	13.226	11.026	1.50	1.50	0.80	109.3	
2	3	5.07	152.0	661	17,529	1.4	35.8	3.00	107.4	450	382	490	13.06	12.39	10.075	8.810	2.46	3.05	0.80	109.3	
3	9	66.71	218.7	8,691	26,220	17.8	53.6	2.50	133.9	500	544	560	12.39	9.22	8.650	6.563	3.16	2.08	0.80	135.4	
4	5	31.72	31.7	3,183	3,183	6.5	6.5	3.00	19.5	300	234	280	12.23	11.52	9.310	8.474	2.54	2.67	0.81	49.0	
5	6	13.74	45.5	1,379	4,562	2.8	9.3	3.00	28.0	300	285	280	11.52	10.58	8.474	7.456	2.67	2.74	0.81	49.0	
6	7	19.95	65.4	2,002	6,564	4.1	13.4	3.00	40.2	300	287	280	10.58	9.72	7.456	6.431	2.74	2.91	0.81	49.0	
7	8	9.40	74.8	943	7,507	1.9	15.3	3.00	46.0	400	526	410	9.72	9.28	6.331	5.048	2.91	3.75	0.81	87.3	
8	9	51.09	125.9	5,127	12,634	10.5	25.8	3.00	77.4	400	710	410	9.28	9.22	5.048	3.316	3.75	5.42	0.81	87.3	
9	10	0.00	344.6	0	38,854	0.0	79.4	2.50	198.4	700	49	880	9.22	9.22	3.016	2.960	5.42	5.48	0.80	264.8	Trench less (Crossing railway track)
10	11	0.00	344.6	0	38,854	0.0	79.4	2.50	198.4	700	400	880	9.22	6.58	2.950	2.226	5.49	3.57	0.80	264.8	
11	12	4.43	349.0	411	39,265	0.8	80.2	2.50	200.5	700	195	880	6.58	6.40	2.216	1.935	3.58	3.69	0.80	264.8	
12	13	5.27	354.3	489	39,754	1.0	81.2	2.50	203.0	700	232	880	6.40	6.45	1.925	1.591	3.70	4.08	0.80	264.8	
13	14 (PS)	8.66	362.9	804	40,558	1.6	82.9	2.50	207.1	700	484	880	6.45	4.93	1.581	0.858	4.09	3.29	0.80	264.8	
14 (PS)	15	39.16	402.1	3,637	44,195	7.4	90.3	2.50	225.7	400	642	PM	4.93	7.67	2.950	5.690	1.50	1.50	1.80		
15	16	6.26	408.3	581	44,776	1.2	91.5	2.50	228.7	700	297	880	7.67	5.65	5.106	3.370	1.78	1.50	0.80	264.8	
16	17	12.98	421.3	1,206	45,982	2.5	93.9	2.50	234.8	700	284	880	5.65	4.97	3.198	2.631	1.67	1.56	0.80	264.8	
17	18	19.26	440.6	1,789	47,771	3.7	97.6	2.50	244.0	700	262	880	4.97	4.49	2.621	1.198	1.57	2.51	0.80	264.8	
18	19	6.31	446.9	586	48,357	1.2	98.8	2.50	247.0	700	182	880	4.49	4.88	1.188	0.922	2.52	3.18	0.80	264.8	
19	20	20.42	467.3	2,409	50,766	4.9	103.7	2.25	233.3	700	310	880	4.88	7.03	0.912	0.449	3.19	5.80	0.80	264.8	
20	21	7.19	474.5	1,012	51,778	2.1	105.8	2.25	238.0	700	251	880	7.03	4.10	0.439	0.054	5.81	3.27	0.80	264.8	
21	22 (STP)	3.65	478.2	514	52,292	1.1	106.8	2.25	240.4	700	233	880	4.10	2.90	0.044	-0.300	3.28	2.42	0.80	264.8	
via North trunk		32.79		4,614		9.4															

(2) Flow Calculation Sheet for Mapusa (F/S)

Node		Area (ha) (2025)		Population (2025)		Average Flow (lps) (2025)		Peak Factor	Peak Flow (2025) (lps)	Diameter (mm)	Length (m)	Gradient (1/x)	Ground level (m)		Invert level (m)		Covering (m)		Velocity at 80% depth (m/sec)	Flow Capacity at 80% depth (lps)	Remarks
From	To	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative						Upstream	Downstream	Upstream	Downstream	Upstream	Downstream			
1	2	9.48	9.48	2,143	2,143	3.9	3.9	3.00	11.7	200	247	165	34.24	18.35	30.097	16.570	3.86	1.50	0.804	21.7	
2	3	3.41	12.89	771	2,914	1.4	5.3	3.00	15.9	200	176	165	18.35	13.38	15.843	11.600	2.23	1.50	0.804	21.7	
3	4	12.97	25.86	2,933	5,847	5.4	10.7	3.00	32.1	250	35	220	13.38	12.66	10.690	10.531	2.36	1.80	0.808	34.0	
4	5	19.08	44.94	4,314	10,161	7.9	18.6	3.00	55.8	350	233	350	12.66	12.09	10.431	9.695	1.80	1.97	0.802	66.2	
5	6	6.45	51.39	1,458	11,619	2.7	21.3	3.00	63.9	350	264	350	12.09	10.29	9.685	8.363	1.98	1.50	0.802	66.2	
6	7	7.62	59.01	1,723	13,342	3.2	24.5	3.00	73.5	400	88	410	10.29	9.07	7.976	7.090	1.83	1.50	0.810	87.3	
7	8	12.62	71.63	2,853	16,195	5.2	29.7	3.00	89.1	450	184	490	9.07	7.91	6.956	5.880	1.58	1.50	0.801	109.3	
8	9	12.87	84.50	2,910	19,105	5.3	35.0	3.00	105.0	450	76	490	7.91	7.19	5.709	5.160	1.67	1.50	0.801	109.3	
9	10	6.60	91.10	1,492	20,597	2.7	37.7	2.50	94.3	450	110	490	7.19	6.47	5.036	4.440	1.62	1.50	0.801	109.3	
10	11	15.92	107.02	3,599	24,196	6.6	44.3	2.50	110.8	500	395	560	6.47	4.35	3.686	2.030	2.20	1.74	0.804	135.4	
11	12	20.80	127.82	4,703	28,899	8.6	52.9	2.50	132.3	500	274	560	4.35	4.22	2.020	1.441	1.75	2.20	0.804	135.4	
12	18	2.96	130.78	669	29,568	1.2	54.1	2.50	135.3	500	183	560	4.22	4.34	1.431	1.044	2.21	2.72	0.804	135.4	
From MP area		117.31		18,738		34.3															
13	14	0.91	118.22	206	18,944	0.4	34.7	3.00	104.1	450	82	490	36.77	31.95	33.194	29.920	3.05	1.50	0.801	109.3	
14	15	8.83	127.05	1,996	20,940	3.6	38.3	2.50	95.8	450	220	490	31.95	21.44	28.194	19.410	3.23	1.50	0.801	109.3	
15	16	2.28	129.33	516	21,456	0.9	39.2	2.50	98.0	450	202	490	21.44	9.28	15.579	7.250	5.33	1.50	0.801	109.3	
16	17	2.65	131.98	599	22,055	1.1	40.3	2.50	100.8	450	352	490	9.28	7.46	7.030	5.198	1.72	1.73	0.801	109.3	
17	18	13.31	145.29	3,009	25,064	5.5	45.8	2.50	114.5	500	57	560	7.46	4.34	3.883	2.260	3.00	1.50	0.804	135.4	
18	19	1.60	277.67	362	54,994	0.7	100.6	2.25	226.4	700	225	880	4.34	5.96	0.844	0.518	2.72	4.66	0.802	264.8	
19	20	2.67	280.34	604	55,598	1.1	101.7	2.25	228.8	700	237	880	5.96	3.54	0.508	0.169	4.67	2.59	0.802	264.8	
20	21	13.36	293.70	3,021	58,619	5.5	107.2	2.25	241.2	700	600	880	3.54	4.62	0.159	-0.713	2.60	4.55	0.802	264.8	
21	22	8.31	302.01	1,879	60,498	3.4	110.6	2.25	248.9	700	34	880	4.62	4.62	-0.723	-0.762	4.56	4.60	0.802	264.8	
22	23	0.00	302.01	0	60,498	0.0	110.6	2.25	248.9	700	203	880	4.62	4.12	-0.772	-1.062	4.61	4.40	0.802	264.8	
23	24	8.69	310.70	1,965	62,463	3.6	114.2	2.25	257.0	700	234	880	4.12	3.20	-1.072	-1.408	4.41	3.83	0.802	264.8	
24	25(STP)	0.00	310.70	0	62,463	0.0	114.2	2.25	257.0	700	288	880	3.20	2.16	-1.418	-1.836	3.84	3.22	0.802	264.8	
From MP area		11.30		5,792		10.6															

(3) Flow Calculation Sheet for North Coastal belt (F/S)

Node		Area (ha) (2025)		Population (2025)		Average Flow (lps) (2025)		Peak Factor	Peak Flow (2025) (lps)	Diameter (mm)	Length (m)	Gradient (1/x)	Ground level (m)		Invert level (m)		Covering (m)		Velocity at 80% depth (m/sec)	Flow Capacity at 80% depth (lps)	Remarks
From	To	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative						Upstream	Downstream	Upstream	Downstream	Upstream	Downstream			
From Condirim PS		153.81		10,152		36.7															
1	2	27.28	27.28	1,800	11,952	6.5	43.2	3.00	129.6	500	409	560	12.18	11.22	10.049	8.945	1.55	1.70	0.80	135.4	
2	3	19.28	46.56	1,272	13,224	4.6	47.8	3.00	143.4	600	280	720	11.22	10.96	8.845	8.366	1.70	1.91	0.80	194.1	
3	4	38.40	84.96	2,363	15,587	7.4	55.2	3.00	165.5	600	381	720	10.96	10.73	8.356	7.707	1.92	2.34	0.80	194.1	
4	6	42.53	127.49	2,616	18,203	8.2	63.3	3.00	190.0	600	396	720	10.73	13.05	7.697	7.016	2.35	5.35	0.80	194.1	
5	6	23.41	23.41	1,440	1,440	4.5	4.5	3.00	13.5	200	515	165	13.53	13.05	11.750	8.459	1.50	4.31	0.80	21.7	
6	7	53.55	204.45	3,293	22,936	10.3	78.1	2.50	195.2	700	283	880	13.05	13.00	6.916	6.505	5.35	5.72	0.80	264.8	
7	8	2.53	206.98	157	23,093	0.5	78.6	2.50	196.5	700	272	880	13.00	9.58	6.495	6.096	5.73	2.70	0.80	264.8	
8	9 (PS)	14.16	221.14	870	23,963	2.7	81.3	2.50	203.2	700	223	880	9.58	8.40	6.086	5.753	2.71	1.87	0.80	264.8	
9 (PS)	10	26.38	247.52	1,623	25,586	5.1	86.4	2.50	215.9	400	478	PM	8.40	13.94	6.420	11.960	1.50	1.50			
10	11	34.95	282.47	2,151	27,737	6.7	93.1	2.50	232.7	700	386	880	13.94	12.99	10.097	9.210	3.06	3.00	0.80	264.8	
11	12	31.09	313.56	1,913	29,650	6.0	99.0	2.50	247.6	700	321	880	12.99	12.17	9.200	8.390	3.01	3.00	0.80	264.8	
12	13	8.00	321.56	491	30,141	1.5	100.6	2.50	251.4	700	128	880	12.17	11.56	8.249	7.780	3.14	3.00	0.80	264.8	
13	14	34.35	355.91	2,114	32,255	6.6	107.2	2.50	267.9	800	426	1,050	11.56	8.75	7.531	4.870	3.15	3.00	0.80	346.1	
From Calan. No.2 PS		70.74		4,351		13.6															
14	15	9.37	365.28	578	37,184	1.8	122.5	2.50	306.3	800	120	1,050	8.75	7.91	4.689	4.030	3.18	3.00	0.80	346.1	
15	16	13.25	378.53	815	37,999	2.5	125.1	2.50	312.7	800	304	1,050	7.91	6.13	3.704	1.572	3.33	3.68	0.80	346.1	
16	17	12.63	391.16	776	38,775	2.4	127.5	2.50	318.7	800	296	1,050	6.13	4.82	1.562	0.939	3.69	3.00	0.80	346.1	
17	18	9.47	400.63	583	39,358	1.8	129.3	2.50	323.3	800	285	1,050	4.82	1.08	0.508	-1.507	3.43	1.71	0.80	346.1	
18	19	0.00	400.63	0	39,358	0.0	129.3	2.50	323.3	800	46	1,050	1.08	1.08	-1.517	-1.571	1.72	1.77	0.80	346.1	
19	20 (STP)	0.00	400.63	0	39,358	0.0	129.3	2.50	323.3	800	297	1,050	1.08	0.68	-1.581	-1.954	1.78	1.75	0.80	346.1	

Appendix F52

Activated Sludge Method/ Oxidation Ditch Method

Contents for Appendix F52

Appendix 52.1 Activated Sludge Method

CAPACITY CALCULATION OF SEWAGE TREATMENT PLANT

1 BASIC CONDITIONS

1-1 Basic Items

(1) Name : **Margao Sewage Treatment Plant**

(2) Land Area : Approximately 31,080 m^2

(3) Ground Level : + 2.90 m

(4) Inlet Pipe Level : + m

(5) Pipe Diameter : 1,200 mm (Northern Trunk Sewer)

(6) Land Use : Exclusively use for STP

(7) Collection System : Combined System [✓ Separate System]

(8) Treatment Process :
Sewage ; Pre-treatment + Primary settling + Conventional activated sludge
+ Secondary settling + Sand filtration (Future plan) + Disinfection
Sludge ; Thickening + Digestion + Dewatering (Existing drying beds as stand-by)

(9) Effluent Point : Sal River

(10) Water Level at the Effluent Point :
High water level = m
Low water level = m

(11) Target Year : **2015 (F/S Stage) , 2025 (M/P Stage)**

1-2 Design Population and Service Area

Item		Year 2015	Year 2025
Design Population	person	80,700	118,200
Service Area	ha		753.0

1-3 Design Sewage Flow

(Year 2015)

Item	m^3/day	m^3/hr	m^3/min	m^3/sec	Remarks
Daily Average	13,700	570.8	9.51	0.159	
Peak Flow	30,825	1,284.4	21.41	0.357	Peak factor = 2.25

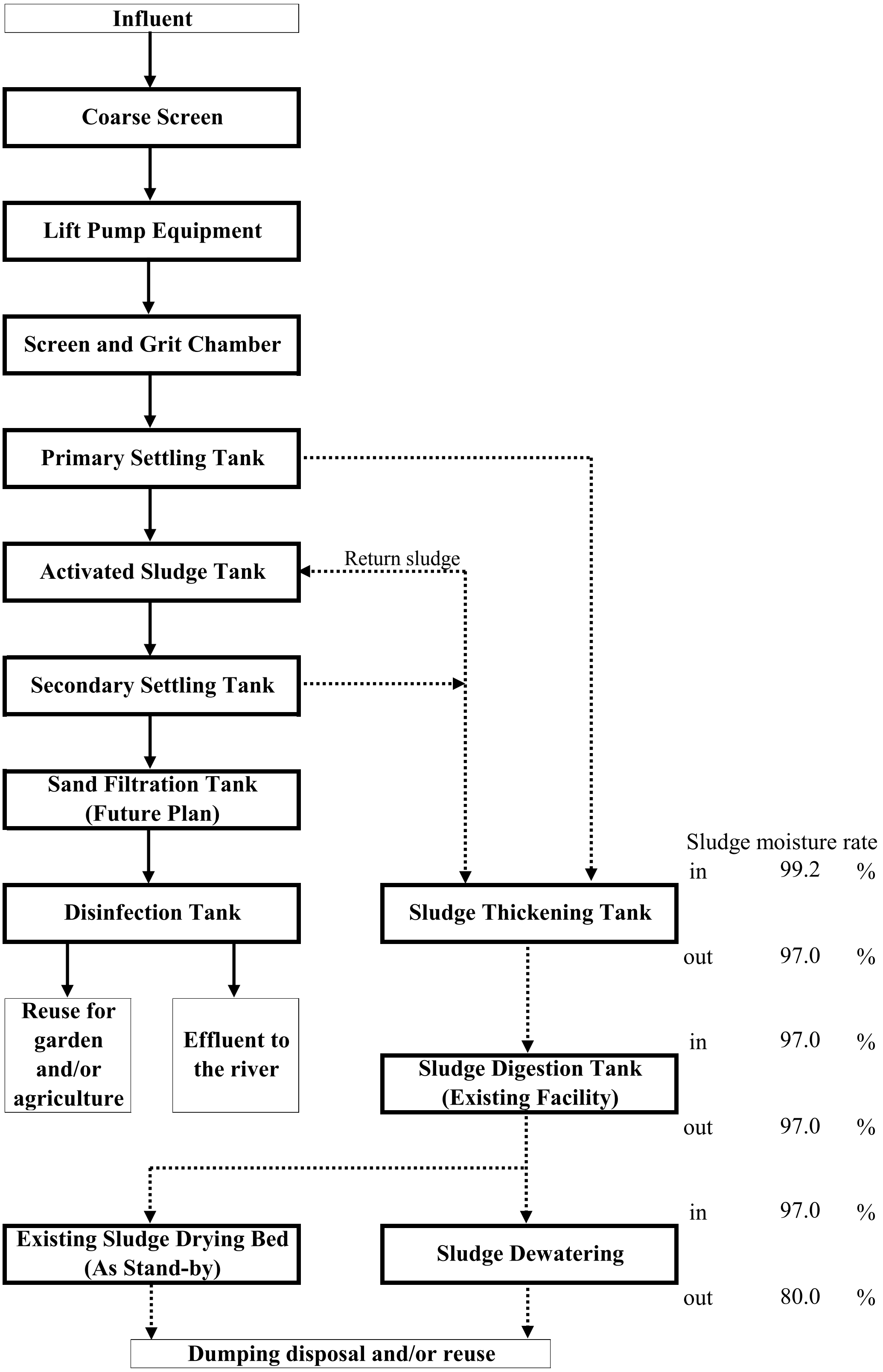
(Year 2025)

Item	m^3/day	m^3/hr	m^3/min	m^3/sec	Remarks
Daily Average	20,900	870.8	14.51	0.242	
Peak Flow	47,025	1,959.4	32.66	0.544	Peak factor = 2.25

1-4 Design Sewage Quality

Item	Influent	Removal rate	Effluent	Remarks
	(mg/l)	(%)	(mg/l)	
BOD	300	90	30	Effluent quality regulation 30 mg/l
SS	250	80	50	Effluent quality regulation 100 mg/l

1-5 Flow Chart (Biological Activated Sludge Process)



1-6 Design Criteria for STP

Items	Unit	Figure *1	Figure *2	Adoption
1-6-1 Grit Chamber				
(1) Water surface load	m3/m2/day	1,800	2,160	2,160
(2) Average velocity	m/sec	0.3	0.15 - 0.30	0.3
1-6-2 Wet Well with Pump Facilities				
(1) Pump inlet flow velocity	m/sec	1.5 - 3.0	-	1.5 - 3.0
(2) Retention time in Wet Wel	min	-	> 5.0	9.0
1-6-3 Primary Settling Tank				
(1) Water surface load	m3/m2/day	35.0 - 70.0	35.0 - 50.0	45.0
(2) Water depth	m	2.5 - 4.0	2.5 - 3.5	3.0
1-6-4 Activated Sludge Tank				
(1) Type	-	-	-	Conventional
(2) MLSS concentration	mg/L	1,500 - 2,000	1,500 - 3,000	2,000
(3) BOD-SS Load	kgBOD/kgSS･day	0.2 - 0.4	0.3 - 0.4	0.40
(4) Retention time	hr	6.0 - 8.0	4.0 - 6.0	5.0
(5) Water depth	m	4.0 - 6.0	3.0 - 4.5	4.0
1-6-5 Secondary Settling Tank				
(1) Water surface load	m3/m2/day	20.0 - 30.0	15.0 - 35.0	25.0
(2) Water depth	m	2.5 - 4.0	3.5 - 4.5	4.0
1-6-6 Disinfection Tank				
(1) Retention time	min	15.0	-	15.0
(2) Dosage	mg/L	2 - 8	-	3.0
1-6-7 Sludge Thickening Tank				
(1) Sludge surface load	kg/m2/day	60 - 90	25 - 30	30.0
(2) Depth	m	4.0	3.0	3.0
1-6-8 Sludge Digestion Tank				
(1) Solids retention time	days	15 0 - 20.0	14.0	14.0
(2) Operating temperature	℃	-	30.0	30.0
(3) Depth	m	> 7.5	6.0 - 12.0	8.0
(4) Digestion rate	%	35.0	-	35.0
1-6-9 Sludge Dewatering				
(1) Operation time	hr/day	-	-	8.0
1-6-10 Sludge Drying Bed				
(1) Retention time	day	10 - 15	< 2 weeks	10
(2) Depth of sludge bed	m	0.20 - 0.30	max 0.30	0.3
1-6-11 Sand Filtration				
(1) Filtration rate	m/day	max 300	-	200

*1: Design Criteria in Japanese standard and "Wastewater Engineering" by Metcalf & Eddy

*2: Design Criteria in India named "Manual on Sewerage and Sewage Treatment" by CPHEEO

2 CAPACITY CALCULATION OF STP FACILITIES

2-1 Wet Well with Pump Equipment

Item	Sign	Unit	Calculation	Feasibility Study	Master Plan
2-1-1 Wet Well					
Design sewage flow	Q1	m^3/day	Peak flow	30,825	47,025
	Q2	m^3/min	Peak flow	21.41	32.66
Basin number	BN	basin	Existing	1	1
Retention time	RT	min		9.0	9.0
Required volume	RV	m^3	Q2×RT	192.7	293.9
Depth of existing tank	H	m		15.0	15.0
Required area	RA	m^2	RV/H	12.84	19.59
Required well diameter	D1	m	$(4\times RA/3.14)^{0.5}$	4.04	5.00
Diameter of existing well	D2	m		12.3	12.3
Area of existing well	A	m^2	$D2^2\times3.14/4$	118.8	118.8

In case of F/S stage : Area of existing well = 118.8 m^2 > Required area = 12.84 m^2

In case of M/P stage : Area of existing well = 118.8 m^2 > Required area = 19.59 m^2

Therefore, the existing well is useful against the design flow (= 30,825 m^3/day in F/S stage and 47,025 m^3/day in M/P stage)

Item	Sign	Unit	Calculation	Feasibility Study	Master Plan
2-1-2 Pump Equipment					
Design sewage flow	Q1	m^3/day	Peak flow	30,825	47,025
	Q2	m^3/min	Peak flow	21.41	32.66

Specification of the existing pump equipment (useful life = 2000 ~ 2015 year)

- mm × 200.0 m^3/hr = 3.33 m^3/min × 12.0 m × 25.0 HP × 2 units
- mm × 400.0 m^3/hr = 6.67 m^3/min × 12.0 m × 50.0 HP × 2 units

New pump equipment in M/P stage (year 2025) is proposed as shown below and its in F/S stage is planned based on the capacity of the existing facilities and installation plan of M/P stage.

Item	Sign	Unit	Calculation	Feasibility Study	Master Plan
(1) Maste Plan Stage					
Pump unit number	UN1	unit	1/10×Q	-	2
	UN2	unit	2/10×Q	-	2
	UN3	unit	4/10×Q, including 1 stand-by	-	2
Pump discharging flow	DF1	m^3/min/unit		-	3.27
	DF2	m^3/min/unit		-	6.53
	DF3	m^3/min/unit		-	13.06
Pump inflow velocity	PV	m/sec		-	1.5 - 3.0
Required pump diameter	D1-1	mm	$146\times(DF1/3.0)^{0.5}$	-	152
	D1-2	mm	$146\times(DF1/1.5)^{0.5}$	-	215
	D1	mm	*Therefore*	-	200
	D2-1	mm	$146\times(DF2/3.0)^{0.5}$	-	215
	D2-2	mm	$146\times(DF2/1.5)^{0.5}$	-	305
	D2	mm	*Therefore*	-	250
	D3-1	mm	$146\times(DF3/3.0)^{0.5}$	-	305
	D3-2	mm	$146\times(DF3/1.5)^{0.5}$	-	431
	D3	mm	*Therefore*	-	350
Pump total head	H	m		-	12.0
Pump efficiency	PE	-		-	0.60
Axis power	AP1	kw	0.163×DF1×H/PE	-	10.65
	AP2	kw	0.163×DF2×H/PE	-	21.29
	AP3	kw	0.163×DF3×H/PE	-	42.58
Motor allowance	MA	-		-	0.15
Pump power	P1	kw	AP1×(1+MA)	-	12.24
			Therefore	-	13.0
	P2	kw	AP2×(1+MA)	-	24.49
			Therefore	-	25.0
	P3	kw	AP3×(1+MA)	-	48.97
			Therefore	-	49.0

Pump specification (New equipment in M/P stage)	200 mm × 3.27 m^3/min × 12.0 m × 13.0 kw × 2 units
	250 mm × 6.53 m^3/min × 12.0 m × 25.0 kw × 2 units
	350 mm × 13.06 m^3/min × 12.0 m × 49.0 kw × 2 (1) units

(2) Feasibility Study Stage					
Pump discharging flow	DF4	m^3/min/unit	Existing facility	3.33	-
	DF5	m^3/min/unit	Existing facility	6.67	-
Pump unit number	UN4	unit	Existing	2	-
	UN5	unit	Existing, including 1 stand-by	2	-
Total pump discharging flow	TDF	m^3/min	(DF4×UN4)+((DF5×(UN5-1))	13.33	-
Discharging flow of the existing pumps 13.33 m^3/min < Design flow = 21.41 m^3/min Required additional flow capacity = 21.41 - 13.33 = 8.07 m^3/min					
Additional flow capacilty	AF	m^3/min	Q2-TDF	8.07	-
Additional pump number	UN6	unit		2	-
Pump discharging flow	DF6	m^3/min/unit		4.04	-
Pump inflow velocity	PV	m/sec		1.5 - 3.0	-
Required pump diameter	D6-1	mm	$146\times(DF6/3.0)^{0.5}$	169	-
	D6-2	mm	$146\times(DF6/1.5)^{0.5}$	240	-
	D6	mm	*Therefore*	200	-
Pump total head	H	m		12.0	-
Pump efficiency	PE	-		0.60	-
Axis power	AP6	kw	0.163×DF6×H/PE	13.16	-
Motor allowance	MA	-		0.15	-
Pump power	P6	kw	AP6×(1+MA)	15.13	-
			Therefore	16.0	-
Proposed additional pumps for F/S stage are adopted the equipment same as that capacity in M/P stage.					
Pump specification (New facilities in F/S stage)	250 mm × 6.53 m^3/min × 12.0 m × 25.0 kw × 2 units				

2-2 Screen and Grit Chamber

Item	Sign	Unit	Calculation	Feasibility Study	Master Plan
2-2-1 Grit Chamber					
Type	-	-	Parallel flow type	-	-
Design sewage flow	Q1	m^3/day	Peak flow	30,825	47,025
	Q2	m^3/sec	Peak flow	0.357	0.544
Water surface load	SL	m^3/m^2/day		2,160	2,160
Required surface area	RA	m^2	Q1/SL	14.27	21.77
Number of existing basin	BN1	basin		1	1
Width of existing basin	W1	m		1.25	1.25
Length of existing basin	L1	m		8.00	8.00
Depth of existing basin	H1	m		0.35	0.35
Surface area of existing	A1	m^2	W1×L1	10.00	10.00
Required additional area	AA	m^2	RA-A1	4.27	11.77
Number of new basin	BN2	basin		1	1
Depth of new basin	H2	m		0.35	0.35
Width of new basin	W2	m		1.25	1.25
Length of new basin	L2	m	AA/(BN2×W2)	3.42	9.42
	L	m	*Therefore*	9.50	9.50
Dimension (Width)	W	m	**Additional New Facility**	**1.25**	**1.25**
(Length)	L	m		**9.50**	**9.50**
(Depth)	H	m		**0.35**	**0.35**
(Number)	BN	basin		**1**	**1**
2-2-2 Fine Screen					
Type	-	-	One rake type intermittent rake-up		
Set number of existing	SN	set		1	1
Screen opening	-	mm	10 to 20	20	20
Existing screen equipment is using for the channel of the existing grit chamber and a new facility is proposed for the additional channel (grit chamber).					
Additional set number	SN	set	**Additional New Facility**	1	1
Screen opening	-	mm		20	20
2-2-3 Volume of Screenings					
Design sewage flow	Q	m^3/day	Daily average	13,700	20,900
Unit removed screenings	RS	$m^3/1{,}000m^3$		0.010	0.010
Volume of screenings	VS	m^3/day	Q×RS/1,000	**0.137**	**0.209**
				↓	↓
				Carry out to the outside	

2-3 Primary Settling Tank

Item	Sign	Unit	Calculation	Feasibility Study	Master Plan
Type	-	-	Radial flow circular type	-	-
Design sewage flow	Q1	m^3/day	Daily average	13,700	20,900
	Q2	m^3/hr	Daily average	570.8	870.8
Water surface load	SL	m^3/m^2/day		45.0	45.0
Required surface area	RA	m^2	Q1/SL	304.4	464.4
Number of existing tank	BN	basin		1	1
Diameter of existing tank	D1	m		18.0	18.0
Depth of existing tank	H1	m		3.0	3.0
Surface area of existing	EA	m^2	$(D1)^2$×3.14×BN/4	254.3	254.3
Required additional area	AA	m^2	RA-EA	50.1	210.1
Number of new tank	NT	basin		1	2
Depth of new tank	H2	m		3.0	3.0
Required tank diameter	D2	m	$(AA×4/(3.14×NT))^{0.5}$	8.0	11.6
	D	m	*Therefore*	12.0	12.0
Dimension (Diameter)	D	m	**Additional New Facility**	**12.0**	**12.0**
(Depth)	H	m		**3.0**	**3.0**
(Number)	BN	basin		**1**	**2**

2-4 Activated Sludge Tank

Item	Sign	Unit	Calculation	Feasibility Study	Master Plan
Type	-	-	Conventional Activated sludge process		
Design sewage flow	Q1	m^3/day	Daily average	13,700	20,900
	Q2	m^3/hr	Daily average	570.8	870.8
BOD-SS load	BS	kgBOD/kgSS/day		0.40	0.40
Inlet BOD to STP	BD	mg/l		300	300
Inlet BOD to reactor tank	BDR	mg/l	BD×50% (removal rate)	150	150
MLSS concentration	MLS	mg/l		2,000	2,000
Required volume-1	RV1	m^3	Q1×BDR/(MLS×BS)	2,569	3,919
Retention time	RT	hr		5.0	5.0
Required volume-2	RV2	m^3	Q2×RT	2,854	4,354
Required volume	RV	m^3	RV1 < RV2	2,854	4,354
Width of existing tank	W1	m		12.0	12.0
Depth of existing tank	H1	m		3.0	3.0
Length of existing tank	L1	m		33.0	33.0
Number of existing tank	BN	basin		1	1
Volume of existing tank	VE	m^3	W1×H1×L1×BN	1,188	1,188
Required additional volume	AV	m^3	RV-VE	1,666	3,166
Number of new tank	NT	basin		1	2
Depth of new tank	H2	m		4.0	4.0
Width of new tank	W2	m		12.0	12.0
Length of new tank	L2	m	AV/(NT×H2×W2)	34.7	33.0
	L	m	*Therefore*	35.0	35.0
Dimension (Width)	W	m	**Additional New Facility**	**12.0**	**12.0**
(Length)	L	m		**35.0**	**35.0**
(Depth)	H	m		**4.0**	**4.0**
(Number)	BN	basin		**1**	**2**

2-5 Secondary Settling Tank

Item	Sign	Unit	Calculation	Feasibility Study	Master Plan
Type	-	-	Radial flow circular type	-	-
Design sewage flow	Q1	m^3/day	Daily average	13,700	20,900
	Q2	m^3/hr	Daily average	570.8	870.8
Water surface load	SL	m^3/m^2/day		25.0	25.0
Required surface area	RA	m^2	Q1/SL	548.0	836.0
Number of existing tank	BN	basin		1	1
Diameter of existing tank	D1	m		21.0	21.0
Depth of existing tank	H1	m		3.0	3.0
Surface area of existing	EA	m^2	$(D1)^2$×3.14×BN/4	346.2	346.2
Required additional area	AA	m^2	RA-EA	201.8	489.8
Number of new tank	NT	basin		1	2
Depth of new tank	H2	m		4.0	4.0
Required tank diameter	D2	m	$(AA×4/(3.14×NT))^{0.5}$	16.0	17.7
	D	m	*Therefore*	18.0	18.0
Dimension (Diameter)	D	m	**Additional New Facility**	**18.0**	**18.0**
(Depth)	H	m		**4.0**	**4.0**
(Number)	BN	basin		**1**	**2**

2-6 Sand Filtration Tank (Future Plan)

Item	Sign	Unit	Calculation	Feasibility Study	Master Plan
Type	-	-	Gravity upflow filter type	-	-
Design sewage flow	Q1	m^3/day	Daily average	-	20,900
	Q2	m^3/sec	Daily average	-	0.242
Filtration rate	FR	m/day		-	200
Required surface area	RA	m^2	Q1/FR	-	104.5
Required basin number	BN	basin		-	4
Width	W	m		-	5.5
Length	L1	m	RA/(W×BN)	-	4.8
	L2	m	*Therefore*	-	5.0
Dimension (Width)	W	m	**New Facility**	**-**	**5.5**
(Length)	L	m		**-**	**5.0**
(Number)	BN	basin		**-**	**4**

2-7 Disinfection Tank

Item	Sign	Unit	Calculation	Feasibility Study	Master Plan
Chemical type	-	-	Hypochlorite type	-	-
Design sewage flow	Q1	m^3/day	Daily average	13,700	20,900
	Q2	m^3/min	Daily average	9.51	14.51
Retention time	RT	min		15.0	15.0
Required volume	RV	m^3	Q2×RT	142.7	217.7
Width of channel	W	m		1.5	1.5
Depth of channel	H	m		1.5	1.5
Pass number	PN	pass		6	8
Length of channel	L1	m	RV/(W×H×PN)	10.6	12.1
	L2	m	*Therefore*	12.5	12.5
Dimension (Width)	W	m	**New Facility**	**1.5**	**1.5**
(Depth)	H	m		**1.5**	**1.5**
(Length)	L	m		**12.5**	**12.5**
(Number)	PN	pass		**6**	**8**

2-8 Sludge Thickening Tank

Item	Sign	Unit	Calculation	Feasibility Study	Master Plan
Type	-	-	Radial flow circular type	-	-
Design sewage flow	Q1	m^3/day	Daily average	13,700	20,900
	Q2	m^3/hr	Daily average	570.8	870.8
Influent SS quality	IS	mg/l		250	250
Effluent SS quality	ES	mg/l		50	50
Generated sludge	GS	kg/day	$Q1\times(IS-ES)\times10^{-3}$	2,740	4,180
Sludge surface load	SL	kg/m^2/day		30.0	30.0
Required surface area	RA	m^2	GS/SL	91.3	139.3
Depth of tank	H	m		3.0	3.0
Basin number	BN	basin		2	2
Required tank diameter	D1	m	$(RA\times4/(3.14\times BN))^{0.5}$	7.6	9.4
	D2	m	*Therefore*	9.5	9.5
Dimension (Diameter)	D	m	**New Facility**	**9.5**	**9.5**
(Depth)	H	m		**3.0**	**3.0**
(Number)	BN	basin		**2**	**2**

2-9 Sludge Digestion Tank

Item	Sign	Unit	Calculation	Feasibility Study	Master Plan
Type	-	-	Anaerobic digestion	-	-
Design sewage flow	Q1	m^3/day	Daily average	13,700	20,900
	Q2	m^3/hr	Daily average	570.8	870.8
Generated sludge weight	GS1	kg/day	refer to 2-8	2,740	4,180
	GS2	ton/day	GS1/1,000	2.74	4.18
Sludge moisture rate	MR	%	thickened sludge	97.0	97.0
Sludge volume	SV	m^3/day	GS2×100/(100-MR)	91.3	139.3
Sludge retention time	T	day		14	14
Required tank volume	RV1	m^3/basin	SV×T	1,279	1,951
Diameter of existing tank	D1	m		18.0	18.0
Depth of existing tank	H1	m		10.65	10.65
Number of existing tank	BN	basin		1	1
Volume of existing tank	VE	m^3	$D1^2\times3.14\times H1/4$	2,709	2,709

In case of F/S stage : Volume of existing tank = 2,709 m^3 > Required volume = 1,279.0 m^3

In case of M/P stage : Volume of existing tank = 2,709 m^3 > Required volume = 1,951.0 m^3

Therefore, the existing tank is useful against the design flow (= 13,700 m^3/day in F/S stage and 20,900 m^3/day in M/P stage)

2-10 Digestion Gas Tank

Item	Sign	Unit	Calculation	Feasibility Study	Master Plan
Generated sludge weight	GS	kg/day	refer to 2-9	2,740	4,180
Organic matter ratio	OM	%		70	70
Generation ratio of gas	GR	%		35	35
Retention time	RT	day		0.5	0.5
Required tank volume	RV	m^3	GS×OM×GR×RT/10^4	336	512
Depth of tank	H	m		5.0	5.0
Basin number	BN	basin		1	1
Required tank diameter	D1	m	2×$(RV/(3.14×H×BN))^{0.5}$	9.2	11.4
	D2			11.5	11.5
Dimension (Diameter)	D	m	**New Facility**	**11.5**	**11.5**
(Depth)	H	m		**5.0**	**5.0**
(Number)	BN	basin		**1**	**1**

2-11 Sludge Dewatering Equipment

Item	Sign	Unit	Calculation	Feasibility Study	Master Plan
Type	-	-	Centrifugal type	-	-
Digestion rate	DR	%		35.0	35.0
Thickened sludge weight	GS	ton/day	refer to 2-9	2.74	4.18
Digested sludge weight	DS	ton/day	GS×(100-DR)/100	1.78	2.72
Sludge moisture rate	MR	%	digested sludge	97.0	97.0
Sludge volume	SV	m^3/day	DS×100/(100-MR)	59.4	90.6
Unit number	UN	unit	1 stand-by in M/P	1	2
Operation time	OT	hr/day		8.0	8.0
Required capacity	RC1	m^3/hr	SV/(UN×OT)	7.4	11.3
	RC2	m^3/hr	*Therefore*	12.0	12.0
Dimension (Capacity)	C	m^3/hr	**New Facility**	**12.0**	**12.0**
(Unit)	U	unit		**1**	**2**
Generated sludge (weight)	GS	ton/day		1.78	2.72
Sludge moisture rate	MR	%	dewatered sludge	80.0	80.0
Dewatered sludge volume	DV	m^3/day	GS×100/(100-MR)	**8.9**	**13.6**
				↓	↓
				Carry out to the outside	

2-11 Sludge Drying Bed

Item	Sign	Unit	Calculation	Feasibility Study	Master Plan
Digested sludge volume	DV	m^3/day	refer to 2-10	59.4	90.6
Retention time	RT	day		10	10
Sludge thickness in bed	H1	m		0.3	0.3
Required area	RA	m^2	DV×RT/H1	1,979	3,019
Width of existing bed	W1	m		12.4	12.4
Length of existing bed	L1	m		12.8	12.8
Number of existing bed	BN	basin		14	14
Total area of existing bed	TA	m^2	W1×L1×BN	2,222	2,222

In case of F/S stage : Area of existing bed = 2,222 m^2 > Required area = 1,979 m^2
Therefore, the existing tank is useful against the design flow in F/S stage (= 13,700 m^3/day)
Retention time by the existing beds in M/P st : 2,222×0.3/90.6 = 7.4 days

3 Summary of Proposed Facilities for Margao STP

Treatment facilities	**Feasibility Study (target year 2015)**	
	Exisiting Facility	Additional Facility
Wet well	12.3mdia×15.0mH×1unit	-
Pump equipment	- mm×3.33m3/min×12.0mH×25.0HP×2units	250mm×6.53m3/min×12.0mH×25.0kw×2units
	- mm×6.67m3/min×12.0mH×50.0HP×2units	-
	-	-
Grit chamber	1.25mW×8.00mL×0.35mH×1basin	1.25mW×9.50mL×0.35mH×1basin
Mechanical screen	Type : One rake type intermittent rake-up	Type : One rake type intermittent rake-up
	1unit of mechanical screen with 20mm opening	1unit of mechanical screen with 20mm opening
Primary settling tank	Type : Radial flow circular type	Type : Radial flow circular type
	18.0mdia×3.0mH×1basin	12.0mdia×3.0mH×1basin
Activated sludge tank	Type : Conventional activated sludge process	Type : Conventional activated sludge process
	12.0mW×33.0mL×3.0mH×1basin	12.0mW×35.0mL×4.0mH×1basin
Secondary settling tank	Type : Radial flow circular type	Type : Radial flow circular type
	21.0mdia×3.0mH×1basin	18.0mdia×4.0mH×1basin
Sand filtration tank	-	-
	-	-
Disinfection tank	-	Type : Hypochlorite type
	-	1.5mW×12.5mL×1.5mH×6passes
Sludge thickening tank	-	Type : Radial flow circular type
	-	9.5mdia×3.0mH×2basins
Sludge digestion tank	Type : Anaerobic digestion type	-
	18.0mdia×10.65mH×1basin	-
Digestion gas tank	-	16.5mdia×5.0mH×1basin
Dewatering equipment	-	Type : Centrifugal type
	-	12.0m3/hr×1unit
Sludge drying bed	12.4mW×12.8mL×0.3mH×14basins	-

Treatment facilities	**Master Plan Study (target year 2025)**	
	Exisiting Facility	Additional Facility
Wet well	12.3mdia×15.0mH×1unit	-
Pump equipment	-	200mm×3.27m3/min×12.0mH×13.0kw×2units
	-	250mm×6.53m3/min×12.0mH×25.0kw×2units
	-	350mm×13.06m3/min×12.0mH×49.0kw×2(1)units
Grit chamber	1.25mW×8.00mL×0.35mH×1basin	1.25mW×9.50mL×0.35mH×1basin
Mechanical screen	Type : One rake type intermittent rake-up	Type : One rake type intermittent rake-up
	1unit of mechanical screen with 20mm opening	1unit of mechanical screen with 20mm opening
Primary settling tank	Type : Radial flow circular type	Type : Radial flow circular type
	18.0mdia×3.0mH×1basin	12.0mdia×3.0mH×2basins
Activated sludge tank	Type : Conventional activated sludge process	Type : Conventional activated sludge process
	12.0mW×33.0mL×3.0mH×1basin	12.0mW×35.0mL×4.0mH×2basins
Secondary settling tank	Type : Radial flow circular type	Type : Radial flow circular type
	21.0mdia×3.0mH×1basin	18.0mdia×4.0mH×2basins
Sand filtration tank	-	Type : Gravity upflow filter type
(Future Plan)	-	5.5mW×5.0mL×4basins
Disinfection tank	-	Type : Hypochlorite type
	-	1.5mW×12.5mL×1.5mH×8passes
Sludge thickening tank	-	Type : Radial flow circular type
	-	9.5mdia×3.0mH×2basins
Sludge digestion tank	Type : Anaerobic digestion type	-
	18.0mdia×10.65mH×1basin	-
Digestion gas tank	-	16.5mdia×5.0mH×1basin
Dewatering equipment	-	Type : Centrifugal type
	-	12.0m3/hr×2(1)unit
Sludge drying bed	12.4mW×12.8mL×0.3mH×14basins	-

Appendix F52.2 Oxidation Ditch Method

CAPACITY CALCULATION OF SEWAGE TREATMENT PLANT

1 BASIC CONDITIONS

1-1 Basic Items

(1) Name : **Mapusa Sewage Treatment Plant**

(2) Land Area : Approximately 3 ha

(3) Ground Level : + 3.00 m

(4) Inlet Pipe Level : + m

(5) Pipe Diameter : mm ( )

(6) Land Use : Communal Land

(7) Collection System : Combined System [✓ Separate System]

(8) Treatment Process :
Sewage ; Pre-treatment + Oxidation ditch + Secondary settling
+ Sand filtration (Future plan) + Disinfection
Sludge ; Thickening + <Digestion> + Dewatering
< > : M/P Stage

(9) Effluent Point : Tributary of Mandovi River

(10) Water Level at the Effluent Point :
High water level = m
Low water level = m

(11) Target Year : **2015 (F/S Stage) , 2025 (M/P Stage)**

1-2 Design Population and Service Area

Item		Year 2015	Year 2025
Design Population	person	34,300	68,300
Service Area	ha		309.0

1-3 Design Sewage Flow

(Year 2015)

Item	m^3/day	m^3/hr	m^3/min	m^3/sec	Remarks
Daily Average	5,400	225.0	3.75	0.063	
Peak Flow	13,500	562.5	9.38	0.156	Peak factor = 2.50

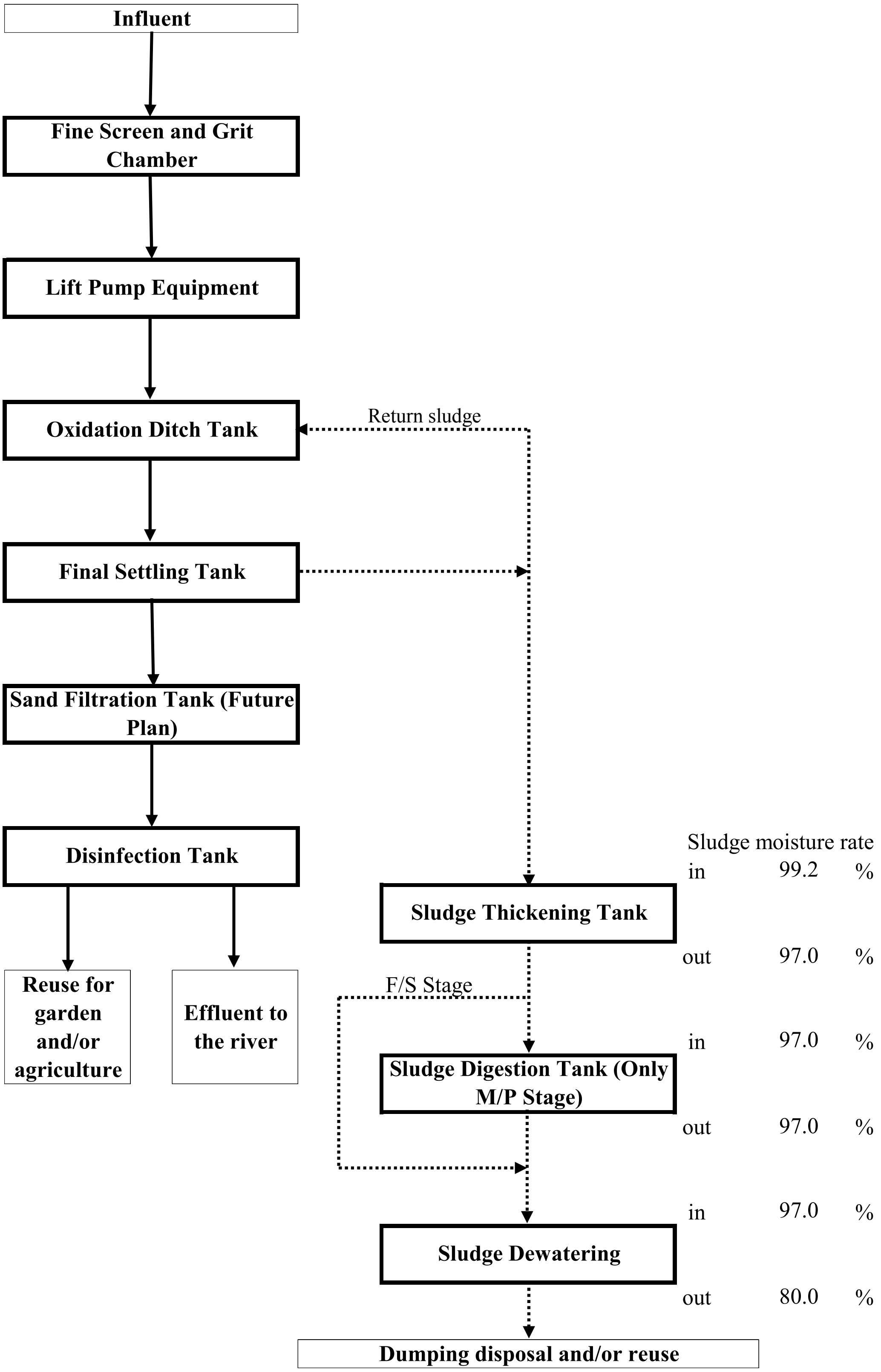
(Year 2025)

Item	m^3/day	m^3/hr	m^3/min	m^3/sec	Remarks
Daily Average	10,800	450.0	7.50	0.125	
Peak Flow	24,300	1,012.5	16.88	0.281	Peak factor = 2.25

1-4 Design Sewage Quality

Item	Influent	Removal rate	Effluent	Remarks
	(mg/l)	(%)	(mg/l)	
BOD	300	90	30	Effluent quality regulation : 30 mg/l
SS	250	80	50	Effluent quality regulation : 100 mg/l

1-5 Flow Chart (Oxidation Ditch Process)



2 Design Criteria for STP

Items		unit	CPHEEO	Japanese Standards	Metcalf&Eddy	Adoption
2-1	Screen and Grit Chamber					
	(1) Fine Screen					
	Openings of screen bars	mm	less than 20	15.0 - 25.0	15.0	20.0
	(2) Grit chamber					
	Water surface load	m3/m2/day	2,160	1,800	1,382 - 1,814	2,160
	Horizontal velocity	m/sec	0.15 - 0.30	0.30	0.24 - 0.39	0.30
2-2	Pump Equipment					
	Pump inflow velocity	m/sec	-	1.5 - 3.0	-	1.5 - 3.0
	Retention time in wet well	min	> 5.0	-	-	9.0
2-3	Oxidation Ditch Tank					
	Hydraulic retention time	hr	12.0 - 24.0	24.0 - 48.0	8.0 - 36.0	15.0
	MLSS concentration	mg/l	3,000 - 5,000	3,000 - 4,000	3,000 - 6,000	3,500
	BOD-SS load	kgBOD/kgSS/day	0.10 - 0.18	0.03 - 0.05	0.05 - 0.30	0.15
	Depth of tank	m	-	1.0 - 3.0	-	3.0
	Width of tank	m	-	2.0 - 6.0	-	4.0
2-4	Final Settling Tank					
	Water surface load	m3/m2/day	8.0 - 15.0	8.0 - 12.0	16.3 - 32.6	15.0
	Depth of tank	m	3.5 - 4.5	3.0 - 4.0	3.7	4.0
2-5	Sand Filtration					
	Filtration rate	m/day	-	max. 300	176	200
2-6	Disinfection Tank					
	Retention time	min	-	15.0	-	15.0
2-7	Sludge Thickening Tank					
	Solid surface load	kg/m2/day	25.0 - 30.0	60.0 - 90.0	12.2 - 34.2	30.0
	Depth of tank	m	3.0	4.0	-	3.0
2-8	Sludge Digestion Tank					
	Solid retention time	day	14.0	20.0	15.0 - 20.0	14.0
	Operating temperature	℃	30.0	30.0	-	30.0
	Digestion rate	%	-	35.0	-	35.0
	Depth of tank	m	6.0 - 12.0	> 4.0	> 7.5	8.0
2-9	Sludge Dewatering Equipment					
	Operation time	hr/day	-	-	-	8.0

CPHEEO : Central Public Health and Environmental Organization, Ministry of Urban Development, New Delhi,1993

3 CAPACITY CALCULATION OF STP FACILITIES

3-1 Screen and Grit Chamber

Item	Sign	Unit	Calculation	Feasibility Study	Master Plan
3-1-1 Grit Chamber					
Type	-	-	Parallel flow type	-	-
Design sewage flow	Q1	m^3/day	Peak flow	13,500	24,300
	Q2	m^3/sec	Peak flow	0.156	0.281
Water surface load	SL	m^3/m^2/day		2,160	2,160
Required surface area	RA	m^2	Q1/SL	6.3	11.3
Basin number	BN	basin		1	2
Horizontal velocity	V	m/sec		0.30	0.30
Water depth	H	m		0.35	0.35
Width	W1	m	Q2/(V×H×BN)	1.49	1.34
	W2	m	*Therefore*	1.50	1.50
Length	L1	m	RA/(W2×BN)	4.17	3.75
	L2	m	*Therefore*	4.20	4.20
Dimension (Width)	W	m	**New Facility**	**1.50**	**1.50**
(Length)	L	m		**4.20**	**4.20**
(Depth)	D	m		**0.35**	**0.35**
(Number)	BN	basin		**1**	**2**
3-1-2 Fine Screen (New Facility)					
Type	-	-	One rake type intermittent rake-up		
Set number	SN	set			
Screen opening	SO	mm		20.0	20.0
Unit removed screenings	RS	$m^3/1,000m^3$		0.010	0.010
Design sewage flow	Q1	m^3/day	Daily average	5,400	10,800
Volume of screenings	SV	m^3/day	Q1×RS/1,000	0.054	0.108
				↓	↓
				Carry out to the outside	

3-2 Wet Well and Pump Equipment

Item	Sign	Unit	Calculation	Feasibility Study	Master Plan
3-2-1 Wet Well (pump pit)					
Design sewage flow	Q1	m^3/day	Peak flow	13,500	24,300
	Q2	m^3/min	Peak flow	9.38	16.88
Basin number	BN	basin		1	2
Retention time	T	min		9.0	9.0
Required volume	RV	m^3	Q2×T	84.4	151.9
Depth of tank	H	m		2.5	2.5
Required area	RA	m^2	RV/H	33.8	60.8
Width of tank	W	m		5.0	5.0
Length of tank	L1	m	RA/(BN×W)	6.8	6.1
	L2	m		7.0	7.0
Dimension (Width)	W	m	**New Facility**	**5.0**	**5.0**
(Length)	L	m		**7.0**	**7.0**
(Depth)	D	m		**2.5**	**2.5**
(Number)	BN	basin		**1**	**2**

3-2-2 Pump Equipment					
Design sewage flow	Q1	m^3/day	Peak flow	13,500	24,300
	Q2	m^3/min	Peak flow	9.38	16.88
Pump unit number	UN1	unit	1/8×Q	1	2
	UN2	unit	2/8×Q	-	1
	UN3	unit	4/8×Q, including 1 stand-by	2	2
Pump discharging flow	DF1	m^3/min/unit		2.11	2.11
	DF2	m^3/min/unit		-	4.22
	DF3	m^3/min/unit		8.44	8.44
Pump inflow velocity	PV	m/sec		1.5 - 3.0	1.5 - 3.0
Required pump diameter	D1-1	mm	$146\times(DF1/3.0)^{0.5}$	122	122
	D1-2	mm	$146\times(DF1/1.5)^{0.5}$	173	173
	D1	mm	*Therefore*	150	150
	D2-1	mm	$146\times(DF2/3.0)^{0.5}$	-	173
	D2-2	mm	$146\times(DF2/1.5)^{0.5}$	-	245
	D2	mm	*Therefore*	-	200
	D3-1	mm	$146\times(DF3/3.0)^{0.5}$	245	245
	D3-2	mm	$146\times(DF3/1.5)^{0.5}$	346	346
	D3	mm	*Therefore*	300	300
Pump total head	H	m		12.0	12.0
Pump efficiency	PE	-		0.6	0.6
Axis power	AP1	kw	0.163×DF1×H/PE	6.88	6.88
	AP2	kw	0.163×DF2×H/PE	-	13.75
	AP3	kw	0.163×DF3×H/PE	27.51	27.51
Motor allowance	MA	-		0.15	0.15
Pump power	P1	kw	AP1×(1+MA)	7.91	7.91
			Therefore	8.0	8.0
	P2	kw	AP2×(1+MA)	-	15.82
			Therefore	-	16.0
	P3	kw	AP3×(1+MA)	31.63	31.63
			Therefore	32.0	32.0
New Pump specification (F/S stage)	150	mm × 2.11	m^3/min × 12.0 m ×	8.0 kw ×	1 units
	-	mm × -	m^3/min × 12.0 m ×	- kw × -	units
	300	mm × 8.44	m^3/min × 12.0 m ×	32.0 kw ×	2 (1) units
New Pump specification (M/P stage)	150	mm × 2.11	m^3/min × 12.0 m ×	8.0 kw ×	2 units
	200	mm × 4.22	m^3/min × 12.0 m ×	16.0 kw ×	1 units
	300	mm × 8.44	m^3/min × 12.0 m ×	32.0 kw ×	2 (1) units

3-3 Oxidation Ditch Tank

Item	Sign	Unit	Calculation	Feasibility Study	Master Plan
Type	-	-	Endless oval ditch flow type	-	-
Design sewage flow	Q1	m^3/day	Daily average	5,400	10,800
	Q2	m^3/hr	Daily average	225.0	450.0
BOD-SS load	BS	kgBOD/kgSS/day		0.15	0.15
Inlet BOD quality	IQ	mg/l		300	300
MLSS concentration	ML	mg/l		3,500	3,500
Required volume-1	RV1	m^3	Q1×IQ/(ML×BS)	3,086	6,171
Hydraulic retention time	HT	hr		15.0	15.0
Required volume-2	RV2	m^3	Q2×HT	3,375	6,750
	RV	m^3	RV2 > RV1 *Therefore*	3,375	6,750
Basin number	BN	basin		2	4
Depth of tank	H	m		3.0	3.0
Width of tank	W	m		4.0	4.0
Length of tank	L1	m	RV/(H×W×BN)	140.6	140.6
	L2	m	*Therefore*	141.0	141.0
Dimension (Width)	W	m	**New Facility**	**4.0**	**4.0**
(Length)	L	m		**141.0**	**141.0**
(Depth)	D	m		**3.0**	**3.0**
(Number)	BN	basin		**2**	**4**

3-4 Final Sedimentation Tank

Item	Sign	Unit	Calculation	Feasibility Study	Master Plan
Type	-	-	Radial flow circular type	-	-
Design sewage flow	Q1	m^3/day	Daily average	5,400	10,800
	Q2	m^3/hr	Daily average	225.0	450.0
Water surface load	SL	m^3/m^2/day		15.0	15.0
Required surface area	RA	m^2	Q1/SL	360.0	720.0
Basin number	BN	basin		2	4
Depth of tank	H	m		4.0	4.0
Required tank diameter	D1	m	$(RA\times4/(3.14\times BN))^{0.5}$	15.1	15.1
	D2	m	*Therefore*	15.5	15.5
Dimension (Diameter)	D	m	**New Facility**	**15.5**	**15.5**
(Depth)	H	m		**4.0**	**4.0**
(Number)	BN	basin		**2**	**4**

3-5 Sand Filtration Tank (Future Plan)

Item	Sign	Unit	Calculation	Feasibility Study	Master Plan
Type	-	-	Gravity upflow filter type	-	-
Design sewage flow	Q1	m^3/day	Daily average	-	10,800
	Q2	m^3/sec	Daily average	-	0.125
Filtration rate	FR	m/day		-	200
Required surface area	RA	m^2	Q1/FR	-	54.0
Required basin number	BN	basin		-	4
Width	W	m		-	4.0
Length	L1	m	RA/(W×BN)	-	3.4
	L2	m	*Therefore*	-	3.5
Dimension (Width)	W	m	**New Facility**	**-**	**4.0**
(Length)	L	m		**-**	**3.5**
(Number)	BN	basin		**-**	**4**

3-6 Disinfection Tank

Item	Sign	Unit	Calculation	Feasibility Study	Master Plan
Chemical type	-	-	Hypochlorite type	-	-
Design sewage flow	Q1	m^3/day	Daily average	5,400	10,800
	Q2	m^3/min	Daily average	3.75	7.50
Retention time	RT	min		15.0	15.0
Required volume	RV	m^3	Q2×RT	56.3	112.5
Width of channel	W	m		1.5	1.5
Depth of channel	H	m		1.5	1.5
Pass number	PN	pass		2	4
Length of channel	L1	m	RV/(W×H×PN)	12.5	12.5
	L2	m	*Therefore*	12.5	12.5
Dimension (Width)	W	m	**New Facility**	**1.5**	**1.5**
(Depth)	H	m		**1.5**	**1.5**
(Length)	L	m		**12.5**	**12.5**
(Number)	PN	pass		**2**	**4**

3-7 Sludge Thickening Tank

Item	Sign	Unit	Calculation	Feasibility Study	Master Plan
Type	-	-	Radial flow circular type	-	-
Design sewage flow	Q1	m^3/day	Daily average	5,400	10,800
	Q2	m^3/hr	Daily average	225.0	450.0
Influent SS quality	IS	mg/l		250	250
Effluent SS quality	ES	mg/l		50	50
Generated sludge	GS	kg/day	$Q1\times(IS-ES)\times10^{-3}$	1,080	2,160
Sludge surface load	SL	kg/m^2/day		30.0	30.0
Required surface area	RA	m^2	GS/SL	36.0	72.0
Depth of tank	H	m		3.0	3.0
Basin number	BN	basin		1	2
Required tank diameter	D1	m	$(RA\times4/(3.14\times BN))^{0.5}$	6.8	6.8
	D2	m	*Therefore*	7.0	7.0
Dimension (Diameter)	D	m	**New Facility**	**7.0**	**7.0**
(Depth)	H	m		**3.0**	**3.0**
(Number)	BN	basin		**1**	**2**

3-8 Sludge Digestion Tank

Item	Sign	Unit	Calculation	Feasibility Study	Master Plan
Type	-	-	Anaerobic digestion	-	-
Design sewage flow	Q1	m^3/day	Daily average	-	10,800
	Q2	m^3/hr	Daily average	-	450.0
Generated sludge weight	GS1	kg/day	refer to 3-7	-	2,160
	GS2	ton/day	GS1/1,000	-	2.16
Sludge moisture rate	MR	%	thickened sludge	-	97.0
Sludge volume	SV	m^3/day	$GS2\times100/(100-MR)$	-	72.0
Sludge retention time	T	day		-	14.0
Required tank volume	RV1	m^3/basin	$SV\times T$	-	1,008.0
Basin number	BN	basin		-	2
Depth of tank	H	m		-	8.0
Required tank diameter	D1	m	$(RV1\times4/(3.14\times H\times BN))^{0.5}$	-	9.0
	D2	m	*Therefore*	-	9.0
Dimension (Diameter)	D	m	**New Facility**	**-**	**9.0**
(Depth)	H	m		**-**	**8.0**
(Number)	BN	basin		**-**	**2**

3-9 Digestion Gas Tank

Item	Sign	Unit	Calculation	Feasibility Study	Master Plan
Generated sludge weight	GS	kg/day	refer to 3-8	-	2,160
Organic matter ratio	OM	%		-	70
Generation ratio of gas	GR	%		-	35
Retention time	RT	day		-	0.5
Required tank volume	RV	m^3	$GS\times OM\times GR\times RT/10^4$	-	265
Depth of tank	H	m		-	5.0
Basin number	BN	basin		-	1
Required tank diameter	D1	m	$2\times(RV/(3.14\times H\times BN))^{0.5}$	-	8.2
	D2			-	8.5
Dimension (Diameter)	D	m	**New Facility**	**-**	**8.5**
(Depth)	H	m		**-**	**5.0**
(Number)	BN	basin		**-**	**1**

3-10 Sludge Dewatering Equipment

Item	Sign	Unit	Calculation	Feasibility Study	Master Plan
Type	-	-	Centrifugal type	-	-
Digestion rate	DR	%		-	35.0
Thickened sludge weight	GS	ton/day	refer to 3-7(F/S), 3-8(M/P)	1.08	2.16
Digested sludge weight	DS	ton/day	$GS\times(100-DR)/100$	-	1.40
Sludge moisture rate	MR	%	digested sludge	97.0	97.0
Sludge volume	SV	m^3/day	$DS\times100/(100-MR)$	36.0	46.8
Unit number	UN	unit	including 1 stand-by	1	2
Operation time	OT	hr/day		8.0	8.0
Required capacity	RC1	m^3/hr	$SV/((UN-1)\times OT)$	4.5	5.9
	RC2	m^3/hr	*Therefore*	6.0	6.0
Dimension (Capacity)	C	m^3/hr		**6.0**	**6.0**
(Unit)	U	unit	F/S	**1**	**-**
(Unit)	U	unit	M/P including 1 stand-by	**-**	**2**
Generated sludge (weight)	GS	ton/day		1.08	1.40
Sludge moisture rate	MR	%	dewatered sludge	80.0	80.0
Dewatered sludge volume	DV	m^3/day	$GS\times100/(100-MR)$	**5.4**	**7.0**
				↓	↓
				Carry out to the outside	

4 Summary of Proposed Facilities for Mapusa STP

Proposed Facilities	Feasibility Study (target year 2015)	Master Plan Study (target year 2025)
Grit chamber	1.50mW × 4.20mL × 0.35H × 1basin	1.50mW × 4.20mL × 0.35H × 2basins
Mechanical fine screen	Type : One rake type intermittent rake-up	Type : One rake type intermittent rake-up
	1unit with 20mm opening	2units with 20mm opening
Wet well	5.0mW × 7.0mL × 2.5mH × 1basin	5.0mW × 7.0mL × 2.5mH × 2basins
Pump equipment	150mm × 2.11m3/min × 12.0mH × 8.0kw × 1unit	150mm × 2.11m3/min × 12.0mH × 8.0kw × 2units
	- mm × - m3/min × - mH × - kw × - unit	200mm × 4.22m3/min × 12.0mH × 16.0kw × 1unit
	300mm × 8.44m3/min × 12.0mH × 32.0kw × 2(1)units	300mm × 8.44m3/min × 12.0mH × 32.0kw × 2(1)units
Oxidation ditch	Type : Endless oval ditch flow type	Type : Endless oval ditch flow type
	4.0mW × 141.0mL × 3.0mH × 2basins	4.0mW × 141.0mL × 3.0mH × 4basins
Final settling tank	Type : Radial flow circular type	Type : Radial flow circular type
	15.5mdia × 4.0mH × 2basins	15.5mdia × 4.0mH × 4basins
Sand filtration	-	Type : Gravity upflow filter type
	-	4.0mW × 3.5mL × 4basins
Disinfection tank	Type : Hypochlorite type	Type : Hypochlorite type
	1.5mW × 12.5mL × 1.5mH × 2passes	1.5mW × 12.5mL × 1.5mH × 4passes
Sludge thickening tank	Type : Radial flow circular type	Type : Radial flow circular type
	7.0mdia × 3.0mH × 1basin	7.0mdia × 3.0mH × 2basins
Sludge digestion tank	-	Type : Anaerobic digestion type
	-	9.0mdia × 8.0mH × 2basins
Digestion gas tank	-	12.0mdia × 5.0mH × 1basin
Sludge dewatering	Type : Centrifugal type	Type : Centrifugal type
	6.0m3/hr × 1unit	6.0m3/hr × 2(1)units

Appendix F52.3 Oxidation Ditch Method

CAPACITY CALCULATION OF SEWAGE TREATMENT PLANT

1 BASIC CONDITIONS

1-1 Basic Items

(1) Name : **Baga Sewage Treatment Plant (North Coastal Belt)**

(2) Land Area : Approximately 2 ha

(3) Ground Level : + 1.50 m

(4) Inlet Pipe Level : + m

(5) Pipe Diameter : mm ( )

(6) Land Use : Governmental Land

(7) Collection System : Combined System [✓ Separate System]

(8) Treatment Process :
Sewage ; Pre-treatment + Oxidation ditch + Secondary settling
+ Sand filtration + Disinfection
Sludge ; Thickening + <Digestion> + Dewatering
< > : M/P Stage

(9) Effluent Point : Baga River

(10) Water Level at the Effluent Point :
High water level = m
Low water level = m

(11) Target Year : **2015 (F/S Stage) , 2025 (M/P Stage)**

1-2 Design Population and Service Area

Item		Year 2015	Year 2025
Design Population	person	21,000	39,400
Service Area	ha		593.0

1-3 Design Sewage Flow

(Year 2015)

Item	m^3/day	m^3/hr	m^3/min	m^3/sec	Remarks
Daily Average	5,500	229.2	3.82	0.064	
Peak Flow	13,750	572.9	9.55	0.159	Peak factor = 2.50

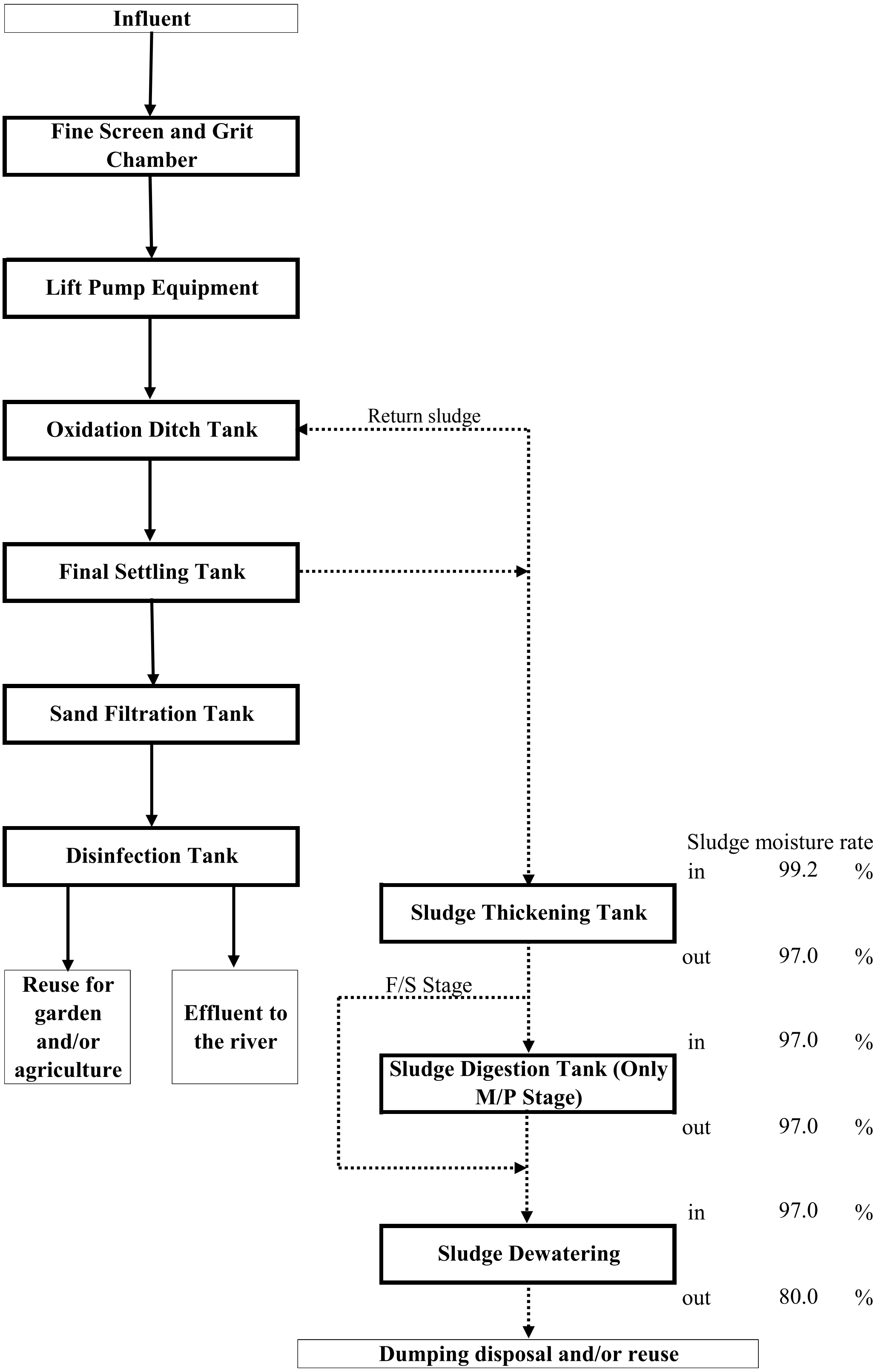
(Year 2025)

Item	m^3/day	m^3/hr	m^3/min	m^3/sec	Remarks
Daily Average	11,200	466.7	7.78	0.130	
Peak Flow	28,000	1,166.7	19.44	0.324	Peak factor = 2.50

1-4 Design Sewage Quality

Item	Influent	Removal rate	Effluent	Remarks
	(mg/l)	(%)	(mg/l)	
BOD	240	87.5	30	Effluent quality regulation : 30 mg/l
SS	200	75	50	Effluent quality regulation : 100 mg/l

1-5 Flow Chart (Oxidation Ditch Process)



2 Design Criteria for STP

Items		unit	CPHEEO	Japanese Standards	Metcalf&Eddy	Adoption
2-1	Screen and Grit Chamber					
	(1) Fine Screen					
	Openings of screen bars	mm	less than 20	15.0 - 25.0	15.0	20.0
	(2) Grit chamber					
	Water surface load	m3/m2/day	2,160	1,800	1,382 - 1,814	2,160
	Horizontal velocity	m/sec	0.15 - 0.30	0.30	0.24 - 0.39	0.30
2-2	Pump Equipment					
	Pump inflow velocity	m/sec	-	1.5 - 3.0	-	1.5 - 3.0
	Retention time in wet well	min	> 5.0	-	-	9.0
2-3	Oxidation Ditch Tank					
	Hydraulic retention time	hr	12.0 - 24.0	24.0 - 48.0	8.0 - 36.0	15.0
	MLSS concentration	mg/l	3,000 - 5,000	3,000 - 4,000	3,000 - 6,000	3,500
	BOD-SS load	kgBOD/kgSS/day	0.10 - 0.18	0.03 - 0.05	0.05 - 0.30	0.15
	Depth of tank	m	-	1.0 - 3.0	-	3.0
	Width of tank	m	-	2.0 - 6.0	-	4.0
2-4	Final Settling Tank					
	Water surface load	m3/m2/day	8.0 - 15.0	8.0 - 12.0	16.3 - 32.6	15.0
	Depth of tank	m	3.5 - 4.5	3.0 - 4.0	3.7	4.0
2-5	Sand Filtration					
	Filtration rate	m/day	-	max. 300	176	200
2-6	Disinfection Tank					
	Retention time	min	-	15.0	-	15.0
2-7	Sludge Thickening Tank					
	Solid surface load	kg/m2/day	25.0 - 30.0	60.0 - 90.0	12.2 - 34.2	30.0
	Depth of tank	m	3.0	4.0	-	3.0
2-8	Sludge Digestion Tank					
	Solid retention time	day	14.0	20.0	15.0 - 20.0	14.0
	Operating temperature	℃	30.0	30.0	-	30.0
	Digestion rate	%	-	35.0	-	35.0
	Depth of tank	m	6.0 - 12.0	> 4.0	> 7.5	8.0
2-9	Sludge Dewatering Equipment					
	Operation time	hr/day	-	-	-	8.0

CPHEEO : Central Public Health and Environmental Organization, Ministry of Urban Development, New Delhi,1993

3 CAPACITY CALCULATION OF STP FACILITIES

3-1 Screen and Grit Chamber

Item	Sign	Unit	Calculation	Feasibility Study	Master Plan
3-1-1 Grit Chamber					
Type	-	-	Parallel flow type	-	-
Design sewage flow	Q1	m^3/day	Peak flow	13,750	28,000
	Q2	m^3/sec	Peak flow	0.159	0.324
Water surface load	SL	m^3/m^2/day		2,160	2,160
Required surface area	RA	m^2	Q1/SL	6.4	13.0
Basin number	BN	basin		1	2
Horizontal velocity	V	m/sec		0.30	0.30
Water depth	H	m		0.35	0.35
Width	W1	m	Q2/(V×H×BN)	1.52	1.54
	W2	m	*Therefore*	1.60	1.60
Length	L1	m	RA/(W2×BN)	3.98	4.05
	L2	m	*Therefore*	4.10	4.10
Dimension (Width)	W	m	**New Facility**	**1.60**	**1.60**
(Length)	L	m		**4.10**	**4.10**
(Depth)	D	m		**0.35**	**0.35**
(Number)	BN	basin		**1**	**2**
3-1-2 Fine Screen (New Facility)					
Type	-	-	One rake type intermittent rake-up		
Set number	SN	set			
Screen opening	SO	mm		20.0	20.0
Unit removed screenings	RS	$m^3/1,000m^3$		0.010	0.010
Design sewage flow	Q1	m^3/day	Daily average	5,500	11,200
Volume of screenings	SV	m^3/day	Q1×RS/1,000	0.055	0.112
				↓	↓
				Carry out to the outside	

3-2 Wet Well and Pump Equipment

Item	Sign	Unit	Calculation	Feasibility Study	Master Plan
3-2-1 Wet Well (pump pit)					
Design sewage flow	Q1	m^3/day	Peak flow	13,750	28,000
	Q2	m^3/min	Peak flow	9.55	19.44
Basin number	BN	basin		1	2
Retention time	T	min		9.0	9.0
Required volume	RV	m^3	Q2×T	85.9	175.0
Depth of tank	H	m		2.5	2.5
Required area	RA	m^2	RV/H	34.4	70.0
Width of tank	W	m		5.0	5.0
Length of tank	L1	m	RA/(BN×W)	6.9	7.0
	L2	m		7.0	7.0
Dimension (Width)	W	m	**New Facility**	**5.0**	**5.0**
(Length)	L	m		**7.0**	**7.0**
(Depth)	D	m		**2.5**	**2.5**
(Number)	BN	basin		**1**	**2**

3-2-2 Pump Equipment					
Design sewage flow	Q1	m^3/day	Peak flow	13,750	28,000
	Q2	m^3/min	Peak flow	9.55	19.44
Pump unit number	UN1	unit	1/8×Q	2	2
	UN2	unit	2/8×Q	1	1
	UN3	unit	4/8×Q, including 1 stand-by	1	2
Pump discharging flow	DF1	m^3/min/unit		2.43	2.43
	DF2	m^3/min/unit		4.86	4.86
	DF3	m^3/min/unit		9.72	9.72
Pump inflow velocity	PV	m/sec		1.5 - 3.0	1.5 - 3.0
Required pump diameter	D1-1	mm	146×(DF1/3.0)$^{0.5}$	131	131
	D1-2	mm	146×(DF1/1.5)$^{0.5}$	186	186
	D1	mm	*Therefore*	150	150
	D2-1	mm	146×(DF2/3.0)$^{0.5}$	186	186
	D2-2	mm	146×(DF2/1.5)$^{0.5}$	263	263
	D2	mm	*Therefore*	200	200
	D3-1	mm	146×(DF3/3.0)$^{0.5}$	263	263
	D3-2	mm	146×(DF3/1.5)$^{0.5}$	372	372
	D3	mm	*Therefore*	300	300
Pump total head	H	m		12.0	12.0
Pump efficiency	PE	-		0.6	0.6
Axis power	AP1	kw	0.163×DF1×H/PE	7.92	7.92
	AP2	kw	0.163×DF2×H/PE	15.85	15.85
	AP3	kw	0.163×DF3×H/PE	31.69	31.69
Motor allowance	MA	-		0.15	0.15
Pump power	P1	kw	AP1×(1+MA)	9.11	9.11
			Therefore	10.0	10.0
	P2	kw	AP2×(1+MA)	18.22	18.22
			Therefore	19.0	19.0
	P3	kw	AP3×(1+MA)	36.45	36.45
			Therefore	37.0	37.0
New Pump specification (F/S stage)	150	mm × 2.43	m^3/min × 12.0 m ×	10.0 kw ×	2 units
	200	mm × 4.86	m^3/min × 12.0 m ×	19.0 kw ×	1 units
	300	mm × 9.72	m^3/min × 12.0 m ×	37.0 kw ×	1 (1) units
New Pump specification (M/P stage)	150	mm × 2.43	m^3/min × 12.0 m ×	10.0 kw ×	2 units
	200	mm × 4.86	m^3/min × 12.0 m ×	19.0 kw ×	1 units
	300	mm × 9.72	m^3/min × 12.0 m ×	37.0 kw ×	2 (1) units

3-3 Oxidation Ditch Tank

Item	Sign	Unit	Calculation	Feasibility Study	Master Plan
Type	-	-	Endless oval ditch flow type	-	-
Design sewage flow	Q1	m^3/day	Daily average	5,500	11,200
	Q2	m^3/hr	Daily average	229.2	466.7
BOD-SS load	BS	kgBOD/kgSS/day		0.15	0.15
Inlet BOD quality	IQ	mg/l		240	240
MLSS concentration	ML	mg/l		3,500	3,500
Required volume-1	RV1	m^3	Q1×IQ/(ML×BS)	2,514	5,120
Hydraulic retention time	HT	hr		15.0	15.0
Required volume-2	RV2	m^3	Q2×HT	3,438	7,000
	RV	m^3	RV2 > RV1 *Therefore*	3,438	7,000
Basin number	BN	basin		2	4
Depth of tank	H	m		3.0	3.0
Width of tank	W	m		4.0	4.0
Length of tank	L1	m	RV/(H×W×BN)	143.2	145.8
	L2	m	*Therefore*	146.0	146.0
Dimension (Width)	W	m	**New Facility**	**4.0**	**4.0**
(Length)	L	m		**146.0**	**146.0**
(Depth)	D	m		**3.0**	**3.0**
(Number)	BN	basin		**2**	**4**

3-4 Final Sedimentation Tank

Item	Sign	Unit	Calculation	Feasibility Study	Master Plan
Type	-	-	Radial flow circular type	-	-
Design sewage flow	Q1	m^3/day	Daily average	5,500	11,200
	Q2	m^3/hr	Daily average	229.2	466.7
Water surface load	SL	m^3/m^2/day		15.0	15.0
Required surface area	RA	m^2	Q1/SL	366.7	746.7
Basin number	BN	basin		2	4
Depth of tank	H	m		4.0	4.0
Required tank diameter	D1	m	$(RA \times 4/(3.14 \times BN))^{0.5}$	15.3	15.4
	D2	m	*Therefore*	16.0	16.0
Dimension (Diameter)	D	m	**New Facility**	**16.0**	**16.0**
(Depth)	H	m		**4.0**	**4.0**
(Number)	BN	basin		**2**	**4**

3-5 Sand Filtration Tank

Item	Sign	Unit	Calculation	Feasibility Study	Master Plan
Type	-	-	Gravity upflow filter type	-	-
Design sewage flow	Q1	m^3/day	Daily average	5,500	11,200
	Q2	m^3/sec	Daily average	0.064	0.130
Filtration rate	FR	m/day		200	200
Required surface area	RA	m^2	Q1/FR	27.5	56.0
Required basin number	BN	basin		2	4
Width	W	m		4.0	4.0
Length	L1	m	RA/(W×BN)	3.4	3.5
	L2	m	*Therefore*	3.5	3.5
Dimension (Width)	W	m	**New Facility**	**4.0**	**4.0**
(Length)	L	m		**3.5**	**3.5**
(Number)	BN	basin		**2**	**4**

3-6 Disinfection Tank

Item	Sign	Unit	Calculation	Feasibility Study	Master Plan
Chemical type	-	-	Hypochlorite type	-	-
Design sewage flow	Q1	m^3/day	Daily average	5,500	11,200
	Q2	m^3/min	Daily average	3.82	7.78
Retention time	RT	min		15.0	15.0
Required volume	RV	m^3	Q2×RT	57.3	116.7
Width of channel	W	m		1.5	1.5
Depth of channel	H	m		1.5	1.5
Pass number	PN	pass		2	4
Length of channel	L1	m	RV/(W×H×PN)	12.7	13.0
	L2	m	*Therefore*	13.0	13.0
Dimension (Width)	W	m	**New Facility**	**1.5**	**1.5**
(Depth)	H	m		**1.5**	**1.5**
(Length)	L	m		**13.0**	**13.0**
(Number)	PN	pass		**2**	**4**

3-7 Sludge Thickening Tank

Item	Sign	Unit	Calculation	Feasibility Study	Master Plan
Type	-	-	Radial flow circular type	-	-
Design sewage flow	Q1	m^3/day	Daily average	5,500	11,200
	Q2	m^3/hr	Daily average	229.2	466.7
Influent SS quality	IS	mg/l		200	200
Effluent SS quality	ES	mg/l		50	50
Generated sludge	GS	kg/day	$Q1 \times (IS-ES) \times 10^{-3}$	825	1,680
Sludge surface load	SL	kg/m^2/day		30.0	30.0
Required surface area	RA	m^2	GS/SL	27.5	56.0
Depth of tank	H	m		3.0	3.0
Basin number	BN	basin		1	2
Required tank diameter	D1	m	$(RA \times 4/(3.14 \times BN))^{0.5}$	5.9	6.0
	D2	m	*Therefore*	6.0	6.0
Dimension (Diameter)	D	m	**New Facility**	**6.0**	**6.0**
(Depth)	H	m		**3.0**	**3.0**
(Number)	BN	basin		**1**	**2**

3-8 Sludge Digestion Tank

Item	Sign	Unit	Calculation	Feasibility Study	Master Plan
Type	-	-	Anaerobic digestion	-	-
Design sewage flow	Q1	m^3/day	Daily average	-	11,200
	Q2	m^3/hr	Daily average	-	466.7
Generated sludge weight	GS1	kg/day	refer to 3-7	-	1,680
	GS2	ton/day	GS1/1,000	-	1.68
Sludge moisture rate	MR	%	thickened sludge	-	97.0
Sludge volume	SV	m^3/day	GS2×100/(100-MR)	-	56.0
Sludge retention time	T	day		-	14.0
Required tank volume	RV1	m^3/basin	SV×T	-	784.0
Basin number	BN	basin		-	2
Depth of tank	H	m		-	8.0
Required tank diameter	D1	m	$(RV1\times4/(3.14\times H\times BN))^{0.5}$	-	7.9
	D2	m	*Therefore*	-	8.0
Dimension (Diameter)	D	m	**New Facility**	**-**	**8.0**
(Depth)	H	m		**-**	**8.0**
(Number)	BN	basin		**-**	**2**

3-9 Digestion Gas Tank

Item	Sign	Unit	Calculation	Feasibility Study	Master Plan
Generated sludge weight	GS	kg/day	refer to 3-8	-	1,680
Organic matter ratio	OM	%		-	70
Generation ratio of gas	GR	%		-	35
Retention time	RT	day		-	0.5
Required tank volume	RV	m^3	$GS\times OM\times GR\times RT/10^4$	-	206
Depth of tank	H	m		-	5.0
Basin number	BN	basin		-	1
Required tank diameter	D1	m	$2\times(RV/(3.14\times H\times BN))^{0.5}$	-	7.2
	D2			-	7.5
Dimension (Diameter)	D	m	**New Facility**	**-**	**7.5**
(Depth)	H	m		**-**	**5.0**
(Number)	BN	basin		**-**	**1**

3-10 Sludge Dewatering Equipment

Item	Sign	Unit	Calculation	Feasibility Study	Master Plan
Type	-	-	Centrifugal type	-	-
Digestion rate	DR	%		-	35.0
Thickened sludge weight	GS	ton/day	refer to 3-6(F/S), 3-7(M/S)	0.825	1.68
Digested sludge weight	DS	ton/day	GS×(100-DR)/100	-	1.09
Sludge moisture rate	MR	%	digested sludge	97.0	97.0
Sludge volume	SV	m^3/day	DS×100/(100-MR)	27.5	36.4
Unit number	UN	unit	including 1 stand-by	1	2
Operation time	OT	hr/day		8.0	8.0
Required capacity	RC1	m^3/hr	SV/((UN-1)×OT)	3.4	4.6
	RC2	m^3/hr	*Therefore*	5.0	5.0
Dimension (Capacity)	C	m^3/hr		**5.0**	**5.0**
(Unit)	U	unit	F/S	**1**	**-**
(Unit)	U	unit	M/P including 1 stand-by	**-**	**2**
Generated sludge (weight)	GS	ton/day		0.83	1.09
Sludge moisture rate	MR	%	dewatered sludge	80.0	80.0
Dewatered sludge volume	DV	m^3/day	GS×100/(100-MR)	**4.1**	**5.5**
				↓	↓
				Carry out to the outside	

4 Summary of Proposed Facilities for Baga STP

Proposed Facilities	Feasibility Study (target year 2015)	Master Plan Study (target year 2025)
Grit chamber	1.60mW × 4.10mL × 0.35H × 1basin	1.60mW × 4.10mL × 0.35H × 2basins
Mechanical fine screen	Type : One rake type intermittent rake-up	Type : One rake type intermittent rake-up
	1unit with 20mm opening	2units with 20mm opening
Wet well	5.0mW × 7.0mL × 2.5mH × 1basin	5.0mW × 7.0mL × 2.5mH × 2basins
Pump equipment	150mm × 2.43m3/min × 12.0mH × 10.0kw × 2units	150mm × 2.43m3/min × 12.0mH × 10.0kw × 2units
	200mm × 4.86m3/min × 12.0mH × 19.0kw × 1unit	200mm × 4.86m3/min × 12.0mH × 19.0kw × 1unit
	300mm × 9.72m3/min × 12.0mH × 37.0kw × 1(1)unit	300mm × 9.72m3/min × 12.0mH × 37.0kw × 2(1)units
Oxidation ditch	Type : Endless oval ditch flow type	Type : Endless oval ditch flow type
	4.0mW × 146.0mL × 3.0mH × 2basins	4.0mW × 146.0mL × 3.0mH × 4basins
Final settling tank	Type : Radial flow circular type	Type : Radial flow circular type
	16.0mdia × 4.0mH × 2basins	16.0mdia × 4.0mH × 4basins
Sand filtration	Type : Gravity upflow filter type	Type : Gravity upflow filter type
	4.0mW × 3.5mL × 2basins	4.0mW × 3.5mL × 4basins
Disinfection tank	Type : Hypochlorite type	Type : Hypochlorite type
	1.5mW × 13.0mL × 1.5mH × 2passes	1.5mW × 13.0mL × 1.5mH × 4passes
Sludge thickening tank	Type : Radial flow circular type	Type : Radial flow circular type
	6.0mdia × 3.0mH × 1basin	6.0mdia × 3.0mH × 2basins
Sludge digestion tank	-	Type : Anaerobic digestion type
	-	8.0mdia × 8.0mH × 2basins
Digestion gas tank	-	10.5mdia × 5.0mH × 1basin
Sludge dewatering	Type : Centrifugal type	Type : Centrifugal type
	5.0m3/hr × 1unit	5.0m3/hr × 2(1)units

APPENDIX F7

This appendix is reference to and supporting data of

Volume 3 Main Report – Feasibility Study

Chapter 7 Institutional Development and Capacity Building

F71	Improvement of Financial Management and Control

Appendix F71

Improvement of Financial Management and Control

Contents for Appendix F71

Appendix 71.1 Improvement of Financial Management and Control

Table F71.1.1 Sample of Journal Book

Year XXXX		Abstract	Debit	Credit
Date	Month			

Notes: All the transactions shall be recorded on the above table from 1st day on the top to the last day at the bottom, filling all the account titles in abstract.

Table F71.1.2 Sample of General Ledger

Cash & Bank account

Year XXXX		Abstract	Debit	Year XXXX		Abstract	Credit
Date	Month			Date	Month		

Account receivables

Year XXXX		Abstract	Debit	Year XXXX		Abstract	Credit
Date	Month			Date	Month		

Inventory

Year XXXX		Abstract	Debit	Year XXXX		Abstract	Credit
Date	Month			Date	Month		

Land

Year XXXX		Abstract	Debit	Year XXXX		Abstract	Credit
Date	Month			Date	Month		

Building, plant & equipment

Year XXXX		Abstract	Debit	Year XXXX		Abstract	Credit
Date	Month			Date	Month		

Short-term loan

Year XXXX		Abstract	Debit	Year XXXX		Abstract	Credit
Date	Month			Date	Month		

Account payable

Year XXXX		Abstract	Debit	Year XXXX		Abstract	Credit
Date	Month			Date	Month		

Long-term loan

Year XXXX		Abstract	Debit	Year XXXX		Abstract	Credit
Date	Month			Date	Month		

Capital

Year XXXX		Abstract	Debit	Year XXXX		Abstract	Credit
Date	Month			Date	Month		

Water Sales

Year XXXX		Abstract	Debit	Year XXXX		Abstract	Credit
Date	Month			Date	Month		

Meter rent charge

Year XXXX		Abstract	Debit	Year XXXX		Abstract	Credit
Date	Month			Date	Month		

Connection charge

Year XXXX		Abstract	Debit	Year XXXX		Abstract	Credit
Date	Month			Date	Month		

Notes: Above table are sample, which does not include all of the expected account titles.

Table F71.1.3 Sample of Trial Balance

Accounting period: 1/Apr./20XX to 30/Apr./20xx

As of: Date 30 Month April, Year 20XX

No.	Account title	Total		Balance	
		Debit	Credit	Debit	Credit
1	Cash & Bank account				
2	Account receivable				
3	Inventory				
4	Land				
5	Buiding, plant & equipment				
6	Short-term loan				
7	Account payable				
8	Long-term loan				
9	Capital				
10	Water sales				
11	Meter rent charge				
12	Connection charge				
13	Electricity cost				
14	Chemical cost				
15	Maintenance cost				
16	Personnel cost				
17	Office & administration				
18	Depreciation cost				
19	Interest payment				

Notes: Above table are sample, which does not include all of the expected account titles.

APPENDIX F8

This appendix is reference to and supporting data of

Volume 3 Main Report – Feasibility Study

Chapter 8 Cost Estimation and Implementation Schedule

Appendix F81

Cost Estimation and Implementation Schedule

Contents for Appendix F81

Appendix F81 Improvement of Financial Management and Control

F81.1 Calculation basis of Water Supply Cost for Feasibility Study

Description	Detail	Quantity	Unit	Unit Cost (Rs.)	Amount (Rs. In Million)
1 Salaulim Water Supply Scheme					
1.1 Rehabilitation/Improvement Works					
1.1.1 Salaulim W.T.P.					
1.1.1.1 Raw Water Intake					
(1)M & E	Phase1 410*6= 2,460 kW	2,460	kW	30,000	73.800
(2)Raw Water Transmission Line (Raising Main)	Flow Meter	1	L.S.	500,000	0.500
	By-pass Pipe with Valve	1	L.S.	500,000	0.500
1.1.1.2 Water Treatment					
(1) Water Treatment Facility		160	MLD	1,800,000	288.000
1.1.2 Transmission main					
(1)Rehabilitation I	MS 1,200	14,199	m	37,880	537.860
1.1.4 Pumping Station					
	Verna MBR 455.3*4= 1,821 kW	1,821	kW	30,000	54.640
1.2 Proposed					
1.2.1 Raw Water Intake Facility					
(1) Raw Water Intake & Pumping House		1	L.S.	10,000,000	10.000
(2) M & E (1st Stage)	280*4= 1,120 kW	1,120	kW	48,000	53.760
1.2.2 Raw Water Transmission Main					
(1) 1st Stage	MS 1,600	1,000	m	52,750	52.750
1.2.3 Treatment Facility					
(1) 1st Stage		100	MLD	5,000,000	500.000
1.2.4 Transmission Pump Facility					
(1)Resorvoir (1sr Stage)	5,000 m3	5,000	m3	5,100	25.500
(3) M & E (1st Stage)	500*4= 2,000 kW	2,000	kW	48,000	96.000
1.2.5 Transmission Main					
(1) Proposed I	MS 1,400	7,500	m	44,700	335.250
	Pipe Bridge D1400 L= 20+20= 40 m	40	m	150,000	6.000
	MS 1,400	19,200	m	44,700	858.240
	Pipe Bridge D1400 L= 100+20+20*2+20= 180 m	180	m	150,000	27.000
	Railway Crossing D14(L= 20*3= 60 m	60	m	447,000	26.820
	DIP 900	850	m	17,820	15.150
(2) Proposed II	DIP 450	2,700	m	6,100	16.470
	DIP 400	3,900	m	5,150	20.090
	DIP 300	2,900	m	3,470	10.060
	DIP 250	8,800	m	2,800	24.640
	DIP 200	14,300	m	2,170	31.030
	DIP 150	14,300	m	1,710	24.450
1.2.6 Resorvoir					
(1) Proposed I	20000+800*2+300*2+200+100= 22,500 m3	22,500	m3	5,100	114.750
1.2.7 Pumping Station					
(1) Proposed I Pumping Pit & Pump House	100+300+300+100+100= 900 m3	900	m3	5,100	4.590
(2)Proposed I M & E	2.6*3+4.3*3+28.6*3+9.3*3+1.5*3= 139 kW	139	kW	30,000	4.170

Total

Expantion	2,256.720
WTP	738.010
T/M	1,395.200
Res.	114.750
P/S	8.760
Rehabilitation	955.300
WTP	362.800
T/M	537.860
P/S	54.640
Improvement O/M	289.860
Quality Control	17.500
Total	3,519.380

F81.2 Calculation basis of Sanitation Cost for Feasibility Study

Description	Detail	Quantity	Unit	Unit Cost (Rs.)	Amount (Rs. In Million)
1. Margao					
1.1 Trunk Sewer					
	700mm - 300mm L=85,885m	1	L.S.		108.180
1.2 Branch Sewer					
	L=36,145m	1	L.S.		132.150
1.3 Pumping Station					
	3.5m3/min*15kw*1				
	7.5m3/min*29kw*2(1)	1	L.S.		10.840
1.4 STP					
	6.7MLD,Expansion	1	L.S.		93.800
2. Mapusa					
2.1 Trunk Sewer					
	700mm - 250mm L=58,710m	1	L.S.		77.730
2.2 Branch Sewer					
	L=20,680m	1	L.S.		75.330
2.3 STP					
	5.4MLD	1	L.S.		81.500
3. Margao					
3.1 Trunk Sewer					
	700mm - 300mm L=75,720m	1	L.S.		79.230
3.2 Branch Sewer					
	L=25,180m	1	L.S.		103.440
3.3 Pumping Station					
	3.3m3/min*14kw*1				
	6.5m3/min*26kw*2(1)	1	L.S.		10.400
3.4 STP					
	5.6MLD	1	L.S.		93.600

APPENDIX F9

This appendix is reference to and supporting data of

Volume 3 Main Report – Feasibility Study

Chapter 9 Economic and Financial Evaluation

Appendix F91

Methodology of Economic and Financial Evaluation

Contents for Appendix F91

Appendix F91.1 Methodology of Economic and Financial Evaluation

Table F91.1.1 Calculation of Risk Premium Rate

Infrastructure/Natural Resources

Annual Base Rates per $100 of Coverage

Coverage	**Active/Current**
Inconvertibility	$0.25 - $0.45
Expropriation	$0.55 - $0.85
Business Income	$0.30 - $0.55
Assets	$0.40 - $0.75

Source: "Election of Coverage and Premium Based Rates", Overseas Private Investment Corporation

Average of the Annual Base Rate

Coverage	Annual Base Rate
Inconvertibility	**0.35 %**
Expropriation	**0.70 %**
Business Income	**0.425 %**
Assets	**0.575 %**
Total	**2.05 %**

Appendix F92

Economic and Financial Evaluation of Priority Projects for Water Supply

Contents for Appendix F92

Appendix F92.1 Economic and Financial Evaluation of Priority Projects for Water Supply

Table F92.1.1 Excess water demand for existing capacity and incremental number of connections served by priority projects in Salaulim water supply scheme

Salaulim Water Supply Scheme (Mormugao, Salcete, Quepem, and Sanguem taluka)

(Unit: m^3/day)

	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
Excess demand for existing capacity	0	0	66	5,765	11,686	17,851	24,234	30,881	37,798	45,010	52,520	60,335	68,481	91,543	100,000	100,000	100,000	100,000	100,000	100,000	100,000
% of Domestic	67.6%	67.0%	66.4%	65.8%	65.2%	64.6%	64.0%	63.4%	62.7%	62.1%	61.4%	60.8%	60.1%	59.4%	58.8%	58.1%	57.4%	56.7%	56.0%	55.3%	54.6%
Domestic **Day Max.**	**0**	**0**	**44**	**3,795**	**7,622**	**11,533**	**15,506**	**19,565**	**23,706**	**27,941**	**32,263**	**36,668**	**41,165**	**54,415**	**58,768**	**58,088**	**57,401**	**56,709**	**56,010**	**55,306**	**54,596**
Day Ave.	**0**	**0**	**36**	**3,136**	**6,299**	**9,532**	**12,815**	**16,169**	**19,592**	**23,092**	**26,663**	**30,304**	**34,020**	**44,971**	**48,568**	**48,007**	**47,439**	**46,867**	**46,289**	**45,707**	**45,120**
% of Tourism	2.6%	2.6%	2.6%	2.6%	2.7%	2.7%	2.7%	2.7%	2.7%	2.7%	2.7%	2.7%	2.7%	2.8%	2.8%	2.8%	2.8%	2.8%	2.8%	2.8%	2.8%
Tourism	**0**	**0**	**2**	**153**	**311**	**478**	**652**	**835**	**1,026**	**1,226**	**1,435**	**1,654**	**1,882**	**2,521**	**2,759**	**2,764**	**2,768**	**2,770**	**2,772**	**2,773**	**2,773**
% of Other Non-Domestic	29.8%	30.4%	30.9%	31.5%	32.1%	32.7%	33.3%	33.9%	34.6%	35.2%	35.8%	36.5%	37.1%	37.8%	38.5%	39.1%	39.8%	40.5%	41.2%	41.9%	42.6%
Other Non-Domestic	**0**	**0**	**20**	**1,817**	**3,753**	**5,840**	**8,076**	**10,482**	**13,066**	**15,843**	**18,822**	**22,014**	**25,435**	**34,607**	**38,473**	**39,148**	**39,832**	**40,521**	**41,218**	**41,921**	**42,631**
Non-Domestic Total	**0**	**0**	**22**	**1,970**	**4,064**	**6,318**	**8,728**	**11,316**	**14,092**	**17,069**	**20,257**	**23,667**	**27,316**	**37,128**	**41,232**	**41,912**	**42,599**	**43,291**	**43,990**	**44,694**	**45,404**
Excess demand served by M/P (Day Ave.)	0	0	58	5,106	10,363	15,849	21,543	27,485	33,684	40,161	46,921	53,971	61,337	82,099	89,801	89,919	90,038	90,158	90,279	90,401	90,525
Incremental number of connections (for Expansion facilities)																					
Domestic	**0**	**0**	**0**	**3,101**	**3,157**	**3,217**	**3,266**	**3,330**	**3,393**	**3,461**	**3,528**	**3,595**	**3,666**	**3,737**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Non-Domestic	**0**	**0**	**0**	**163**	**166**	**169**	**172**	**175**	**179**	**182**	**186**	**189**	**193**	**197**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Incremental no. of connections (for Existing Facilities)																					
Domestic	0	2,990	3,043	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Domestic	0	157	160	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Incremental no. of connections (total)																					
Domestic	0	2,990	3,043	3,101	3,157	3,217	3,266	3,330	3,393	3,461	3,528	3,595	3,666	3,737	0	0	0	0	0	0	0
Non-Domestic	0	157	160	163	166	169	172	175	179	182	186	189	193	197	0	0	0	0	0	0	0
Existing no. of connections (2005)																					
Domestic	100,815																				
Non-Domestic	5,306																				
Total no. of connections (for Expansion Facilities)																					
Domestic	0	0	0	3,101	6,258	9,475	12,741	16,071	19,464	22,925	26,453	30,048	33,713	37,451	37,451	37,451	37,451	37,451	37,451	37,451	37,451
Non-Domestic	0	0	0	163	329	499	671	846	1,024	1,207	1,392	1,581	1,774	1,971	1,971	1,971	1,971	1,971	1,971	1,971	1,971
Total no. of connections (for Existing Facilities)																					
Domestic	100,815	103,805	106,848	106,848	106,848	106,848	106,848	106,848	106,848	106,848	106,848	106,848	106,848	106,848	106,848	106,848	106,848	106,848	106,848	106,848	106,848
Non-Domestic	5,306	5,463	5,624	5,624	5,624	5,624	5,624	5,624	5,624	5,624	5,624	5,624	5,624	5,624	5,624	5,624	5,624	5,624	5,624	5,624	5,624

Table F92.1.2 Total Population and total served population in Salaulim water supply scheme

Total Population in Salaulim Water Supply Scheme (x 1,000)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Mormugao	156.677	159.496	162.353	165.262	168.213	171.214	174.271	177.388	180.564	183.803	187.113	190.497	193.955	197.496	201.124	204.847	208.667	212.586	216.621	220.770	225.042
Salcete	275.984	280.228	284.548	288.948	293.430	297.994	302.643	307.377	312.200	317.115	322.115	327.205	332.387	337.663	343.022	348.484	354.025	359.659	365.386	371.196	377.096
Quepem	77.705	78.644	79.571	80.502	81.428	82.357	83.285	84.210	85.133	86.057	86.982	87.904	88.831	89.754	90.678	91.607	92.536	93.466	94.397	95.330	96.264
Sanguem	67.853	68.530	69.213	69.899	70.588	71.289	71.992	72.708	73.420	74.145	74.868	75.607	76.344	77.077	77.820	78.561	79.298	80.044	80.775	81.512	82.242
TOTAL	578.219	586.898	595.685	604.611	613.659	622.854	632.191	641.683	651.317	661.120	671.078	681.213	691.517	701.990	712.644	723.499	734.526	745.755	757.179	768.808	780.644

Total Served Population in Salaulim Water Supply Scheme (x 1,000)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Mormugao	109.419	113.921	118.526	123.247	128.077	133.023	138.041	143.193	148.480	153.908	159.486	165.219	171.110	177.171	183.408	189.832	196.449	203.264	210.297	217.552	225.042
Salcete	251.594	256.899	262.297	267.791	273.384	279.075	284.868	290.762	296.762	302.871	309.082	315.399	321.826	328.363	335.001	341.758	348.612	355.575	362.647	369.819	377.096
Quepem	68.864	69.976	71.082	72.199	73.317	74.444	75.576	76.711	77.850	78.996	80.149	81.286	82.434	83.583	84.739	85.906	87.078	88.257	89.443	90.636	91.836
Sanguem	18.865	21.328	23.832	26.375	28.958	31.584	34.249	36.960	39.708	42.503	45.335	48.217	51.138	54.095	57.099	60.140	63.218	66.342	69.492	72.685	75.909
TOTAL	448.742	462.124	475.737	489.612	503.736	518.126	532.734	547.626	562.800	578.278	594.052	610.121	626.508	643.212	660.247	677.636	695.357	713.438	731.879	750.692	769.883

Number of served household in Salaulim Water Supply Scheme (x 1,000)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Number of Served Households	100.390	103.383	106.429	109.533	112.693	115.912	119.180	122.511	125.906	129.369	132.898	136.492	140.158	143.895	147.706	151.596	155.561	159.606	163.731	167.940	172.233

Table F92.1.3 Average size of household in Salaulim WSS in the year 2005

	Population (x 1,000)	Number of households (x 1,000)	Average household size (persons/household)
Mormugao	156.677	34.949	4.483
Salcete	275.984	62.988	4.382
Quepem	77.705	16.860	4.609
Sanguem	67.853	14.545	4.665
TOTAL	**578.219**	**129.342**	**4.470**

Table F92.1.4 Total economic benefit of saving water tank cost

Year	Number of served household	% of users in the total number of customers		Annual cost for facilities (Rs./year per household)		Total Water Tank Cost (Rs./year)			% of reduction of tank users	Total Economic Benefit of Saving Water Tanks (Rs./year)
		Ground Water Tank & Pump	Overhead Tank	Ground Water Tank & Pump	Overhead Tank	Ground Water Tank & Pump	Overhead Tank	TOTAL		
2012	122,511	69.0%	79.0%	1,231	382	104,059,618	36,971,370	141,030,988	5%	7,051,549
2013	125,906	69.0%	79.0%	1,231	382	106,943,297	37,995,913	144,939,210	10%	14,493,921
2014	129,369	69.0%	79.0%	1,231	382	109,884,735	39,040,977	148,925,712	15%	22,338,857
2015	132,898	69.0%	79.0%	1,231	382	112,882,232	40,105,958	152,988,190	20%	30,597,638
2016	136,492	69.0%	79.0%	1,231	382	115,934,940	41,190,556	157,125,496	25%	39,281,374
2017	140,158	69.0%	79.0%	1,231	382	119,048,804	42,296,881	161,345,685	30%	48,403,706
2018	143,895	69.0%	79.0%	1,231	382	122,222,974	43,424,633	165,647,607	35%	57,976,662
2019	143,895	69.0%	79.0%	1,231	382	122,222,974	43,424,633	165,647,607	40%	66,259,043
2020	143,895	69.0%	79.0%	1,231	382	122,222,974	43,424,633	165,647,607	45%	74,541,423
2021	143,895	69.0%	79.0%	1,231	382	122,222,974	43,424,633	165,647,607	50%	82,823,804
2022	143,895	69.0%	79.0%	1,231	382	122,222,974	43,424,633	165,647,607	50%	82,823,804
2023	143,895	69.0%	79.0%	1,231	382	122,222,974	43,424,633	165,647,607	50%	82,823,804
2024	143,895	69.0%	79.0%	1,231	382	122,222,974	43,424,633	165,647,607	50%	82,823,804
2025	143,895	69.0%	79.0%	1,231	382	122,222,974	43,424,633	165,647,607	50%	82,823,804

Table F92.1.5 Total economic benefit with the water supply priority projects by saving cost for bottled water

Year	Total served population	Number of household	Total cost for bottled water (Rs.x1,000)	Total saved amount with the project (Rs.x1,000)
2012	547,626	122,511	429,279	214,640
2013	562,800	125,906	441,175	220,588
2014	578,278	129,369	453,309	226,655
2015	594,052	132,898	465,675	232,838
2016	610,121	136,492	478,268	239,134
2017	626,508	140,158	491,114	245,557
2018	643,212	143,895	504,208	252,104
After 2018	643,212	143,895	504,208	252,104

Table F92.1.6 Economic benefit from reduction of waterborne diseases

Year			2012	2013	2014	2015	2016	2017	2018	After 2018
Population in Salaulim WSS (x 1,000)			642	651	661	671	681	692	702	702
Saving of decrease of medical cost in Goa (Rs.1,000)										
	% in total population	Cost/case								
Dairrhea (out-patients)	3.74%	230	1,657	1,680	1,706	1,732	1,757	1,786	1,812	1,812
Dairrhea (in-patients)	1.05%	2,030	4,105	4,163	4,227	4,291	4,355	4,425	4,489	4,489
Typhoid (out-patients)	0.01%	230	4	4	5	5	5	5	5	5
Typhoid (in-patients)	0.11%	5,030	1,066	1,081	1,097	1,114	1,130	1,149	1,165	1,165
Hepatitis (out-patients)	0.10%	230	44	45	46	46	47	48	48	48
Hepatitis (in-patients)	0.10%	2,030	391	396	403	409	415	421	428	428
Malaria (out-patients)	6.48%	230	2,871	2,911	2,955	3,000	3,045	3,094	3,139	3,139
Malaria (in-patients)	2.78%	2,030	10,869	11,022	11,191	11,360	11,529	11,716	11,885	11,885
Sub-total			21,007	21,302	21,629	21,956	22,283	22,643	22,970	22,970
Savings due to reduction of absence from working (Rs.1,000)										
	absence days	Min. wage								
Dairrhea (out-patients)	1.6	87	702	712	723	734	745	757	767	767
Dairrhea (in-patients)	3.2	87	394	400	406	412	418	425	431	431
Typhoid (out-patients)	4.2	87	5	5	5	5	5	5	5	5
Typhoid (in-patients)	8.3	87	107	109	110	112	114	115	117	117
Hepatitis (out-patients)	7.5	87	88	89	91	92	93	95	96	96
Hepatitis (in-patients)	15.0	87	176	178	181	184	187	190	192	192
Malaria (out-patients)	2.3	87	1,748	1,773	1,800	1,827	1,854	1,884	1,912	1,912
Malaria (in-patients)	4.5	87	1,467	1,488	1,511	1,534	1,556	1,582	1,604	1,604
Sub-total			4,687	4,753	4,826	4,899	4,972	5,052	5,125	5,125
TOTAL			25,694	26,055	26,455	26,855	27,255	27,696	28,096	28,096

Note: For example, economic benefit of ‘Saving of decrease of medical cost in Goa’ is calculated for diarrhea as follows;

Diarrhea, Out-patient: Saved amount = Population x 3.74% x (Ave. cost of out-patient treatment + Ave. cost of transportation to hospital) x 30%

Diarrhea, In-patient: Saved amount = Population x 1.05% x (Ave. cost of in-patient treatment + Ave. cost of transportation to hospital) x 30%

For example, economic benefit of ‘Savings due to reduction of absence from working’ is calculated as follows;

Diarrhea, Out-patient: Saved amount = Population x 3.74% x 3.2(Ave. days of out-patient treatment) x 30% x 87(minimum wage) x 0.7(shadow wage rate)

Diarrhea, In-patient: Saved amount = Population x 1.05% x 1.6(Ave. days of in-patient treatment) x 30% x 87(minimum wage) x 0.7(shadow wage rate)

Table F92.1.7 Financial Costs of Initial Investment, Water Supply Project

Financial Costs

(Unit: Rs. In million)

Item	Total	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
1. Construction cost																				
1) Expansion project																				
(1) Water Treatment Plant	738.01	0.00	0.00	0.00	147.61	369.01	221.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(2) Transmission Main	1,395.20	0.00	0.00	0.00	279.07	837.16	278.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(3) Reservoir	114.75	0.00	0.00	0.00	22.95	68.85	22.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(4) Pumping Station	8.76	0.00	0.00	0.00	1.76	5.27	1.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(5) Distribution Pipe	451.57	0.00	0.00	0.00	0.00	0.00	36.11	36.81	37.55	38.29	39.02	39.81	41.77	44.30	45.17	45.94	46.80	0.00	0.00	0.00
(6) House Connection	95.69	0.00	0.00	0.00	0.00	0.00	7.60	7.74	7.90	8.06	8.21	8.38	9.47	9.32	9.50	9.66	9.85	0.00	0.00	0.00
Sub total	2,803.98	0.00	0.00	0.00	451.39	1,280.29	568.75	44.55	45.45	46.35	47.23	48.19	51.24	53.62	54.67	55.60	56.65	0.00	0.00	0.00
2) Rehabilitation works																				
(1) Water Treatment Plant	362.80	0.00	0.00	0.00	72.71	181.40	108.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(2) Transmission Main	537.86	0.00	0.00	0.00	107.58	322.72	107.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(3) Reservoir	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(4) Pumping Station	54.64	0.00	0.00	0.00	10.93	32.79	10.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(5) Distribution Pipe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(6) House Connection	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sub total	955.30	0.00	0.00	0.00	191.22	536.91	227.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3) Water Quality Control	17.50	0.00	0.00	0.00	0.00	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sub total	17.50	0.00	0.00	0.00	0.00	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4) O&M Improvement																				
(1) Water supply system O&M Improvement	266.06	0.00	0.00	0.00	71.5	71.5	123.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(2) NRW reduction improvements	23.80	0.00	0.00	0.00	23.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sub total	289.86	0.00	0.00	0.00	95.3	71.5	123.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5) Institutional/organizational improvement [*1]	28.23	4.87	4.90	4.92	4.91	4.41	4.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sub total	28.23	4.87	4.90	4.92	4.91	4.41	4.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	4,094.87	4.87	4.90	4.92	742.82	1,910.61	923.20	44.55	45.45	46.35	47.23	48.19	51.24	53.62	54.67	55.60	56.65	0.00	0.00	0.00
2. Engineering cost [*2]	354.82	0.50	70.50	130.50	44.29	71.07	37.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Administration cost [*3]	195.12	0.27	3.77	6.77	39.36	99.08	45.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4. Land acquisition cost [*4]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5. Physical contingency [*5]	464.50	0.56	7.92	14.22	82.65	208.08	100.70	4.46	4.55	4.64	4.72	4.82	5.12	5.36	5.47	5.56	5.67	0.00	0.00	0.00
6. Price contingency (7%) [*6]	2,003.98	0.00	6.10	22.66	204.59	711.36	445.92	24.54	30.29	36.62	43.56	51.27	62.27	73.85	84.79	96.54	109.62	0.00	0.00	0.00
TOTAL minus Price contingency	5,109.31	6.20	87.09	156.41	909.12	2,288.84	1,107.73	49.01	50.00	50.99	51.95	53.01	56.36	58.98	60.14	61.16	62.32	0.00	0.00	0.00
TOTAL minus Price contingency (in million US	112.93	0.14	1.93	3.46	20.10	50.59	24.49	1.08	1.11	1.13	1.15	1.17	1.24	1.30	1.32	1.35	1.37	0.00	0.00	0.00
TOTAL	7,113.29	6.20	93.19	179.07	1,113.71	3,000.20	1,553.65	73.55	80.29	87.61	95.51	104.28	118.63	132.83	144.93	157.70	171.94	0.00	0.00	0.00
TOTAL (in million US$)	157.25	0.14	2.06	3.96	24.62	66.32	34.34	1.63	1.77	1.94	2.11	2.31	2.62	2.94	3.20	3.49	3.80	0.00	0.00	0.00

Notes: *1; 3% of the total direct construction cost. Total amount for each three phase is calculated and allocated equally to every year. Phase 1: 2007-2012, Phase 2: 2013-2018, Phase 3: 2019-2025

*2; 10% of the total construction cost

*3; 5% of the total construction cost and engineering cost

*4; 0.5% of the total of Water Treatment Plant, Transmission Main, Reservior, and Pumping Station.

*5; 10% of Construction cost, Engineering cost, and administration cost.

*6; Excluding minor equipment, construction cost is to be procured in India.

Table M92.1.8 Economic Costs of Initial Investment, Water Supply Project

Economic Costs

(Unit: Rs. In million)

Item	Total	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
1. Construction cost *1																				
1) Expansion project																				
(1) Water Treatment Plant	691.37	0.00	0.00	0.00	138.28	345.69	207.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(2) Transmission Main	1,307.02	0.00	0.00	0.00	261.43	784.25	261.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(3) Reservoir	107.50	0.00	0.00	0.00	21.50	64.50	21.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(4) Pumping Station	8.21	0.00	0.00	0.00	1.65	4.94	1.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(5) Distribution Pipe	423.03	0.00	0.00	0.00	0.00	0.00	33.83	34.48	35.18	35.87	36.55	37.29	39.13	41.50	42.32	43.04	43.84	0.00	0.00	0.00
(6) House Connection	89.64	0.00	0.00	0.00	0.00	0.00	7.12	7.25	7.40	7.55	7.69	7.85	8.87	8.73	8.90	9.05	9.23	0.00	0.00	0.00
Sub total	2,626.77	0.00	0.00	0.00	422.86	1,199.38	532.81	41.73	42.58	43.42	44.24	45.14	48.00	50.23	51.22	52.09	53.07	0.00	0.00	0.00
2) Rehabilitation works																				
(1) Water Treatment Plant	339.87	0.00	0.00	0.00	68.11	169.94	101.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(2) Transmission Main	503.86	0.00	0.00	0.00	100.78	302.32	100.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(3) Reservoir	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(4) Pumping Station	51.19	0.00	0.00	0.00	10.24	30.72	10.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(5) Distribution Pipe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(6) House Connection	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sub total	894.92	0.00	0.00	0.00	179.13	502.98	212.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3) Water Quality Control	16.39	0.00	0.00	0.00	0.00	16.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sub total	16.39	0.00	0.00	0.00	0.00	16.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4) O&M Improvement																				
(1) Water supply system O&M Improvement	257.44	0.82	0.82	0.82	67.80	67.80	116.10	0.82	0.82	0.82	0.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(2) NRW reduction improvements	22.30	0.00	0.00	0.00	22.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sub total	279.74	0.82	0.82	0.82	90.10	67.80	116.10	0.82	0.82	0.82	0.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5) Institutional/organizational improvement	24.68	4.56	4.59	4.14	4.13	3.71	3.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sub total	24.68	4.56	4.59	4.14	4.13	3.71	3.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	3,842.50	5.38	5.41	4.96	696.22	1,790.26	865.27	42.55	43.40	44.24	45.06	45.14	48.00	50.23	51.22	52.09	53.07	0.00	0.00	0.00
2. Engineering cost *2	351.29	0.50	69.80	129.20	43.85	70.36	37.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Administration cost *3	145.79	0.20	2.82	5.06	29.41	74.03	34.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4. Land acquisition cost	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5. Physical contingency	419.39	0.59	7.52	13.42	74.01	186.06	90.29	4.26	4.34	4.42	4.51	4.51	4.80	5.02	5.12	5.21	5.31	0.00	0.00	0.00
TOTAL	4,758.97	6.67	85.55	152.64	843.49	2,120.71	1,027.41	46.81	47.74	48.66	49.57	49.65	52.80	55.25	56.34	57.30	58.38	0.00	0.00	0.00
TOTAL (in million US$)	105.20	0.15	1.89	3.37	18.64	46.88	22.71	1.03	1.06	1.08	1.10	1.10	1.17	1.22	1.25	1.26	1.29	0.00	0.00	0.00

Notes: *1; 20% of each each portion of the project is assumed to be labour cost. 80% of the labour is assumed to be unskilled labours

*2; It is assumed that 10% of the engineering cost is paid to local engineers.

Personel Income tax	10%	
Shadow Exchange Rate	49.90	Rs./US$ (Exchange rate 45.24 Rs./US$)
Shadow Wage Rate for unskilled labour	70%	of market price
Shadow Wage Rate for skilled labour	100%	of market price
Opportunity cost of land	100%	of market price

*3; It is assumed that 80% of the staff are unskilled labour.

Table M92.1.9 Financial and Economic Costs of Operation and Maintenance, Water Supply Project

Financial Costs

(Unit: Rs. In million)

Item	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
1. Electricity																			
WTP	0.00	0.00	0.00	0.00	0.00	0.00	41.78	43.35	44.98	46.69	48.47	37.18	38.61	40.11	41.67	43.31	45.02	46.81	48.69
Others	0.00	0.00	0.00	0.00	0.00	0.00	1.12	1.19	1.25	1.32	1.39	1.47	1.54	1.62	1.70	1.78	1.86	1.94	2.03
Sub-total	0.00	0.00	0.00	0.00	0.00	0.00	42.90	44.54	46.23	48.01	49.86	38.65	40.15	41.73	43.37	45.09	46.88	48.75	50.72
2. Chemical cost	0.00	0.00	0.00	0.00	0.00	0.00	3.51	3.65	3.79	3.93	4.08	2.92	3.03	3.15	3.27	3.40	3.54	3.68	3.83
3. Personnel cost	0.00	0.00	0.00	0.00	0.00	0.00	32.70	32.70	32.70	32.70	32.70	32.70	32.70	32.70	32.70	32.70	32.70	32.70	32.70
4. Maintenance	0.00	0.00	0.00	0.00	0.00	0.00	19.78	20.22	20.68	21.16	21.66	18.57	18.97	19.40	19.84	20.30	20.78	21.28	21.81
5. Administration	0.00	0.00	0.00	0.00	0.00	0.00	2.97	3.03	3.10	3.17	3.25	2.79	2.85	2.91	2.98	3.05	3.12	3.19	3.27
TOTAL	0.00	0.00	0.00	0.00	0.00	0.00	101.86	104.14	106.50	108.97	111.55	95.63	97.70	99.89	102.16	104.54	107.02	109.60	112.33

Economic Costs

(Unit: Rs. In million)

Item	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
1. Electricity																			
WTP	0.00	0.00	0.00	0.00	0.00	0.00	41.78	43.35	44.98	46.69	48.47	37.18	38.61	40.11	41.67	43.31	45.02	46.81	48.69
Others	0.00	0.00	0.00	0.00	0.00	0.00	1.12	1.19	1.25	1.32	1.39	1.47	1.54	1.62	1.70	1.78	1.86	1.94	2.03
Sub-total	0.00	0.00	0.00	0.00	0.00	0.00	42.90	44.54	46.23	48.01	49.86	38.65	40.15	41.73	43.37	45.09	46.88	48.75	50.72
2. Chemical cost	0.00	0.00	0.00	0.00	0.00	0.00	3.51	3.65	3.79	3.93	4.08	2.92	3.03	3.15	3.27	3.40	3.54	3.68	3.83
3. Personnel cost *1	0.00	0.00	0.00	0.00	0.00	0.00	22.37	22.37	22.37	22.37	22.37	22.37	22.37	22.37	22.37	22.37	22.37	22.37	22.37
4. Maintenance	0.00	0.00	0.00	0.00	0.00	0.00	19.78	20.22	20.68	21.16	21.66	18.57	18.97	19.40	19.84	20.30	20.78	21.28	21.81
5. Administration *1	0.00	0.00	0.00	0.00	0.00	0.00	2.22	2.27	2.32	2.37	2.43	2.08	2.13	2.17	2.22	2.28	2.33	2.39	2.44
TOTAL	0.00	0.00	0.00	0.00	0.00	0.00	90.78	93.05	95.39	97.84	100.40	84.59	86.65	88.82	91.07	93.44	95.90	98.47	101.17

Notes: *1; 80% of labour is assumed to be unskilled labours

Personel Income tax	10%	
Shadow Exchange Rate	49.90	Rs./US$
Shadow Wage Rate for unskilled labour	70%	of market price
Shadow Wage Rate for skilled labour	100%	of market price

Table F92.1.10 Financial Benefit of Water Supply Project

Domestic

(Unit: Rs. In million)

Item	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	After 2025
1. Water Charge																				
(1) Water supply volume (m^3/day)	0	0	0	0	0	19,565	23,706	27,941	32,263	36,668	41,165	54,415	58,768	58,088	57,401	56,709	56,010	55,306	54,596	54,596
Water supply volume (m^3/day): Day Av	0	0	0	0	0	16,169	19,592	23,092	26,664	30,304	34,021	44,971	48,569	48,007	47,439	46,867	46,289	45,707	45,121	45,121
(2) NRW ratio	33.7%	33.0%	32.3%	31.7%	31.0%	30.3%	29.7%	29.0%	28.3%	27.7%	27.0%	26.3%	25.7%	25.0%	24.3%	23.7%	23.0%	22.3%	21.7%	21.7%
(3) Billed water volume (m^3/day)	0	0	0	0	0	11,270	13,773	16,395	19,118	21,910	24,835	33,144	36,087	36,005	35,911	35,760	35,643	35,514	35,330	35,330
(4) Unit Price *1	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41
(5) Total water charge billed per year	0.00	0.00	0.00	0.00	0.00	18.14	22.17	26.39	30.77	35.27	39.98	53.35	58.09	57.96	57.80	57.56	57.37	57.17	56.87	56.87
(6) Collection Efficiency	95.6%	95.7%	95.8%	95.9%	96.0%	96.1%	96.2%	96.3%	96.4%	96.5%	96.6%	96.7%	96.8%	96.9%	97.0%	97.1%	97.2%	97.3%	97.4%	97.4%
(7) Total Water Revenue	0.00	0.00	0.00	0.00	0.00	17.43	21.33	25.41	29.66	34.04	38.62	51.59	56.23	56.16	56.07	55.89	55.76	55.63	55.39	55.39
2. Installation Charge																				
(1) Number of new customer	0	0	0	0	12,741	3,330	3,393	3,461	3,528	3,595	3,666	3,737	0	0	0	0	0	0	0	0
(2) Total Installation Revenue *2	0.00	0.00	0.00	0.00	6.37	1.67	1.70	1.73	1.76	1.80	1.83	1.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Meter Rent Charge																				
(1) Number of customer	0	0	0	0	12,741	16,071	19,464	22,925	26,453	30,048	33,714	37,451	37,451	37,451	37,451	37,451	37,451	37,451	37,451	37,451
(2) Total Meter Rent Revenue *3	0.00	0.00	0.00	0.00	2.37	2.99	3.63	4.27	4.93	5.60	6.28	6.98	6.98	6.98	6.98	6.98	6.98	6.98	6.98	6.98
TOTAL REVENUE	0.00	0.00	0.00	0.00	8.74	22.09	26.66	31.41	36.35	41.44	46.73	60.44	63.21	63.14	63.05	62.87	62.74	62.61	62.37	62.37

Note: *1 Unit price:Rs.4.41/m^3 per month
*2 Weighted average installation cost: Rs.500/case
*3 Weighted average meter rent charge: Rs.15.53/case per month

Non-Domestic

(Unit: Rs. In million)

Item	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	After 2025
1. Water Charge																				
(1) Water supply volume (m^3/day)	0	0	0	0	0	11,316	14,092	17,069	20,257	23,667	27,316	37,128	41,232	41,912	42,599	43,291	43,990	44,694	45,404	45,404
(2) NRW ratio	33.7%	33.0%	32.3%	31.7%	31.0%	30.3%	29.7%	29.0%	28.3%	27.7%	27.0%	26.3%	25.7%	25.0%	24.3%	23.7%	23.0%	22.3%	21.7%	21.7%
(3) Billed water volume (m^3/day)	0	0	0	0	0	7,887	9,907	12,119	14,524	17,111	19,941	27,363	30,635	31,434	32,247	33,031	33,872	34,727	35,551	35,551
(4) Unit Price *1	27.49	27.49	27.49	27.49	27.49	27.49	27.49	27.49	27.49	27.49	27.49	27.49	27.49	27.49	27.49	27.49	27.49	27.49	27.49	27.49
(5) Total water charge billed	0.00	0.00	0.00	0.00	0.00	79.14	99.41	121.60	145.73	171.69	200.09	274.56	307.39	315.40	323.56	331.43	339.87	348.45	356.71	356.71
(6) Collection Efficiency	95.6%	95.7%	95.8%	95.9%	96.0%	96.1%	96.2%	96.3%	96.4%	96.5%	96.6%	96.7%	96.8%	96.9%	97.0%	97.1%	97.2%	97.3%	97.4%	97.4%
(7) Total Water Revenue	0.00	0.00	0.00	0.00	0.00	76.05	95.63	117.10	140.48	165.68	193.29	265.50	297.55	305.62	313.85	321.82	330.35	339.04	347.44	347.44
2. Installation Charge																				
(1) Number of new customer	0	0	0	0	670	175	179	182	186	189	193	197	0	0	0	0	0	0	0	0
(2) Total Installation Revenue *2	0.00	0.00	0.00	0.00	1.88	0.49	0.50	0.51	0.52	0.53	0.54	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Meter Rent Charge																				
(1) Number of customer	0	0	0	0	670	845	1,024	1,206	1,392	1,581	1,774	1,971	1,971	1,971	1,971	1,971	1,971	1,971	1,971	1,971
(2) Total Meter Rent Revenue *3	0.00	0.00	0.00	0.00	0.21	0.26	0.32	0.38	0.43	0.49	0.55	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62
TOTAL REVENUE	0.00	0.00	0.00	0.00	2.09	76.80	96.45	117.99	141.43	166.70	194.38	266.67	298.17	306.24	314.47	322.44	330.97	339.66	348.06	348.06

Note: *1 Unit price:Rs.27.49/m^3 per month
*2 Weighted average installation cost: Rs.2,804/case
*3 Weighted average meter rent charge: Rs.26.03/case per month

Table F92.1.11 Cost Benefit Stream of Proposed Water Supply Project: Case 2

Annual tariff increase at: 3.00% for Domestic *1
Annual tariff increase at: 1.50% for Non-Domestic *1

(Unit: Rs.in million)

Year		Cost				Benefit			Balance
		Const-ruction	O&M	Replace-ment	Total	Domestic	Non-domestic	Total	
-5	2007	6.20	0.00		6.20	0.00	0.00	0.00	-6.20
-4	2008	87.09	0.00		87.09	0.00	0.00	0.00	-87.09
-3	2009	156.41	0.00		156.41	0.00	0.00	0.00	-156.41
-2	2010	909.12	0.00		909.12	0.00	0.00	0.00	-909.12
-1	2011	2,288.84	0.00		2,288.84	8.74	2.09	10.83	-2,278.01
0	2012	1,107.73	0.00		1,107.73	24.86	82.67	107.53	-1,000.20
1	2013	49.01	101.86		150.87	30.77	105.35	136.12	-14.75
2	2014	50.00	104.14		154.14	37.23	130.81	168.04	13.90
3	2015	50.99	106.50		157.49	44.23	159.17	203.40	45.91
4	2016	51.95	108.97		160.92	51.77	190.38	242.15	81.23
5	2017	53.01	111.55		164.56	59.95	225.31	285.26	120.70
6	2018	56.36	95.63		151.99	80.21	313.80	394.01	242.02
7	2019	58.98	97.70		156.68	87.05	356.29	443.34	286.66
8	2020	60.14	99.89		160.03	89.37	371.40	460.77	300.74
9	2021	61.16	102.16		163.32	91.66	387.09	478.75	315.43
10	2022	62.32	104.54		166.86	93.92	402.86	496.78	329.92
11	2023		107.02		107.02	96.38	419.78	516.16	409.14
12	2024		109.60		109.60	98.80	437.21	536.01	426.41
13	2025		112.33		112.33	101.19	454.73	555.92	443.59
14	2026		112.33	73.81	186.14	101.19	454.73	555.92	369.78
15	2027		112.33	184.51	296.84	101.19	454.73	555.92	259.08
16	2028		112.33	110.70	223.03	101.19	454.73	555.92	332.89
17	2029		112.33		112.33	101.19	454.73	555.92	443.59
18	2030		112.33		112.33	101.19	454.73	555.92	443.59
19	2031		112.33		112.33	101.19	454.73	555.92	443.59
20	2032		112.33		112.33	101.19	454.73	555.92	443.59
21	2033		112.33		112.33	101.19	454.73	555.92	443.59
22	2034		112.33		112.33	101.19	454.73	555.92	443.59
23	2035		112.33		112.33	101.19	454.73	555.92	443.59
24	2036		112.33		112.33	101.19	454.73	555.92	443.59
25	2037		112.33		112.33	101.19	454.73	555.92	443.59
26	2038		112.33		112.33	101.19	454.73	555.92	443.59
27	2039		112.33		112.33	101.19	454.73	555.92	443.59
28	2040		112.33		112.33	101.19	454.73	555.92	443.59
29	2041		112.33	73.81	186.14	101.19	454.73	555.92	369.78
30	2042		112.33	184.51	296.84	101.19	454.73	555.92	259.08

FIRR: 4.50% NPV: -350 million Rs. B/C: 0.933

Note: *1: Increase ratio excludes the inflation rate.

Table F92.1.12 Financial Benefit of proposed water supply project: Case 2

Domestic

(Unit: Rs. In million)

Item	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	After 2025
1. Water Charge																				
(1) Water supply volume (m^3/day)	0	0	0	0	0	19,565	23,706	27,941	32,263	36,668	41,165	54,415	58,768	58,088	57,401	56,709	56,010	55,306	54,596	54,596
Water supply volume (m^3/day): Day Av	0	0	0	0	0	16,169	19,592	23,092	26,664	30,304	34,021	44,971	48,569	48,007	47,439	46,867	46,289	45,707	45,121	45,121
(2) NRW ratio	33.7%	33.0%	32.3%	31.7%	31.0%	30.3%	29.7%	29.0%	28.3%	27.7%	27.0%	26.3%	25.7%	25.0%	24.3%	23.7%	23.0%	22.3%	21.7%	21.7%
(3) Billed water volume (m^3/day)	0	0	0	0	0	11,270	13,773	16,395	19,118	21,910	24,835	33,144	36,087	36,005	35,911	35,760	35,643	35,514	35,330	35,330
(4) Unit Price *1	4.41	4.54	4.68	4.82	4.96	5.11	5.26	5.42	5.58	5.75	5.92	6.10	6.28	6.47	6.66	6.86	7.07	7.28	7.50	7.50
(5) Total water charge billed per year	0.00	0.00	0.00	0.00	0.00	21.02	26.44	32.43	38.94	45.98	53.66	73.80	82.72	85.03	87.30	89.54	91.98	94.37	96.72	96.72
(6) Collection Efficiency	95.6%	95.7%	95.8%	95.9%	96.0%	96.1%	96.2%	96.3%	96.4%	96.5%	96.6%	96.7%	96.8%	96.9%	97.0%	97.1%	97.2%	97.3%	97.4%	97.4%
(7) Total Water Revenue	0.00	0.00	0.00	0.00	0.00	20.20	25.44	31.23	37.54	44.37	51.84	71.36	80.07	82.39	84.68	86.94	89.40	91.82	94.21	94.21
2. Installation Charge																				
(1) Number of new customer	0	0	0	0	12,741	3,330	3,393	3,461	3,528	3,595	3,666	3,737	0	0	0	0	0	0	0	0
(2) Total Installation Revenue *2	0.00	0.00	0.00	0.00	6.37	1.67	1.70	1.73	1.76	1.80	1.83	1.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Meter Rent Charge																				
(1) Number of customer	0	0	0	0	12,741	16,071	19,464	22,925	26,453	30,048	33,714	37,451	37,451	37,451	37,451	37,451	37,451	37,451	37,451	37,451
(2) Total Meter Rent Revenue *3	0.00	0.00	0.00	0.00	2.37	2.99	3.63	4.27	4.93	5.60	6.28	6.98	6.98	6.98	6.98	6.98	6.98	6.98	6.98	6.98
TOTAL REVENUE	0.00	0.00	0.00	0.00	8.74	24.86	30.77	37.23	44.23	51.77	59.95	80.21	87.05	89.37	91.66	93.92	96.38	98.80	101.19	101.19

Note: *1 Unit price:Rs.4.41/m^3 per month Tariff is assumed to be raised at 3.00% annually over the inflation rate.

*2 Weighted average installation cost: Rs.500/case

*3 Weighted average meter rent charge: Rs.15.53/case per month

Non-Domestic

(Unit: Rs. In million)

Item	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	After 2025
1. Water Charge																				
(1) Water supply volume (m^3/day)	0	0	0	0	0	11,316	14,092	17,069	20,257	23,667	27,316	37,128	41,232	41,912	42,599	43,291	43,990	44,694	45,404	45,404
(2) NRW ratio	33.7%	33.0%	32.3%	31.7%	31.0%	30.3%	29.7%	29.0%	28.3%	27.7%	27.0%	26.3%	25.7%	25.0%	24.3%	23.7%	23.0%	22.3%	21.7%	21.7%
(3) Billed water volume (m^3/day)	0	0	0	0	0	7,887	9,907	12,119	14,524	17,111	19,941	27,363	30,635	31,434	32,247	33,031	33,872	34,727	35,551	35,551
(4) Unit Price *1	27.49	27.90	28.32	28.74	29.17	29.61	30.05	30.50	30.96	31.42	31.89	32.37	32.86	33.35	33.85	34.36	34.88	35.40	35.93	35.93
(5) Total water charge billed	0.00	0.00	0.00	0.00	0.00	85.24	108.66	134.91	164.13	196.23	232.11	323.30	367.43	382.64	398.42	414.25	431.23	448.71	466.23	466.23
(6) Collection Efficiency	95.6%	95.7%	95.8%	95.9%	96.0%	96.1%	96.2%	96.3%	96.4%	96.5%	96.6%	96.7%	96.8%	96.9%	97.0%	97.1%	97.2%	97.3%	97.4%	97.4%
(7) Total Water Revenue	0.00	0.00	0.00	0.00	0.00	81.92	104.53	129.92	158.22	189.36	224.22	312.63	355.67	370.78	386.47	402.24	419.16	436.59	454.11	454.11
2. Installation Charge																				
(1) Number of new customer	0	0	0	0	670	175	179	182	186	189	193	197	0	0	0	0	0	0	0	0
(2) Total Installation Revenue *2	0.00	0.00	0.00	0.00	1.88	0.49	0.50	0.51	0.52	0.53	0.54	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Meter Rent Charge																				
(1) Number of customer	0	0	0	0	670	845	1,024	1,206	1,392	1,581	1,774	1,971	1,971	1,971	1,971	1,971	1,971	1,971	1,971	1,971
(2) Total Meter Rent Revenue *3	0.00	0.00	0.00	0.00	0.21	0.26	0.32	0.38	0.43	0.49	0.55	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62
TOTAL REVENUE	0.00	0.00	0.00	0.00	2.09	82.67	105.35	130.81	159.17	190.38	225.31	313.80	356.29	371.40	387.09	402.86	419.78	437.21	454.73	454.73

Note: *1 Unit price:Rs.27.49/m^3 per month Tariff is assumed to be raised at 1.50% annually over the inflation rate.

*2 Weighted average installation cost: Rs.2,804/case

*3 Weighted average meter rent charge: Rs.26.03/case per month

Table F92.1.13 Cost Benefit Stream of Proposed Water Supply Project: Case 3

Annual tariff increase at: 3.50% for Domestic *1
Annual tariff increase at: 2.00% for Non-Domestic *1

(Unit: Rs.in million)

Year		Cost				Benefit			Balance
		Const-ruction	O&M	Replace-ment	Total	Domestic	Non-domestic	Total	
-5	2007	6.20	0.00		6.20	0.00	0.00	0.00	-6.20
-4	2008	87.09	0.00		87.09	0.00	0.00	0.00	-87.09
-3	2009	156.41	0.00		156.41	0.00	0.00	0.00	-156.41
-2	2010	909.12	0.00		909.12	0.00	0.00	0.00	-909.12
-1	2011	2,288.84	0.00		2,288.84	8.74	2.09	10.83	-2,278.01
0	2012	1,107.73	0.00		1,107.73	25.38	84.71	110.09	-997.64
1	2013	49.01	101.86		150.87	31.54	108.52	140.06	-10.81
2	2014	50.00	104.14		154.14	38.33	135.41	173.74	19.60
3	2015	50.99	106.50		157.49	45.77	165.55	211.32	53.83
4	2016	51.95	108.97		160.92	53.78	199.01	252.79	91.87
5	2017	53.01	111.55		164.56	62.57	236.70	299.27	134.71
6	2018	56.36	95.63		151.99	84.19	331.27	415.46	263.47
7	2019	58.98	97.70		156.68	92.03	377.95	469.98	313.30
8	2020	60.14	99.89		160.03	94.85	395.96	490.81	330.78
9	2021	61.16	102.16		163.32	97.76	414.71	512.47	349.15
10	2022	62.32	104.54		166.86	100.64	433.76	534.40	367.54
11	2023		107.02		107.02	103.71	454.15	557.86	450.84
12	2024		109.60		109.60	106.87	475.32	582.19	472.59
13	2025		112.33		112.33	109.97	496.81	606.78	494.45
14	2026		112.33	73.81	186.14	109.97	496.81	606.78	420.64
15	2027		112.33	184.51	296.84	109.97	496.81	606.78	309.94
16	2028		112.33	110.70	223.03	109.97	496.81	606.78	383.75
17	2029		112.33		112.33	109.97	496.81	606.78	494.45
18	2030		112.33		112.33	109.97	496.81	606.78	494.45
19	2031		112.33		112.33	109.97	496.81	606.78	494.45
20	2032		112.33		112.33	109.97	496.81	606.78	494.45
21	2033		112.33		112.33	109.97	496.81	606.78	494.45
22	2034		112.33		112.33	109.97	496.81	606.78	494.45
23	2035		112.33		112.33	109.97	496.81	606.78	494.45
24	2036		112.33		112.33	109.97	496.81	606.78	494.45
25	2037		112.33		112.33	109.97	496.81	606.78	494.45
26	2038		112.33		112.33	109.97	496.81	606.78	494.45
27	2039		112.33		112.33	109.97	496.81	606.78	494.45
28	2040		112.33		112.33	109.97	496.81	606.78	494.45
29	2041		112.33	73.81	186.14	109.97	496.81	606.78	420.64
30	2042		112.33	184.51	296.84	109.97	496.81	606.78	309.94

FIRR: 5.20% NPV: 26 million Rs. B/C: 1.005

Note: *1: Increase ratio excludes the inflation rate.

Table F92.1.14 Financial Benefit of proposed water supply project: Case 3

Domestic (Unit: Rs. In million)

Item	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	After 2025
1. Water Charge																				
(1) Water supply volume (m^3/day)	0	0	0	0	0	19,565	23,706	27,941	32,263	36,668	41,165	54,415	58,768	58,088	57,401	56,709	56,010	55,306	54,596	54,596
Water supply volume (m^3/day): Day Av	0	0	0	0	0	16,169	19,592	23,092	26,664	30,304	34,021	44,971	48,569	48,007	47,439	46,867	46,289	45,707	45,121	45,121
(2) NRW ratio	33.7%	33.0%	32.3%	31.7%	31.0%	30.3%	29.7%	29.0%	28.3%	27.7%	27.0%	26.3%	25.7%	25.0%	24.3%	23.7%	23.0%	22.3%	21.7%	21.7%
(3) Billed water volume (m^3/day)	0	0	0	0	0	11,270	13,773	16,395	19,118	21,910	24,835	33,144	36,087	36,005	35,911	35,760	35,643	35,514	35,330	35,330
(4) Unit Price *1	4.41	4.56	4.72	4.89	5.06	5.24	5.42	5.61	5.81	6.01	6.22	6.44	6.67	6.90	7.14	7.39	7.65	7.92	8.20	8.20
(5) Total water charge billed per year	0.00	0.00	0.00	0.00	0.00	21.56	27.25	33.57	40.54	48.06	56.38	77.91	87.86	90.68	93.59	96.46	99.52	102.66	105.74	105.74
(6) Collection Efficiency	95.6%	95.7%	95.8%	95.9%	96.0%	96.1%	96.2%	96.3%	96.4%	96.5%	96.6%	96.7%	96.8%	96.9%	97.0%	97.1%	97.2%	97.3%	97.4%	97.4%
(7) Total Water Revenue	0.00	0.00	0.00	0.00	0.00	20.72	26.21	32.33	39.08	46.38	54.46	75.34	85.05	87.87	90.78	93.66	96.73	99.89	102.99	102.99
2. Installation Charge																				
(1) Number of new customer	0	0	0	0	12,741	3,330	3,393	3,461	3,528	3,595	3,666	3,737	0	0	0	0	0	0	0	0
(2) Total Installation Revenue *2	0.00	0.00	0.00	0.00	6.37	1.67	1.70	1.73	1.76	1.80	1.83	1.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Meter Rent Charge																				
(1) Number of customer	0	0	0	0	12,741	16,071	19,464	22,925	26,453	30,048	33,714	37,451	37,451	37,451	37,451	37,451	37,451	37,451	37,451	37,451
(2) Total Meter Rent Revenue *3	0.00	0.00	0.00	0.00	2.37	2.99	3.63	4.27	4.93	5.60	6.28	6.98	6.98	6.98	6.98	6.98	6.98	6.98	6.98	6.98
TOTAL REVENUE	0.00	0.00	0.00	0.00	8.74	25.38	31.54	38.33	45.77	53.78	62.57	84.19	92.03	94.85	97.76	100.64	103.71	106.87	109.97	109.97

Note: *1 Unit price:Rs.4.41/m^3 per month Tariff is assumed to be raised at 3.50% annually over the inflation rate.
*2 Weighted average installation cost: Rs.500/case
*3 Weighted average meter rent charge: Rs.15.53/case per month

Non-Domestic (Unit: Rs. In million)

Item	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	After 2025
1. Water Charge																				
(1) Water supply volume (m^3/day)	0	0	0	0	0	11,316	14,092	17,069	20,257	23,667	27,316	37,128	41,232	41,912	42,599	43,291	43,990	44,694	45,404	45,404
(2) NRW ratio	33.7%	33.0%	32.3%	31.7%	31.0%	30.3%	29.7%	29.0%	28.3%	27.7%	27.0%	26.3%	25.7%	25.0%	24.3%	23.7%	23.0%	22.3%	21.7%	21.7%
(3) Billed water volume (m^3/day)	0	0	0	0	0	7,887	9,907	12,119	14,524	17,111	19,941	27,363	30,635	31,434	32,247	33,031	33,872	34,727	35,551	35,551
(4) Unit Price *1	27.49	28.04	28.60	29.17	29.75	30.35	30.96	31.58	32.21	32.85	33.51	34.18	34.86	35.56	36.27	37.00	37.74	38.49	39.26	39.26
(5) Total water charge billed	0.00	0.00	0.00	0.00	0.00	87.37	111.95	139.69	170.75	205.17	243.90	341.37	389.80	407.99	426.90	446.08	466.59	487.87	509.44	509.44
(6) Collection Efficiency	95.6%	95.7%	95.8%	95.9%	96.0%	96.1%	96.2%	96.3%	96.4%	96.5%	96.6%	96.7%	96.8%	96.9%	97.0%	97.1%	97.2%	97.3%	97.4%	97.4%
(7) Total Water Revenue	0.00	0.00	0.00	0.00	0.00	83.96	107.70	134.52	164.60	197.99	235.61	330.10	377.33	395.34	414.09	433.14	453.53	474.70	496.19	496.19
2. Installation Charge																				
(1) Number of new customer	0	0	0	0	670	175	179	182	186	189	193	197	0	0	0	0	0	0	0	0
(2) Total Installation Revenue *2	0.00	0.00	0.00	0.00	1.88	0.49	0.50	0.51	0.52	0.53	0.54	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Meter Rent Charge																				
(1) Number of customer	0	0	0	0	670	845	1,024	1,206	1,392	1,581	1,774	1,971	1,971	1,971	1,971	1,971	1,971	1,971	1,971	1,971
(2) Total Meter Rent Revenue *3	0.00	0.00	0.00	0.00	0.21	0.26	0.32	0.38	0.43	0.49	0.55	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62
TOTAL REVENUE	0.00	0.00	0.00	0.00	2.09	84.71	108.52	135.41	165.55	199.01	236.70	331.27	377.95	395.96	414.71	433.76	454.15	475.32	496.81	496.81

Note: *1 Unit price:Rs.27.49/m^3 per month Tariff is assumed to be raised at 2.00% annually over the inflation rate.
*2 Weighted average installation cost: Rs.2,804/case
*3 Weighted average meter rent charge: Rs.26.03/case per month

Table F92.1.15 Cost Benefit Stream of Proposed Water Supply Project: Case 4

Annual tariff increase at: 4.00% for Domestic *1
Annual tariff increase at: 2.50% for Non-Domestic *1

(Unit: Rs.in million)

Year		Cost				Benefit			Balance
		Construction	O&M	Replacement	Total	Domestic	Non-domestic	Total	
-5	2007	6.20	0.00		6.20	0.00	0.00	0.00	-6.20
-4	2008	87.09	0.00		87.09	0.00	0.00	0.00	-87.09
-3	2009	156.41	0.00		156.41	0.00	0.00	0.00	-156.41
-2	2010	909.12	0.00		909.12	0.00	0.00	0.00	-909.12
-1	2011	2,288.84	0.00		2,288.84	8.74	2.09	10.83	-2,278.01
0	2012	1,107.73	0.00		1,107.73	25.89	86.79	112.68	-995.05
1	2013	49.01	101.86		150.87	32.31	111.72	144.03	-6.84
2	2014	50.00	104.14		154.14	39.43	140.10	179.53	25.39
3	2015	50.99	106.50		157.49	47.26	172.15	219.41	61.92
4	2016	51.95	108.97		160.92	55.79	207.98	263.77	102.85
5	2017	53.01	111.55		164.56	65.20	248.58	313.78	149.22
6	2018	56.36	95.63		151.99	88.16	349.63	437.79	285.80
7	2019	58.98	97.70		156.68	96.87	400.89	497.76	341.08
8	2020	60.14	99.89		160.03	100.32	421.98	522.30	362.27
9	2021	61.16	102.16		163.32	103.86	444.17	548.03	384.71
10	2022	62.32	104.54		166.86	107.36	466.78	574.14	407.28
11	2023		107.02		107.02	111.18	491.16	602.34	495.32
12	2024		109.60		109.60	115.07	516.64	631.71	522.11
13	2025		112.33		112.33	118.89	542.70	661.59	549.26
14	2026		112.33	73.81	186.14	118.89	542.70	661.59	475.45
15	2027		112.33	184.51	296.84	118.89	542.70	661.59	364.75
16	2028		112.33	110.70	223.03	118.89	542.70	661.59	438.56
17	2029		112.33		112.33	118.89	542.70	661.59	549.26
18	2030		112.33		112.33	118.89	542.70	661.59	549.26
19	2031		112.33		112.33	118.89	542.70	661.59	549.26
20	2032		112.33		112.33	118.89	542.70	661.59	549.26
21	2033		112.33		112.33	118.89	542.70	661.59	549.26
22	2034		112.33		112.33	118.89	542.70	661.59	549.26
23	2035		112.33		112.33	118.89	542.70	661.59	549.26
24	2036		112.33		112.33	118.89	542.70	661.59	549.26
25	2037		112.33		112.33	118.89	542.70	661.59	549.26
26	2038		112.33		112.33	118.89	542.70	661.59	549.26
27	2039		112.33		112.33	118.89	542.70	661.59	549.26
28	2040		112.33		112.33	118.89	542.70	661.59	549.26
29	2041		112.33	73.81	186.14	118.89	542.70	661.59	475.45
30	2042		112.33	184.51	296.84	118.89	542.70	661.59	364.75

FIRR: 5.88% NPV: 427 million Rs. B/C: 1.081

Note: *1: Increase ratio excludes the inflation rate.

Table F92.1.16 Financial Benefit of proposed water supply project: Case 4

Domestic (Unit: Rs. In million)

Item	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	After 2025
1. Water Charge																				
(1) Water supply volume (m^3/day)	0	0	0	0	0	19,565	23,706	27,941	32,263	36,668	41,165	54,415	58,768	58,088	57,401	56,709	56,010	55,306	54,596	54,596
Water supply volume (m^3/day): Day Av	0	0	0	0	0	16,169	19,592	23,092	26,664	30,304	34,021	44,971	48,569	48,007	47,439	46,867	46,289	45,707	45,121	45,121
(2) NRW ratio	33.7%	33.0%	32.3%	31.7%	31.0%	30.3%	29.7%	29.0%	28.3%	27.7%	27.0%	26.3%	25.7%	25.0%	24.3%	23.7%	23.0%	22.3%	21.7%	21.7%
(3) Billed water volume (m^3/day)	0	0	0	0	0	11,270	13,773	16,395	19,118	21,910	24,835	33,144	36,087	36,005	35,911	35,760	35,643	35,514	35,330	35,330
(4) Unit Price *1	4.41	4.59	4.77	4.96	5.16	5.37	5.58	5.80	6.03	6.27	6.52	6.78	7.05	7.33	7.62	7.92	8.24	8.57	8.91	8.91
(5) Total water charge billed per year	0.00	0.00	0.00	0.00	0.00	22.09	28.05	34.71	42.08	50.14	59.10	82.02	92.86	96.33	99.88	103.38	107.20	111.09	114.90	114.90
(6) Collection Efficiency	95.6%	95.7%	95.8%	95.9%	96.0%	96.1%	96.2%	96.3%	96.4%	96.5%	96.6%	96.7%	96.8%	96.9%	97.0%	97.1%	97.2%	97.3%	97.4%	97.4%
(7) Total Water Revenue	0.00	0.00	0.00	0.00	0.00	21.23	26.98	33.43	40.57	48.39	57.09	79.31	89.89	93.34	96.88	100.38	104.20	108.09	111.91	111.91
2. Installation Charge																				
(1) Number of new customer	0	0	0	0	12,741	3,330	3,393	3,461	3,528	3,595	3,666	3,737	0	0	0	0	0	0	0	0
(2) Total Installation Revenue *2	0.00	0.00	0.00	0.00	6.37	1.67	1.70	1.73	1.76	1.80	1.83	1.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Meter Rent Charge																				
(1) Number of customer	0	0	0	0	12,741	16,071	19,464	22,925	26,453	30,048	33,714	37,451	37,451	37,451	37,451	37,451	37,451	37,451	37,451	37,451
(2) Total Meter Rent Revenue *3	0.00	0.00	0.00	0.00	2.37	2.99	3.63	4.27	4.93	5.60	6.28	6.98	6.98	6.98	6.98	6.98	6.98	6.98	6.98	6.98
TOTAL REVENUE	0.00	0.00	0.00	0.00	8.74	25.89	32.31	39.43	47.26	55.79	65.20	88.16	96.87	100.32	103.86	107.36	111.18	115.07	118.89	118.89

Note: *1 Unit price:Rs.4.41/m^3 per month Tariff is assumed to be raised at 4.00% annually over the inflation rate.
*2 Weighted average installation cost: Rs.500/case
*3 Weighted average meter rent charge: Rs.15.53/case per month

Non-Domestic (Unit: Rs. In million)

Item	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	After 2025
1. Water Charge																				
(1) Water supply volume (m^3/day)	0	0	0	0	0	11,316	14,092	17,069	20,257	23,667	27,316	37,128	41,232	41,912	42,599	43,291	43,990	44,694	45,404	45,404
(2) NRW ratio	33.7%	33.0%	32.3%	31.7%	31.0%	30.3%	29.7%	29.0%	28.3%	27.7%	27.0%	26.3%	25.7%	25.0%	24.3%	23.7%	23.0%	22.3%	21.7%	21.7%
(3) Billed water volume (m^3/day)	0	0	0	0	0	7,887	9,907	12,119	14,524	17,111	19,941	27,363	30,635	31,434	32,247	33,031	33,872	34,727	35,551	35,551
(4) Unit Price *1	27.49	28.18	28.88	29.60	30.34	31.10	31.88	32.68	33.50	34.34	35.20	36.08	36.98	37.90	38.85	39.82	40.82	41.84	42.89	42.89
(5) Total water charge billed	0.00	0.00	0.00	0.00	0.00	89.53	115.28	144.56	177.59	214.47	256.20	360.35	413.50	434.84	457.27	480.08	504.67	530.34	556.55	556.55
(6) Collection Efficiency	95.6%	95.7%	95.8%	95.9%	96.0%	96.1%	96.2%	96.3%	96.4%	96.5%	96.6%	96.7%	96.8%	96.9%	97.0%	97.1%	97.2%	97.3%	97.4%	97.4%
(7) Total Water Revenue	0.00	0.00	0.00	0.00	0.00	86.04	110.90	139.21	171.20	206.96	247.49	348.46	400.27	421.36	443.55	466.16	490.54	516.02	542.08	542.08
2. Installation Charge																				
(1) Number of new customer	0	0	0	0	670	175	179	182	186	189	193	197	0	0	0	0	0	0	0	0
(2) Total Installation Revenue *2	0.00	0.00	0.00	0.00	1.88	0.49	0.50	0.51	0.52	0.53	0.54	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Meter Rent Charge																				
(1) Number of customer	0	0	0	0	670	845	1,024	1,206	1,392	1,581	1,774	1,971	1,971	1,971	1,971	1,971	1,971	1,971	1,971	1,971
(2) Total Meter Rent Revenue *3	0.00	0.00	0.00	0.00	0.21	0.26	0.32	0.38	0.43	0.49	0.55	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62
TOTAL REVENUE	0.00	0.00	0.00	0.00	2.09	86.79	111.72	140.10	172.15	207.98	248.58	349.63	400.89	421.98	444.17	466.78	491.16	516.64	542.70	542.70

Note: *1 Unit price:Rs.27.49/m^3 per month Tariff is assumed to be raised at 2.50% annually over the inflation rate.
*2 Weighted average installation cost: Rs.2,804/case
*3 Weighted average meter rent charge: Rs.26.03/case per month

Appendix F93

Economic and Financial Evaluation of Priority Projects for Sewerage

Contents for Appendix F93

Appendix F93.1.1 Economic and Financial Evaluation of Priority Projects for Sewerage

Table F93.1 Excess sewage flow from connected customers over the existing treatment capacity (2007 - 2025)

(m^3/day)

Year			2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Margao	Sewage Flow	Average	2,067	2,811	3,582	4,545	5,707	6,678	7,732	8,835	9,955	10,684	11,415	12,149	12,885	13,625	14,367	15,112	15,860	16,612	17,366
	Capacity		7,500	7,500	7,500	7,500	7,500	7,500	14,200	14,200	14,200	14,200	14,200	14,200	14,200	14,200	14,200	14,200	14,200	14,200	14,200
	Ex. sewage flow		0	0	0	0	0	0	232	1,335	2,455	3,184	3,915	4,649	5,385	6,125	6,867	7,612	8,360	9,112	9,866
Mapsa	Sewage Flow	Average	0	0	0	0	0	0	661	1,488	2,479	3,240	3,934	4,528	5,123	5,718	6,313	6,908	7,503	8,098	8,693
	Capacity		0	0	0	0	0	0	5,400	5,400	5,400	5,400	5,400	5,400	5,400	5,400	5,400	5,400	5,400	5,400	5,400
	Ex. sewage flow		0	0	0	0	0	0	661	1,488	2,479	3,240	3,934	4,528	5,123	5,718	6,313	6,908	7,503	8,098	8,693
Calangute & Candolim	Sewage Flow	Average	0	0	0	0	0	0	546	1,229	2,048	2,676	3,249	3,741	4,232	4,724	5,215	5,707	6,198	6,690	7,181
	Capacity		0	0	0	0	0	0	5,600	5,600	5,600	5,600	5,600	5,600	5,600	5,600	5,600	5,600	5,600	5,600	5,600
	Ex. sewage flow		0	0	0	0	0	0	546	1,229	2,048	2,676	3,249	3,741	4,232	4,724	5,215	5,707	6,198	6,690	7,181
TOTAL	Sewage Flow	Average	2,067	2,811	3,582	4,545	5,707	6,678	8,939	11,551	14,482	16,599	18,598	20,418	22,241	24,067	25,896	27,727	29,562	31,399	33,240
	Capacity	Existing	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500
	Ex. sewage flow		**0**	**0**	**0**	**0**	**0**	**0**	**1,439**	**4,051**	**6,982**	**9,099**	**11,098**	**12,918**	**14,741**	**16,567**	**18,396**	**20,227**	**22,062**	**23,899**	**25,740**
	Capacity	Expansion	0	0	0	0	0	0	17,700	17,700	17,700	17,700	17,700	17,700	17,700	17,700	17,700	17,700	17,700	17,700	17,700
	Additional served population		0	0	0	960	1,920	2,880	9,990	11,863	13,544	11,189	10,517	9,508	9,508	9,508	9,508	9,508	9,508	9,508	9,508
	Additional served connections		0	0	0	210	419	629	2,181	2,590	2,957	2,443	2,296	2,076	2,076	2,076	2,076	2,076	2,076	2,076	2,076

Note: Ex. sewage flow' indicates the excess sewage flow from only the customers who are expected to connect over present capacity, which will be treated by master plan for sanitation

Table F93.1.2 Excess sewage flow from connected customers over the existing treatment capacity (2026 - 2042)

(m^3/day)

Year			2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Margao	Sewage Flow	Average	18,627	19,354	19,617	19,915	20,211	20,211	20,211	20,211	20,211	20,211	20,211	20,211	20,211	20,211	20,211	20,211	20,211
	Capacity		14,200	14,200	14,200	14,200	14,200	14,200	14,200	14,200	14,200	14,200	14,200	14,200	14,200	14,200	14,200	14,200	14,200
	Ex. sewage flow		11,127	11,854	12,117	12,415	12,711	12,711	12,711	12,711	12,711	12,711	12,711	12,711	12,711	12,711	12,711	12,711	12,711
Mapsa	Sewage Flow	Average	9,198	9,717	9,982	10,281	10,580	10,580	10,580	10,580	10,580	10,580	10,580	10,580	10,580	10,580	10,580	10,580	10,580
	Capacity		5,400	5,400	5,400	5,400	5,400	5,400	5,400	5,400	5,400	5,400	5,400	5,400	5,400	5,400	5,400	5,400	5,400
	Ex. sewage flow		9,198	9,717	9,982	10,281	10,580	10,580	10,580	10,580	10,580	10,580	10,580	10,580	10,580	10,580	10,580	10,580	10,580
Calangute & Candolim	Sewage Flow	Average	7,673	8,028	8,246	8,478	8,737	8,737	8,737	8,737	8,737	8,737	8,737	8,737	8,737	8,737	8,737	8,737	8,737
	Capacity		5,600	5,600	5,600	5,600	5,600	5,600	5,600	5,600	5,600	5,600	5,600	5,600	5,600	5,600	5,600	5,600	5,600
	Ex. sewage flow		7,673	8,028	8,246	8,478	8,737	8,737	8,737	8,737	8,737	8,737	8,737	8,737	8,737	8,737	8,737	8,737	8,737
TOTAL	Sewage Flow	Average	35,498	37,099	37,845	38,674	39,528	39,528	39,528	39,528	39,528	39,528	39,528	39,528	39,528	39,528	39,528	39,528	39,528
	Capacity	Existing	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500
	Ex. sewage flow		**27,998**	**29,599**	**30,345**	**31,174**	**32,028**	**32,028**	**32,028**	**32,028**	**32,028**	**32,028**	**32,028**	**32,028**	**32,028**	**32,028**	**32,028**	**32,028**	**32,028**
	Capacity	Expansion	17,700	17,700	17,700	17,700	17,700	17,700	17,700	17,700	17,700	17,700	17,700	17,700	17,700	17,700	17,700	17,700	17,700
	Additional served population		9,508	6,867	4,226	1,585	528	0	0	0	0	0	0	0	0	0	0	0	0
	Additional served connections		2,076	1,499	923	346	115	0	0	0	0	0	0	0	0	0	0	0	0

Note: Ex. sewage flow' indicates the excess sewage flow from only the customers who are expected to connect over present capacity, which will be treated by master plan for sanitation

Table F93.1.3 Sewage flow for each category of customer treated by priority projects for sewerage

(Unit: m^3/day)

Year			2007	%	2008	%	2009	%	2010	%	2011	%	2012	%	2013	%	2014	%	2015	%
Excess Sewerage Flow Treated by Proposed Project	Sewage Flow TOTAL	Total	0	100.0%	0	100.0%	0	100.0%	0	100.0%	0	100.0%	0	100.0%	1,439	100.0%	4,051	100.0%	6,982	100.0%
		D&I	0	85.0%	0	84.7%	0	84.3%	0	84.0%	0	83.6%	0	83.4%	1,195.3	83.1%	3,353.6	82.8%	5,759.8	82.5%
		T	0	12.5%	0	12.8%	0	13.1%	0	13.3%	0	13.6%	0	13.8%	202.2	14.0%	577.8	14.3%	1,009.9	14.5%
		I&D	0	2.5%	0	2.5%	0	2.6%	0	2.7%	0	2.8%	0	2.8%	41.5	2.9%	119.6	3.0%	212.3	3.0%
	Number of new connections	Total	0		0		0		210		419		629		2,181		2,590		2,957	
		Domestic	0		0		0		200	95.0%	398	95.0%	598	95.0%	2,072	95.0%	2,461	95.0%	2,809	95.0%
		Non-Dom	0		0		0		10	5.0%	21	5.0%	31	5.0%	109	5.0%	130	5.0%	148	5.0%

D&I:Domestic and Institutional Sewage including groundwater
T: Tourism sewage
I & D: Industry & Defence sewage

(Unit: m^3/day)

Year			2016	%	2017	%	2018	%	2019	%	2020	%	2021	%	2022	%	2023	%	2024	%	2025	%
Excess Sewerage Flow Treated by Proposed Project	Sewage Flow	Total	9,099	100.0%	11,098	100.0%	12,918	100.0%	14,741	100.0%	16,567	100.0%	17,700	100.0%	17,700	100.0%	17,700	100.0%	17,700	100.0%	17,700	100.0%
		D&I	7,474.1	82.1%	9,081.9	81.8%	10,529.8	81.5%	11,970.6	81.2%	13,400.8	80.9%	14,247.3	80.5%	14,180.8	80.1%	14,117.4	79.8%	14,056.9	79.4%	13,999.2	79.1%
		T	1,338.2	14.7%	1,658.4	14.9%	1,958.9	15.2%	2,266.3	15.4%	2,579.6	15.6%	2,798.5	15.8%	2,839.0	16.0%	2,877.5	16.3%	2,914.3	16.5%	2,949.4	16.7%
		I&D	286.6	3.2%	357.7	3.2%	429.3	3.3%	504.1	3.4%	586.7	3.5%	654.2	3.7%	680.3	3.8%	705.1	4.0%	728.8	4.1%	751.4	4.2%
	Number of new connections	Total	2,443		2,296		2,076		2,076		2,076		2,076		2,076		2,076		2,076		2,076	
		Domestic	2,321	95.0%	2,181	95.0%	1,972	95.0%	1,972	95.0%	1,972	95.0%	1,972	95.0%	1,972	95.0%	1,972	95.0%	1,972	95.0%	1,972	95.0%
		Non-Dom	122	5.0%	115	5.0%	104	5.0%	104	5.0%	104	5.0%	104	5.0%	104	5.0%	104	5.0%	104	5.0%	104	5.0%

D&I:Domestic and Institutional Sewage including groundwater
T: Tourism sewage
I & D: Industry & Defence sewage

Table F93.1.4 Number of tourists staying in the sewerage priority project areas and amount of economic benefit

Average number of tourists staying in sewerage project areas

(Person:x1,000)

		% of staying tourists	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Total number of Tourists in Goa	Domestic		1650	1721	1795	1873	1954	2038	2127	2219	2315	2415	2519	2628	2742	2860
	Foreign		398	413	428	442	457	472	487	502	517	532	547	561	576	591
Margao	Domestic	*1 1.2%	20	21	22	23	24	25	26	27	28	30	31	32	34	35
	Foreign	*1 1.9%	8	8	8	8	9	9	9	10	10	10	11	11	11	11
Mapsa	Domestic	1.2%	20	21	22	22	23	24	26	27	28	29	30	32	33	34
	Foreign	2.2%	9	9	9	10	10	10	11	11	11	12	12	12	13	13
Calangute, North Coastal	Domestic	8.6%	142	148	154	161	168	175	183	191	199	208	217	226	236	246
	Foreign	15.7%	62	65	67	69	72	74	76	79	81	84	86	88	90	93
Total	**Domestic**	**11.0%**	**182**	**190**	**198**	**206**	**215**	**224**	**235**	**245**	**255**	**267**	**278**	**290**	**303**	**315**
	Foreign	**19.8%**	**79**	**82**	**84**	**87**	**91**	**93**	**96**	**100**	**102**	**106**	**109**	**111**	**114**	**117**

Note: *1; Regarding Margao, it is assumed that tourists in new sewerage service area is 30% of the total tourists staying in each of the city.

Benefit of water environment preservation perceived of the staying tourists

		Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Total number of staying tourists	Domestic	persons x 1,000	182	190	198	206	215	224	235	245	255	267	278	290	303	315
	Foreign		79	82	84	87	91	93	96	100	102	106	109	111	114	117
Total benefit of tourists expressed by WTP	Domestic	Rs.x1,000	0	0	0	0	0	10,080	10,575	11,025	11,475	12,015	12,510	13,050	13,635	14,175
	Foreign		0	0	0	0	0	100,440	103,680	108,000	110,160	114,480	117,720	119,880	123,120	126,360

Table F93.1.5 Number of tourists to Bardez taluka and amount of economic benefit derived from day trip tourists

(Unit: x1,000)

Year	Domestic	Foreign	Total	Bardez		Benefit of water environment preservation of the day trip tourists (Rs.x1,000)		
				Domestic	Foreign	Domestic	Foreign	Total
2005	1,453	353	1,806	302	135	0	0	0
2006	1,516	368	1,884	315	141	0	0	0
2007	1,581	383	1,964	329	146	0	0	0
2008	1,650	398	2,048	343	152	0	0	0
2009	1,721	413	2,134	358	158	0	0	0
2010	1,795	428	2,223	373	163	0	0	0
2011	1,873	442	2,315	390	169	0	0	0
2012	1,954	457	2,411	406	175	0	0	0
2013	2,038	472	2,510	424	180	229	1,296	1,525
2014	2,127	487	2,614	442	186	239	1,339	1,578
2015	2,219	502	2,721	462	192	249	1,382	1,631
2016	2,315	517	2,832	482	197	260	1,418	1,678
2017	2,415	532	2,947	502	203	271	1,462	1,733
2018	2,519	547	3,066	524	209	283	1,505	1,788
2019	2,628	561	3,189	547	214	295	1,541	1,836
2020	2,742	576	3,318	570	220	308	1,584	1,892
2021	2,860	591	3,451	595	226	321	1,627	1,948

Source: Number of tourist is from the water demand projection by JICA Study Team

Table F93.1.6 Financial Costs of Initial Investment, Sewerage Priority Projects

Financial Costs

(Unit: Rs. In milion)

Item	Total	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
1. Construction cost																				
Expansion projects																				
(1) Trunk Sewer	265.14	0.00	0.00	0.00	88.38	88.38	88.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(2) Branch Sewer	310.92	0.00	0.00	0.00	103.64	103.64	103.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(3) Pump	21.24	0.00	0.00	0.00	0.00	10.62	10.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(4) Sewage Treatment Plant	268.90	0.00	0.00	0.00	55.90	111.70	101.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sub total	866.20	0.00	0.00	0.00	247.92	314.34	303.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rehabilitation works																				
(1) Rehabilitation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sub total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
O&M Improvement																				
(1) Sanitation systems O&M Improvement	15.00	0.00	0.00	0.00	15.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sub total	15.00	0.00	0.00	0.00	15.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Institutional/organizational improvement *1	28.23	4.87	4.90	4.92	4.91	4.41	4.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sub total	28.23	4.87	4.90	4.92	4.91	4.41	4.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	909.43	4.87	4.90	4.92	267.83	318.75	308.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2. Engineering cost *2	108.62	0.50	20.50	40.50	12.05	18.17	16.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Administration cost *3	50.89	0.27	1.27	2.27	13.99	16.84	16.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4. Land Acquisition	18.20	0.00	9.10	9.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5. Physical contingency *4	103.64	0.54	3.45	5.45	27.99	33.70	32.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6. Price contingency (7%) *5	324.22	0.00	2.51	8.22	66.14	109.95	137.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL minus Price contingency	1,190.78	6.18	39.22	62.24	321.86	387.46	373.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL minus Price contingency (in million US$)	26.32	0.14	0.87	1.38	7.11	8.56	8.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	1,515.00	6.18	41.73	70.46	388.00	497.41	511.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL (in million US$)	33.49	0.14	0.92	1.56	8.58	10.99	11.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Notes: *1; 3% of the total direct construction cost. Total amount for each three phase is calculated and allocated equally to every year. Phase 1: 2007-2012, Phase 2: 2013-2018, Phase 3: 2019-2025

*2; 12% of the total construction cost

*3; 5% of the total direct construction cost

*4; 10% of Construction cost and Engineering cost.

*5; Excluding minor equipment, construction cost is expected to be procured by India.

Exchange rate between Rupee per US Dollar is Rs. 45.24/US$.

Table F93.1.7 Economic Costs of Initial Investment, Sewerage Priority Project

Economic Costs

(Unit: Rs. In million)

Item	Total	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
1. Construction cost																				
Expansion projects																				
(1) Trunk Sewer	248.37	0.00	0.00	0.00	82.79	82.79	82.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(2) Branch Sewer	291.27	0.00	0.00	0.00	97.09	97.09	97.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(3) Pump	19.90	0.00	0.00	0.00	0.00	9.95	9.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(4) Sewage Treatment Plant	251.91	0.00	0.00	0.00	52.37	104.64	94.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sub total	811.45	0.00	0.00	0.00	232.25	294.47	284.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rehabilitation works																				
(1) Rehabilitation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sub total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
O&M Improvement																				
(1) Sanitation systems O&M Improvement	14.05	0.00	0.00	0.00	14.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sub total	14.05	0.00	0.00	0.00	14.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Institutional/organizational improvement [*1]	26.44	4.56	4.59	4.61	4.60	4.13	3.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sub total	26.44	4.56	4.59	4.61	4.60	4.13	3.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	851.94	4.56	4.59	4.61	250.90	298.60	288.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2. Engineering cost [*2]	107.55	0.50	20.30	40.10	11.93	17.99	16.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Administration cost [*3]	38.02	0.20	0.95	1.70	10.45	12.58	12.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4. Land Acquisition [*4]	18.20	0.00	9.10	9.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5. Physical contingency	95.95	0.51	2.49	4.47	26.28	31.66	30.54	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1,111.66	5.77	37.43	59.98	299.56	360.83	348.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL (in million US$)	24.58	0.13	0.83	1.33	6.62	7.97	7.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Notes: *1; 20% of each each portion of the project is assumed to be labour cost. 80% of the labour is assumed to be unskilled labours

*2; It is assumed that 10% of the engineering cost is paid to local engineers.

Personel Income tax	10%	
Shadow Exchange Rate	50.081 Rs./US$	(Exchange rate 45.24 Rs./US$)
Shadow Wage Rate for unskilled labour	70% of market price	
Shadow Wage Rate for skilled labour	100% of market price	
Opportunity cost of land	100% of market price	

*3; It is assumed that 80% of the staff are unskilled labour.

*4; Market price is recognized as economic value, since land acquisition cost os less than 1% of the total project cost.

Table F93.1.8 Financial and Economic Costs of Operation and Maintenance, Sewerage Priority Project

Financial Costs

(Unit: Rs. In million)

Item	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	After 2031
1. Electricity																									
(1) STP	0.00	0.00	0.00	0.00	0.00	0.00	7.84	9.40	10.12	10.49	10.71	10.93	11.15	11.38	11.61	11.80	11.93	12.01	12.09	12.15	12.19	12.2	12.2	12.2	12.2
(2) Others	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.49	0.53	0.55	0.56	0.57	0.59	0.60	0.61	0.62	0.63	0.63	0.63	0.64	0.64	0.64	0.64	0.64	0.64
Sub total	0.00	0.00	0.00	0.00	0.00	0.00	8.25	9.89	10.65	11.04	11.27	11.50	11.74	11.98	12.22	12.42	12.56	12.64	12.72	12.79	12.83	12.84	12.84	12.84	12.84
2. Chemical cost	0.00	0.00	0.00	0.00	0.00	0.00	1.97	2.37	2.55	2.64	2.69	2.75	2.81	2.86	2.92	2.97	3.00	3.02	3.04	3.06	3.07	3.07	3.07	3.07	3.07
3. Personnel expenses	0.00	0.00	0.00	0.00	0.00	0.00	3.32	3.32	3.32	3.32	3.32	3.32	3.32	3.32	3.32	3.32	3.32	3.32	3.32	3.32	3.32	3.32	3.32	3.32	3.32
4. Maintenance	0.00	0.00	0.00	0.00	0.00	0.00	2.03	2.34	2.48	2.55	2.59	2.64	2.68	2.72	2.77	2.81	2.83	2.85	2.86	2.88	2.88	2.88	2.89	2.89	2.89
5. Sewer Cleaning	0.00	0.00	0.00	0.00	0.00	0.00	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.6	1.6	1.6	1.6	1.6	1.6
6 Administration	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.59	0.62	0.63	0.64	0.65	0.66	0.67	0.68	0.69	0.70	0.70	0.71	0.71	0.71	0.71	0.71	0.71	0.71
TOTAL	0.00	0.00	0.00	0.00	0.00	0.00	17.69	20.11	21.22	21.78	22.11	22.46	22.81	23.15	23.51	23.81	24.01	24.13	24.25	24.36	24.41	24.42	24.43	24.43	24.43

Economic Costs

(Unit: Rs. In million)

Item	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	After 2031
1. Electricity																									
(1) STP	0.00	0.00	0.00	0.00	0.00	0.00	7.84	9.40	10.12	10.49	10.71	10.93	11.15	11.38	11.61	11.80	11.93	12.01	12.09	12.15	12.19	12.20	12.20	12.20	12.20
(2) Others	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.49	0.53	0.55	0.56	0.57	0.59	0.60	0.61	0.62	0.63	0.63	0.63	0.64	0.64	0.64	0.64	0.64	0.64
Sub total	0.00	0.00	0.00	0.00	0.00	0.00	8.25	9.89	10.65	11.04	11.27	11.50	11.74	11.98	12.22	12.42	12.56	12.64	12.72	12.79	12.83	12.84	12.84	12.84	12.84
2. Chemical cost	0.00	0.00	0.00	0.00	0.00	0.00	1.97	2.37	2.55	2.64	2.69	2.75	2.81	2.86	2.92	2.97	3.00	3.02	3.04	3.06	3.07	3.07	3.07	3.07	3.07
3. Personnel expenses	0.00	0.00	0.00	0.00	0.00	0.00	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27
4. Maintenance	0.00	0.00	0.00	0.00	0.00	0.00	2.03	2.34	2.48	2.55	2.59	2.64	2.68	2.72	2.77	2.81	2.83	2.85	2.86	2.88	2.88	2.88	2.89	2.89	2.89
5. Sewer Cleaning	0.00	0.00	0.00	0.00	0.00	0.00	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
6. Administration	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.44	0.46	0.47	0.48	0.49	0.49	0.50	0.51	0.52	0.52	0.52	0.53	0.53	0.53	0.53	0.53	0.53	0.53
TOTAL	0.00	0.00	0.00	0.00	0.00	0.00	16.51	18.91	20.01	20.57	20.90	21.25	21.59	21.93	22.29	22.59	22.78	22.90	23.02	23.13	23.18	23.19	23.20	23.20	23.20

Notes: *1; 80% of labour is assumed to be paid unskilled labours

Personel Income tax	10%	
Shadow Exchange Rate	50.081	Rs./US$
Shadow Wage Rate for unskille	70%	of market price
Shadow Wage Rate for skilled l	100%	of market price

Table F93.1.9 Financial Benefit of Sanitation Project

Domestic

(Unit: Rs in Million)

Item	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
1. Wastewater Charge																			
sewerage treated volume: Total	0.0	0.0	0.0	0.0	0.0	0.0	1,195.3	3,353.6	5,759.8	7,474.1	9,081.9	10,529.8	11,970.6	13,400.8	14,247.3	14,180.8	14,117.4	14,056.9	13,999.2
(1) Billed water volume (m^3/day) [*1]	0.0	0.0	0.0	0.0	0.0	0.0	1,494.1	4,192.0	7,199.8	9,342.6	11,352.4	13,162.3	14,963.3	16,751.0	17,809.1	17,726.0	17,646.8	17,571.1	17,499.0
(2) Unit Price [*2]	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12
(3) Total sewerage charge billed	0.000	0.000	0.000	0.000	0.000	0.000	0.611	1.714	2.943	3.819	4.641	5.381	6.117	6.848	7.280	7.246	7.214	7.183	7.154
(4) Collection Efficiency	95.6%	95.7%	95.8%	95.9%	96.0%	96.1%	96.2%	96.3%	96.4%	96.5%	96.6%	96.7%	96.8%	96.9%	97.0%	97.1%	97.2%	97.3%	97.4%
(5) Total Sewerage Revenue	0.000	0.000	0.000	0.000	0.000	0.000	0.588	1.651	2.837	3.685	4.483	5.203	5.921	6.636	7.062	7.036	7.012	6.989	6.968
2. Installation Charge																			
(1) Number of customer	0	0	0	200	398	598	2,072	2,461	2,809	2,321	2,181	1,972	1,972	1,972	1,972	0	0	0	0
(2) Total Installation Revenue [*3]	0.000	0.000	0.000	0.043	0.086	0.129	0.445	0.529	0.604	0.499	0.469	0.424	0.424	0.424	0.424	0.000	0.000	0.000	0.000
TOTAL	0.000	0.000	0.000	0.043	0.086	0.129	1.033	2.180	3.441	4.184	4.952	5.627	6.345	7.060	7.486	7.036	7.012	6.989	6.968

Note: *1 Billed water volume is assumed as 100% of sewerage treated volume in Panaji, and 125% of sewerage treated volume in other project areas.

*2 Unit price:Rs.1.12/m^3 per month

*3 Weighted average installation cost: Rs.215/case

Non-Domestic

(Unit: Rs in Million)

Item	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
1. Wastewater Charge																			
Sewerage treated volume: T	0	0	0	0	0	0	202.2	577.8	1,009.9	1,338.2	1,658.4	1,958.9	2,266.3	2,579.6	2,798.5	2,839.0	2,877.5	2,914.3	2,949.4
Sewerage treated volume: I&D	0	0	0	0	0	0	41.5	119.6	212.3	286.6	357.7	429.3	504.1	586.7	654.2	680.3	705.1	728.8	751.4
Sewage treated volume: Total	0.0	0.0	0.0	0.0	0.0	0.0	243.7	697.4	1,222.2	1,624.8	2,016.1	2,388.2	2,770.4	3,166.3	3,452.7	3,519.3	3,582.6	3,643.1	3,700.8
(1) Billed water volume (m^3/day) [*1]	0.0	0.0	0.0	0.0	0.0	0.0	304.6	871.8	1,527.8	2,031.0	2,520.1	2,985.3	3,463.0	3,957.9	4,315.9	4,399.1	4,478.3	4,553.9	4,626.0
(2) Unit Price [*2]	6.85	6.85	6.85	6.85	6.85	6.85	6.85	6.85	6.85	6.85	6.85	6.85	6.85	6.85	6.85	6.85	6.85	6.85	6.85
(3) Total sewerage charge billed	0.000	0.000	0.000	0.000	0.000	0.000	0.762	2.180	3.820	5.078	6.301	7.464	8.658	9.896	10.791	10.999	11.197	11.386	11.566
(4) Collection Efficiency	95.6%	95.7%	95.8%	95.9%	96.0%	96.1%	96.2%	96.3%	96.4%	96.5%	96.6%	96.7%	96.8%	96.9%	97.0%	97.1%	97.2%	97.3%	97.4%
(5) Total Sewerage Revenue	0.000	0.000	0.000	0.000	0.000	0.000	0.733	2.099	3.682	4.900	6.087	7.218	8.381	9.589	10.467	10.680	10.883	11.079	11.265
2. Installation Charge																			
(1) Number of customer	0	0	0	10	21	31	109	130	148	122	115	104	104	104	104	0	0	0	0
(2) Total Installation Revenue [*3]	0.000	0.000	0.000	0.005	0.011	0.016	0.057	0.068	0.077	0.063	0.060	0.054	0.054	0.054	0.054	0.000	0.000	0.000	0.000
TOTAL	0.000	0.000	0.000	0.005	0.011	0.016	0.790	2.167	3.759	4.963	6.147	7.272	8.435	9.643	10.521	10.680	10.883	11.079	11.265

Note: *1 Billed water volume is assumed as 100% of sewerage treated volume in Panaji, and 125% of sewerage treated volume in other project areas.

*2 Unit price:Rs.6.85/m^3 per month

*3 Weighted average installation cost: Rs.520/case

APPENDIX F10

This appendix is reference to and supporting data of

Volume 3 Main Report – Feasibility Study

Chapter 10 Social Considerations and Environmental Impact Assessment

Appendix F101

Public Consultation for the Implementation of Priority Project

Contents for Appendix F101

Appendix F101.1 Note of Discussion From and Attendance Sheet of the Third Stakeholder Meeting

Third Stakeholder Meeting

The main component of the third stage of public consultation was a 3rd stakeholder meeting. The agenda, participants and timing of the third stakeholder meeting were jointly decided by the PWD and the JICA Study Team during the development of the feasibility study.

Objectives of the 3rd stakeholder meeting are to:

- present the outlines of the feasibility study and a result of the 2nd SHM
- discuss specific issues such as the implementation of the priority projects with local stakeholders as regard to environmental and social considerations based on rapid EIA study

The third stakeholder meeting was held by the PWD in cooperation with the JICA Study Team on 18 July 2006. Officially, 75 stakeholders were invited and more than 70% of the invitees attended (54 attendants / 75 invitees). Table F101.1.1 shows the numbers of invitees and attendants for each stakeholder group. A detailed list of the attendants is provided after the page F101-10.

Table F101.1.1 Number of Invitees and Attendants at the Third Stakeholder Meeting

Type of Stakeholder	Number of Invitees	Number of Attendants
MOUD	1	1
Goa Sate	5	1
Embassy of Japan	1	0
JICA Official	1	0
PWD	14	22
JICA Study Team	5	5
Stakeholders living/working around the proposed sites for STPs, WTPs, etc.	9	12
Chairperson, Vice Chairpersion, Councillor, Sarpanch, etc.	19	2
Journalists	4	2
NGO	3	2
College	4	2
Pvt. Engineer Consultant	2	1
Others (Port Trust and Military)	7	4
Total	75	54

The invitation card to the third stakeholder meeting was distributed by the PWD. These were accompanied by a brochure outlining the master plan and the environmental and social considerations (see F101.2 Brochure on the Feasibility Study and Environmental & Social Considerations). The brochure was prepared specially for the third stakeholder meeting by the PWD with support from the JICA Study Team.

The most important purpose of the third stakeholder meeting was to discuss site specific issues (e.g. the construction of sewage treatment plants) regarding the environmental and social considerations identified through the Rapid-EIA with the local stakeholders. Therefore, the invitation cards were directly distributed by hand to concerned stakeholders living/working around the proposed sites for the STPs, WTPs, etc. The locations of proposed sites and types of projects were briefly explained by the PWD staff to those representatives when the invitations were handed to them. Identification of these prominent stakeholders was based on recommendations made by local people. And PWD staff directly made contact with common local NGO groups to provide invitation for the meeting, too.

In the third stakeholder meeting, the following six presentations were given to the stakeholders by the PWD, with support from the JICA Study Team, before discussions were initiated.

Two Main Presentations:

- Outlines of the Study and Public Participation (Progress of Feasibility Study, a report of second stakeholder meeting)
- Explanation of the Priority Projects for Water Supply & Sewerage and the likely Environmental and Social Impacts
  1) Priority Projects for Water Supply Scheme
  2) Sewerage Scheme in the Feasibility Study
  3) Project Benefits and Likely Impacts as regard to Environmental & Social Considerations

Two Additional Presentations:

- Welcome speech by the Secretary, PWD
- NRW Reduction Pilot Project by PWD Goa

Although some of the presentations explained the potential environmental impacts of the proposed STPs and supplementary facilities. Rather, most of the topics raised were related to the current discontent of the public toward the PWD with regards to its water supply services and administrative issues. The need for the PWD to provide better daily customer services was highlighted in the discussion as well as second stakeholder meeting.

The main topics raised in the discussion section were:

1) Fund-raising of the Project
2) Illegal Connections of Water Supply
3) Financial Issues for the Projects
4) Offensive Odour from the STPs
5) Inappropriate Treatment of Sewage
6) Water Quality Control
7) NRW Reduction Pilot Project
9) Bulk Water Supply to the Airport
10) Adoption of Excavation Methods
11) Compensation of Land Acquisition
12) Action Measures for Emergency Troubles
13) Timing of the Projects Starting
13) Continuous Water Supply (24hrs a day, 7 days a week)

14) Service Covering Area and Targeted Population of North Coastal Belt, Baga STP

The topic wise records of the discussion are shown as flows.

< Fund-raising of the Project >

Q(Question): Mr. Roland Martins – I have a query. What about the funding? Last year the minister talked about funding. When agencies like World Bank give loan they need to know about the recipient credibility and transparency. From the first meeting, I have been asking about the Salaulim pipe burst. In Japan scrutiny is important. The NRW emphasis is on consumers. The consumer is baffled. The meters may run by the air. Meter calibrations cannot be guaranteed. You have to look into it. Also the kind of piping used. Vigilance on NRW should be by the department itself.

A(Answer): Mr. Santosh Vaidya (Secretary, PWD) – Some of these points will be clarified. Regarding Salaulim, write to us. On NRW, not only consumer but various other aspects are there. Ensure that connections are metered.

< Illegal connections of water supply >

Q: Mr. Roland Martins, NGO – Just a few queries. Good presentation. You focused on administrative problems. Your own personal pointed 100 illegal connections. Why no person is held responsible till today? We are in study with Electricity Department. We have 2 meters of companies like Havell which are not calibrated properly and this is causing damage to department. Which meters are being used? Are they calibrated? Are new meters being used? We have a meter which is handed over to legal metrology department to check calibration.

A: Ameya Lawande – Administration problems are technical problems like consumer code etc.

Q: Mr. Roland Martins, NGO – Did you find boosters in your study?

A: Ameya Lawande – Bad meters are updating in order of precedence.

Q: Mr. Roland Martins, NGO – We can give information regarding illegal consumers. We can hold meeings at JE level.

A: Ameya Lawande – Yes sure. Thank you.

C(Comment): Mr. Wachasundar – His presentation showed 15% not billed due to administrative reasons. This goes towards awareness. Consumers not getting bills for 1 year; but no water for 1 day and they take up at levels of the hierarchy. 1 month, 2 to 3 months then consumers should come forward for bill. We welcome NGOs to help. If there is an illegal connection, neighbors should point out. I myself may be scared but I am hampered. We will not take drastic steps so please help.

Q: Mr. Roland Martins, NGO – I have a suggestion. Electricity department has a format by MRT which gives notice to consumer. Another phenomenon is boosters like resorts in Calangute and Candolim use. JICA team is here; required help may be taken to provide equipments to find such boosters.

A: Mr. Wachasundar – We agree we have limitations in finding illegal connections. 90% are good, 10% is responsible in spoiling the game.

Q: Mr. Roland Martins, NGO – Appoint nodal officers for vigilance like your helpline through GEL.

A: Mr. Wachasundar – We have appointed an auditing squad like some sort of like a division.

Q: Mr. Roland Martins, NGO – Publicly announce the numbers and address.

A: Mr. Wachasundar – Yes Ok.

C: Mr. Mamiya – Thank you very much. I am Mamiya, JICA study team leader. We have 30 minutes question answers. If you have any questions, we will be ready to answer. As there is Assembly, Secretary and Chief Engineer have left. Questions about Policy matters we will take a memo. About technical matter we will answer.

< Financial issues for the Projects >

Q: – Will somebody talk about financial matters?

A: Study Team– We estimate Rs. 600 – 700 Crores for priority project. We are doing detailed project and how will it impact in our final draft project. For the water supply, Rs.400 Crores, for the Sewerage Rs.100 Crores, and others Rs.50 Crores. Like structuring of institution (management of PWD, operation and maintenance implication, financial implications) we strongly recommend independent accounting system PWD cannot evaluate under present accounting. Organization structuring is not clear presently to us. In Water supply, sewerage, financial system we are proposing administrative restructuring.

In the beginning we propose to extend to also management Information system (MIS). Each division has its data but the format is not uniform to all divisions. The data is not transferred to Head Quarters. This will be included. Transparency is not enough. How water tariff is collected and how it is spent, Operation and maintenance expenditure, financial system component, annual report has to be prepared. A sub total of Rs.550 crores and including price and physical contingencies Rs.600 to Rs.700 crores.

< Offensive odour from the STPs >

Q: – How is the odour problem? How you treat this? This is one major concern for people around.

A: Mr. Mamiya – Yes this is correct, Mr. Sano has explained different systems. Aerobic treatment has achieved odourless. Oxidation ditch has least odor. Proposed STP site are selected as far as possible from residential area, therefore no odor. Tonca was an outside town but with new houses now. If this is the case, then we cover basin. This will not be done in the beginning but then afterwards there is a counter measure. Did I answer your question?

< Inappropriate treatment of sewage >

Q: – There were 2 news report regarding Sirvodem, Margao STP break down. Village Panchayat and consumer forum visited. Lab to be set up worth Rs.3 lacs proposed. Will it solve the problem? Second, town of Vasco. Consumer forum found effluent into lake. Did you read news- paper reports? Consumers are not coming forward due to this. They prefer to put into tank because if Department is dumping into the lake, then why they should take connection?

A: Mr. Santanam – Margao plant there is a bypass arrangement now. The problem is solved. A consultant is appointed, a laboratory for day to day testing is proposed, tertiary treatment is considered and augmentation will be in the same place.

Q: – 50% concession for new consumers.

A: – Government is subsidizing connection and connection from septic tank to trunk sewer is by PWD, still no response.

Q: – Why? Has any survey been done? Panchayats has conducted Gram sabha. We have done a survey. Has PWD done? No justifications.

A: – 70% cost by government.

Q: – Now setting up STP, has department taken any Gram sabha has EIA been conducted? Presently sewerage is released in river Sal.

A: – Releasing as per standard.

Q: – Only consultant? Why not PWD can do it? 3 lacs for laboratory! Can you ensure on similar problem not occurring at Vasco? SDM has arrested officer. You are service provider? Seeing SDM arrested is not good. Under Section 133 public nuisance, a person can be arrested. It is not fair to arrest staff! That's my only request.

A: Mr. Santanam – Thank You.

< Water quality control >

Q : Suresh Gurav – MPT : Treated water will be reused?

A: Study Team– Part of water will be reused after sand filtering.

Q: – pH value?

A: – 6 to 8 no detailed information.

C: – We have pH-5 at MPT. Thank you.

Q: – WRD is doing water quality. Is there coordination with PWD?

A: Mr. Patil – We are doing study at the plant. As of now, there is no coordination. No specific guidelines in the process of my knowledge.

Q: – Data by JICA. Is PWD related?

A: – We are coming to a guideline.

Q: – Project envisaged for 2025 so coordination is necessary.

A: – Water quality of tank, borehole wells, tanker is monitored by WRD. Exact framework of guideline is being done.

< NRW reduction pilot project >

Q: Goa Engineering College – In Amey Lawande's presentation, civil engineering department of GEC will like to come forward to help you in metering.

A: Mr. Patil – Thank you, Secretary has already asked to take help of institutions in 15 to 30 days we will contact you.

C: – We could take up areas close to our college like Bandora.

< Bulk water supply to the airport >

Q: Airport Authority of India – We are having failure of water supply. During this time we have to bring tanker water from private suppliers. Are there any alternative plans for water supply to airport?

A: Mr. Patil – We are having a meeting with all departments. We want to suggest rain water harvesting; like Zuari is using in emergency. We are suggesting to AAI, MES and Army.

Q: – Any special attention to airport? Can you suggest to us.

A: Mr. Patil – JICA study is for 100 mld. We are taking a short term measure for 25 mld at Salaulim, which is already tendered and work order is issued. Another 50 mld by November or December. By this Vasco zone will have solved problem.

Q: – Any additional lines for Airport?

A: – Transmission line, Verna pump house and extra pumps at Verna.

< Adoption of excavation methods >

Q: – Are you going to use different types of excavation in high traffic, congested areas.

A: – Trench less technology in crowded city areas. It is a highly skilled jiob.

< Compensation of land acquisition >

Q: – Is there any income loss due to land acquisition?

A: – In the priority project in water supply, no acquisition.

Q: – What about Baga?

A: – Most sites have no houses, away from residential area, paddy land. Rates fixed by land acquisition officer.

Q: – If it is cashew nuts crop?

A: – It will be compensated.

< Action measures for emergency troubles >

Q: Mr. Roland Martins – When STP is set up, did you take breakdown into account? Whether PWD has thought of conducting program with people into confidence so that people do not oppose unnecessarily? Department should create awareness by publishing articles inn Marathi and Konkani news papers.

A: – We will consider this. We will conduct house to house survey.

< Timing of the projects starting >

Q: – When are you starting this project?

A: Mr. Patil – I am a small man to say this. But it will be started definitely next year.

< Continuous Water Supply (24hrs a day, 7 days a week) >

Q: – With augmentation, how best can you supply water 24 hours?

A: – We are trying best for 24 x 7. Theoretically supply is against demand. We have to consider NRW, repair defective meters, then gradually we can have 24 hour water supply from up stream to down stream. Many steps need to be taken before achieving 24 x 7.

< Service covering area and targeted population of North Coastal Belt, Baga STP >

Q: – You have mentioned 22,000 populations for Baga STP. Which area have you considered? Calangute area itself has 18,000 fixed populations. What about floating population? In 2012 what would be the population?

A: – Target year is taken as 2025.Master plan is made for 2025. Capacity in 2025 will not be constructed at once; it will be divided into stages. 1st STP is targeted for 2015; next 2018 and finally 2025. Priority project capacity is small compared to 2025. To avoid financial constraints it will be taken up in stages.

Q: – You are acquiring 6000 sq m land. What about expansion?

A: – Land space will cover facility of 2025.

Q: – What about growth of population?

A: – Depends on the area.

Q: – Why is population not properly projected? Is it census data you are referring to?

A: – We also provided census data to the JICA team.

Q: – There are rented apartments. Suddenly apartment becomes full. So, total bed capacity has to be taken into account. Also figures are wrong. Why sewerage of one village into another village. Give them the JICA team the proper information.

C: – The land has no capacity to absorb water. People have put wells to collect sewage. This is happening in Calangute, Panchayat has no powers. Health officer has no powers. The people are suffering. For STP project right information is required. If finance is the concern then don't do it.

Mr Mamiya: – Thank you very much for your precious comments.

List of Participants in the 3rd Stakeholder Meeting (1/5)

No.	Name in Print	Title / Station & Organization, Institution	Signature
1	A A Patil	E E IX Margao	
2	GIRISH AGNI		GiriAgni
3	P. Karunakaran	Coordinating Asstt. W.D. IX(PHE), PWD	
4	Hirofumi SANO	JICA Study Team	
5	Daisuke Fukushima	JICA Study Team	
6	Oga Takahiko	"	
7	ISHIHARA TAKETOSHI	"	
8	Takemasa Mamiya	"	
9	Babani S. Desai	Eng. of Quepem Municipality	
10	Suresh B. Gurav	Asst. Engineer. M.P.T. Vasco	
11	N. A. Kulkarni	CM-Utilities, ZIL, Goa.	
12	Ganesh Kadlekar	JE WD IX Vasco	
13	Joseph Valadares	GIDC DyGM	
14	R. Shetty	GIDC	
15	Uday kumar	V Joshi AE	
16	K.P. Raghava	Asst Engg S.D.IV [illegible]	
17	ROLAND MARTINS	COORDINATOR GOACAN	
18	LORNA B-FERNANDES.	SECRETARY, GOACAN.	Fernandes
19	A-RADHAKRISHNAN	AAI, SM(E-C) GOA AIRPORT -	Radhakrishnan -
20	K.D. VERMA	Asstt Mgr(E-C), AAI, Goa Airport	
21	Aditya Anand	The Navhind Times	
22	A.V. De Souza	Citizen of Calangute	
23	S.K. ABDUL SAMAD	CONSULTING ENGINEER, PANJIM.	
24	Clotildes Bragança	J.P. Member Calangute	CBragança
25	Cyriaco Dias	CALANGUTE	

List of Participants in the 3rd Stakeholder Meeting (2/5)

No.	Name in Print	Title / Station & Organization, Institution	Signature
26	J. Martin D'Souza	Konkan Activist	
27	Jose Braganza	Calangute	
28	Joseph Sequeira	Sarpanch V. P. Calangute	
29	Amey Lawande	S.D I, W.D VII, P.W.D	
30	Sandeep Gaud	SD I, WD XX P.W.D	
31	Shailesh Usgaonkar	SD-I WDXX PWD	
32	Devidas Gaude	SD I WD XX PWD	
33	A.S. Gaonkar	SD II WD XX PWD Sanguem	
34	P.S. Varne.	AE I WD XX PWD Curchorem	
35	A. K PATIL	Maintenance officer, BITS Pilani	
36	Nerita Baptista	Herald Reporter, Herald Publicatn	NB.
37	A.W. Watchasundar	Chief Engineer, PWD	
38	Santosh Vaidya	Secretary PWD.	
39	Dr. R. Tamba	State Epidemiologist DHS	
40	K.H. Kamaladinni	EE PWD WD XV	
41	S.G. Walvelkar	AE SD III WD XV Quepem	
42	Sunil Gaonde	T.A SD III WD XX Quepem	
43	V.M. Kudchadkar	AE-S.D II - WD IX, Margao	
44	V.K. Gaonkar	J.E. P.W.D Subdn II WDX	
45	Dr. K.G. Gupta	Prof. & Head, Civil, GEC P'da	
46	Miss Rosalina Borges.	T.A Sub Div IV / Div IX water supply	Borges
47	S.R. Paranjape	EE XII Sanguem	
48	V. Santhanam	SE VIII Margao	
49	Antony Malkey	AE, SD I, WD XXI, Margao	
50	M.S. Kamat	AE SD II / WD XII	

List of Participants in the 3rd Stakeholder Meeting (3/5)

No.	Name in Print	Title / Station & Organization, Institution	Signature
51	G. N. Parrikar	E. E. Div. XVII (PHE), PWD.	
52	E. H. JOYCESON	Goa Shipyard Ltd	I.M
53	Maladkar. G.V.	E.E. (C.P.O) W.R.D. Panaji. Goa	
54	Alban Couto	Indian Administrative Service (Retd.) Advisor, Govt. of Goa	
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Appendix F101.2 Brochure on the Feasibility Study and Environmental & Social Considerations

BRIEF OUTLINES OF PRIORITY PROJECT FOR WATER SUPPLY AND SEWERAGE FOR THE GOA STATE IN THE REPUBLIC OF INDIA

Third Stakeholder Meeting for Public Consultation (July 18, 2006)

Organized by Public Works Department, Goa in Collaboration with JICA Study Team

BACKGROUND AND OBJECTIVES OF THE STUDY

There are seven existing surface water supply schemes in Goa and existing small scale groundwater supply schemes. Water supply service is limited to several hours each day even in the capital city Panaji. Water demand is continuously increasing due to population growth and economic development. This is beginning to constrain socio-economic development in Goa.

Only the cities of Panaji, Vasco, and part of Margao are serviced by conventional sewerage systems. The average coverage ratio is only 13 %, which is lower than the national average. Even where sewer pipelines are installed, the connection ratios remain low (e.g. 30% in Margao and 19% in Vasco). People who are not connected to the sewerage system mainly use on-site sanitation (e.g. pit latrines). During the peak tourism season the populations in coastal areas double and therefore the volume of sewage generated increases. During the rainy season many septic tanks overflow due to rises in the groundwater table.

There is a clear need for additional water supply and sewerage system capacity in Goa, especially for cities, industrial estates and tourism resorts. Therefore, during 2002, the Government of India (GOI) requested an assistance of the Government of Japan (GOJ) concerning the augmentation of water supply and sanitation for Goa. As requested, the JICA Study Team has been currying out its study work on augmentation of water supply and sewerage/sanitation in the study areas shown in Figures F101.2.1 and 101.2.2.

Figure F101.2.1 Water Supply Study Area

Figure F101.2.2 Sewerage/Sanitation Study Areas

The Master Plan formulated in the second phase of the Study by mid-January 2006. The Water Supply Master Plan covers seven water supply schemes. The master plan was developed to solve existing problems, which the PWD and people of Goa currently experience. It was also developed to increase the water supply capacity and to provide an adequate transmission system. The existing supply capacity is not sufficient to meet potential water demand. The sanitation study area covers Margao Municipality; Ponda Municipality; Mapusa Municipality; the Southern Coastal belt; the Northern Coastal belt; and Panaji Municipality including its surrounding area (Porvorim, Taleigao, Dona Paula, Caranzalem, St. Cruz, Merces, Ribandar).

Objectives of the Study are to:

- ■ formulate a master plan for augmentation of water supply and sanitation in Goa State based on requirements up to 2025;
- ■ conduct a feasibility study for priority project(s) which will be selected from the master plan; and.
- ■ pursue technology transfer to the counterpart personnel in the course of the Study.

FEASIBILITY STUDY AND 3rd STAKEHOLDER MEETING

The Study is now undertaking the feasibility study for the selected priority projects. Criteria of selection are as follows;

- Urgency
- Scale/Magnitude of Project
- Impact of improvement
- Financial/Economic adequacy

Since April, the JICA Study Team has been formulating the feasibility study considering urgent priorities for water supply and sewerage, financial feasibility, environmental suitability and inputs from stakeholders on social influences.

The 1st stakeholder meeting held at the end of reconnaissance study in the last August 2005, general concerns of the stakeholders regarding to water supply and sewerage/sanitation were discussed. The results of the 1st stakeholder meeting utilized to formulating the master plan. The 2nd stakeholder meeting was held to consult public discussion on environmental and social impacts of the Master Plan. The selection of proposed sites and engineering options such as a type of wastewater treatment processes was conducted based on alternative studies in consideration of environmental and social effects. Those alternatives are also to be presented for stakeholders' information in the second stakeholder meeting.

Objectives of the 3rd stakeholder meeting are to:

- ■ present the outlines of the feasibility study and a result of the 2nd SHM
- ■ discuss specific issues such as the implementation of the priority projects with local stakeholders as

regard to environmental and social considerations based on rapid EIA study

PRIORITY PROJECT OF WATER SUPPLY SCHEME

The Salaulim Water Supply Scheme was selected as the priority project because it is the most urgent. The first stage of Salaulim Water Supply Scheme is recommended for the priority project, because

- Shortage of water in year 2025 for Salaulim Water Supply Scheme will be the most serious problem among 7 schemes.
- Salaulim Scheme supplies treated water to the major municipalities, which are Vasco, main port of the Goa State, Verna, the largest industrial area of the Goa State, Margao, the most populated city of Goa State, and part of capital city Panaji.

For other water supply scheme, the PWD is implementing projects for expansion of Assonora (40 MLD), Dabose (10MLD) and Canacona (10MLD).

The project scale was set based on a careful examination of water demand, supply capacity, raw water availability and the PWD's financial capabilities. The priority projects have been selected from the components of Stage I of the Salaulim Scheme. The priority projects are described below.

OBJECTIVES

The objectives of priority project in the F/S are to improve water supply situation in Goa,

- Through expanding the existing water supply schemes by constructing new water treatment plants
- Through enhancing the capacities of water transmission and distribution systems of major water supply schemes by rehabilitation of existing facilities, installment of new pipelines and construction of reservoirs, etc.
- Through the improvement of the operation and maintenance of water supply system.

COMPONENTS OF PRIORITY PROJECT

- Expansion of Salaulim Water Supply Scheme (for Mormugao, Salcete, Quepem, Sanguem)
  - Expansion of the Salaulim Treatment Plant by 100,000 m^3/day, resulting in a total capacity of 260,000 m^3/day.
  - Rehabilitation and Improvement of the Existing Salaulim Treatment Plant, which has a production capacity of 160,000 m^3/day.
  - Construction of a 20,000 m^3 Master Balancing Reservoir (MBR) in Sirvoi.
  - Installation of approximately 80 km of Transmission Mains.
  - Construction of six Reservoirs.
  - Construction of five Pumping Stations.
  - Replacement of Pumping Equipment at the Verna Pumping Station.

RELEVANT INFORMATION OF WATER SUPPLY SCHEME

- Emergency Measure
  - ✧ Implementing the emergency measure by 2012 for increase of the Salaulim WTP (plus 50 MLD), Ganjem Scheme (25MLD) and Maisal Scheme (10MLD)
- Facilities Provision for Higher Water Demand
  - ✧ Preparing water supply Master Plan based on higher water demand for unexpected water demand increase in future as Case Study.
- The Second Stage of Salaulim Water Supply Scheme
  - ✧ Another 100 MLD expansion of the Salaulim WTP by 2025

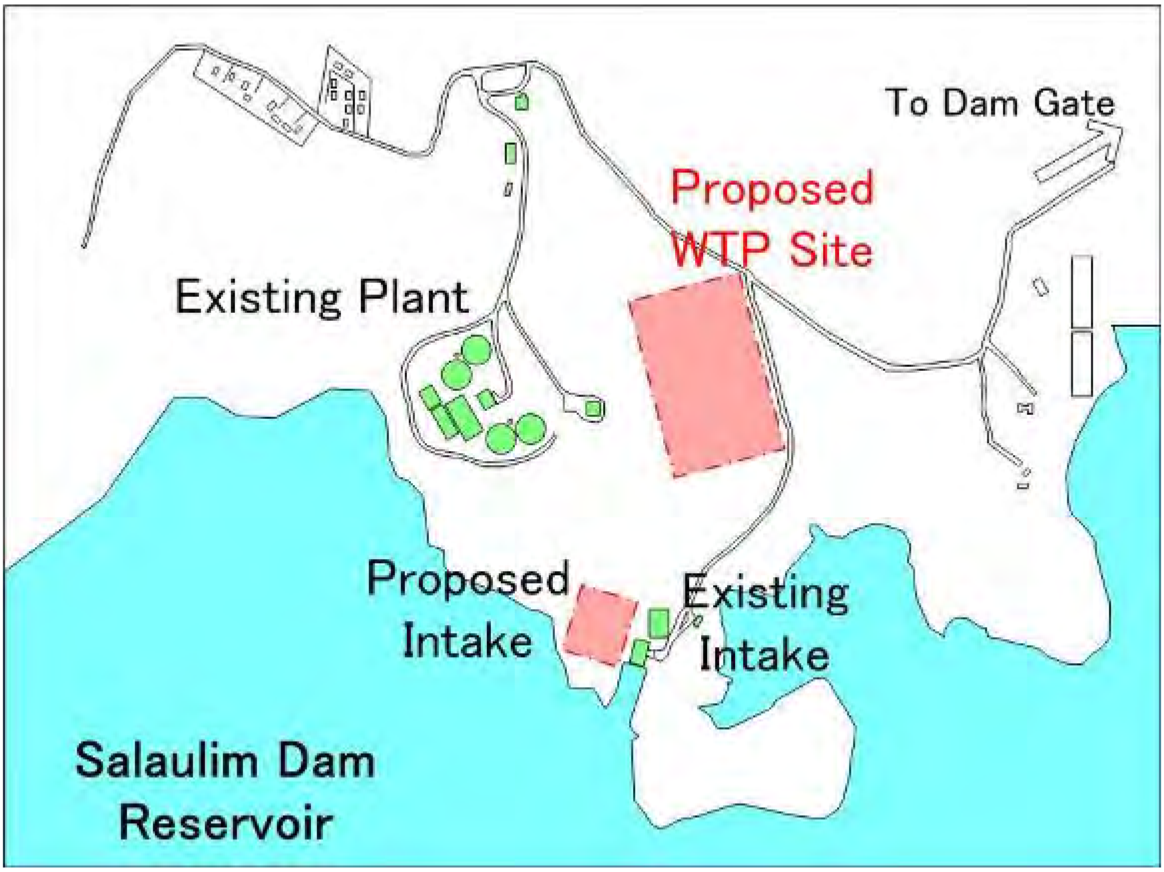
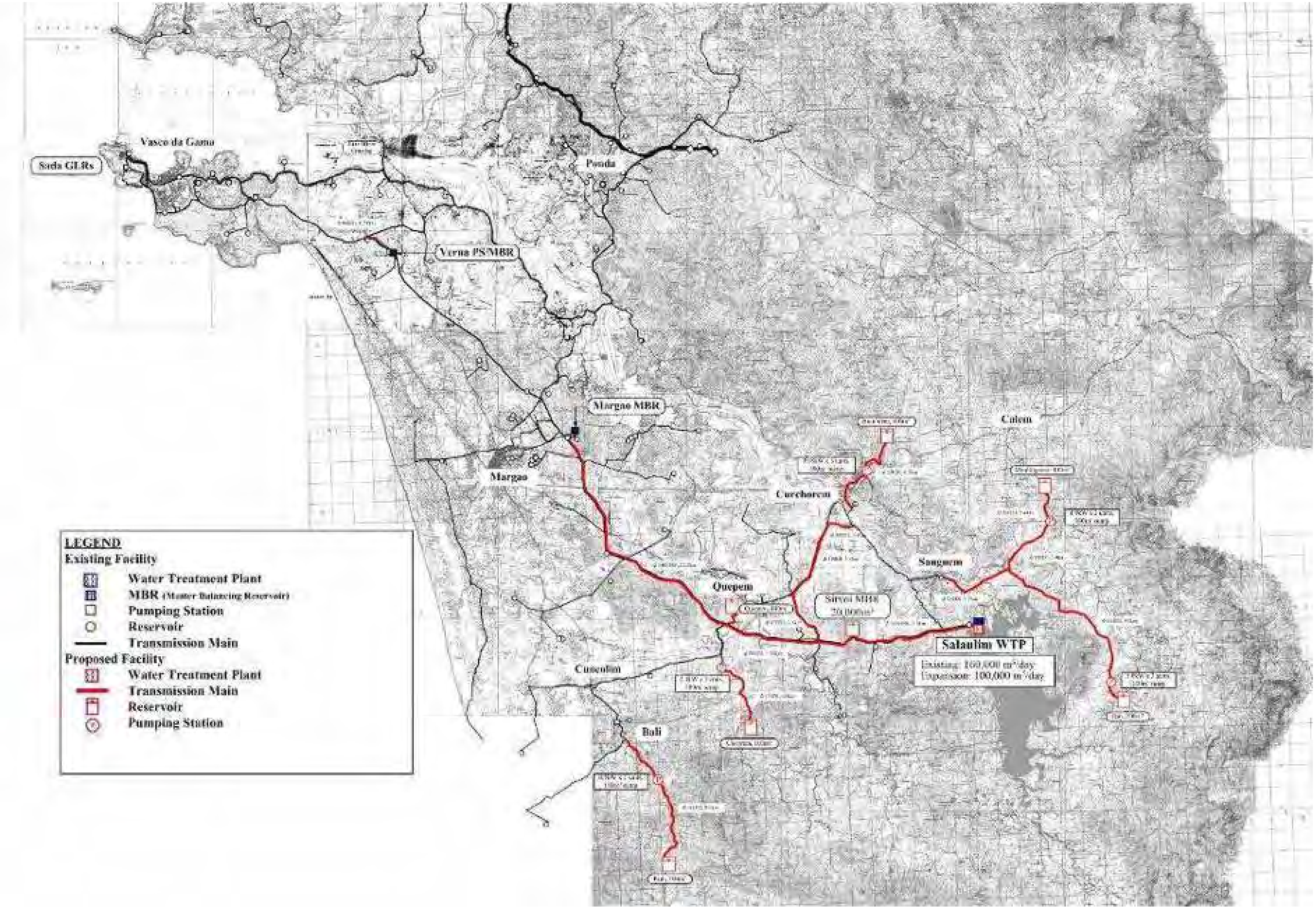


Figure F101.2.3 **Proposed New-Salaulim Water Treatment Plant and Intake Facility**

Figure F101.2.4 Proposed Facilities (Transmission Mains, Reservoir and Pumping Station) for Priority Water Supply Project



PROJECT BENEFITS

- Expansion of water supply service areas, newly 240,000 people can get access to the piped water
- Improvement of water quality
- Transition from intermittent to continuous water supply
- Reduction of waterborne diseases
- More water supply available to tourist facilities and local industries
- Increase in employment opportunities during construction and O&M stage

PRESUMABLE IMPACTS AND POSSIBLE MITIGATION MEASURES

Table F101.2.1 Presumable Impact and Possible Mitigation Measures for Water Supply Project

Major Item	Impact and Mitigation Measures
Water Treatment Plant	
• Resettlement	• New water treatment plant site are selected to avoid resettlement
• Deforestation	• Tree Plantation and protection of greenth landscape
• Drainage and sludge disposal	• No significant impacts. Returned to natural water body
• Noise and vibration causing by construction work	• Adoption of adequate construction method to avoid noise and vibration
Transmission Mains, Pumping Stations and Reservoirs	
• Deforestation	• Tree Plantation

PRIORITY PROJECTS OF SEWERAGE SCHEME

The Expansion of Margao Sewerage Scheme and Consutruction of new sewerage system in North Coastal Belt and Mapusa were selected as the priority project because their priorities are comparatively high. Those areas were recommended for the priority project, because those projects were marked scoring higher than other schemes by evaluation for ordering of priority with Indexes such as Beneficiary, Cost, Positive Impacts, Negative Impacts and Urgency. Table F101.2.2 indicates result of evaluation scoring for selection priority projects.

Table F101.2.2 Scoring Sheet of Priority Project Evaluation

	Beneficiary		Cost Effect		Positive Impacts		Negative Impacts		Urgency		Total	
	Point	Rank	Point	Rank	Point	Rank	Point	Rank	Point	Rank	Point	Rank
Panaji	4.1	4	7.3	5	3.3	4	0	1	1.2	5	15.9	4
St. Crus	1.2	8	4.4	6	1.0	7	0	1	1.5	4	8.1	7
Porvorim	3.9	5	3.7	7	2.9	5	0	1	2.2	3	12.7	5
Margao	4.8	3	9.5	1	5.0	1	0	1	1.2	5	20.5	2
Ponda	1.9	6	7.9	2	1.3	6	0	1	0.4	8	11.5	6
Mapusa	5.4	2	7.6	3	4.0	3	0	1	2.7	2	19.7	3
Colva	1.7	7	0.0	8	0.8	8	0	1	0.5	7	3.0	8
Calangute & Candolim	7.9	1	7.6	4	4.2	2	0	1	3.5	1	23.2	1

OBJECTIVES

The objectives of sewerage projects in the F/S are to improve urban sanitation in Goa,

- Through expanding the existing sewerage systems to areas around south part of Margao.
- Through constructing new sewerage systems in Mapusa and part of North Costal Belt.
- Through the improvement of the operation and maintenance of sewerage.

MAJOR PROJECT COMPONENTS

- Expansion of existing sewerege systems including sewer, pumping sation and treatment plants
  - Expansion of Margao STP (See **Figure F101.2.5**)
  - South Zone (Trunk sewer, Branch Sewer and 1 Pumping Station)
- Consutruction of new sewerage system including sewer, treatment plant and pumping station
  - Mapusa (Mapusa STP, Trunk Sewer, Branch Sewer) (See **Figure F101.2.6**)
  - North Coastal Belt (Baga STP, Trunk Sewer, Branch Sewer and 1 Pumping Station) (See **Figure F101.2.7**)
- Installation of Sewer Cleaning Equipment
  - Mechanized Sewer Cleaning Equipment (Sludge Vacuum vehicle and Pressure Cleaning vehicle)
  - Manual Sewer Cleaning Equipment (Hand Reel Winch Type)

RELEVANT INFORMATION OF SEWERAGE SCHEME

- Adoption of Treatment Method
  - Conventional Activated Sludge Method same as existing facility is adopted in Margao.
  - Oxidation Ditch Method & Sequencing Batch Reactor is examined in North Coastal Belt and Mapusa

Table F101.2.3 shows description of project components in each sewerage scheme.

Table F101.2.3 Rough Description of Priority Project Components in each Sewerage Scheme

Location	Unit	Margao	Mapusa	North Coastal Belt	Remarks
Population in the Expansion Area	Person	36,779	34,942	22,129	
Trunk Sewer Construction	km	6.0	3.9	6.1	
Branch Sewer Construction	km	44.2	31.5	47.8	
Pumping Station Construction	Nos.	1	0	1	
Treatment Plant Capacity	MLD	(7.5)+6.7	5.4	5.6	(Existing)

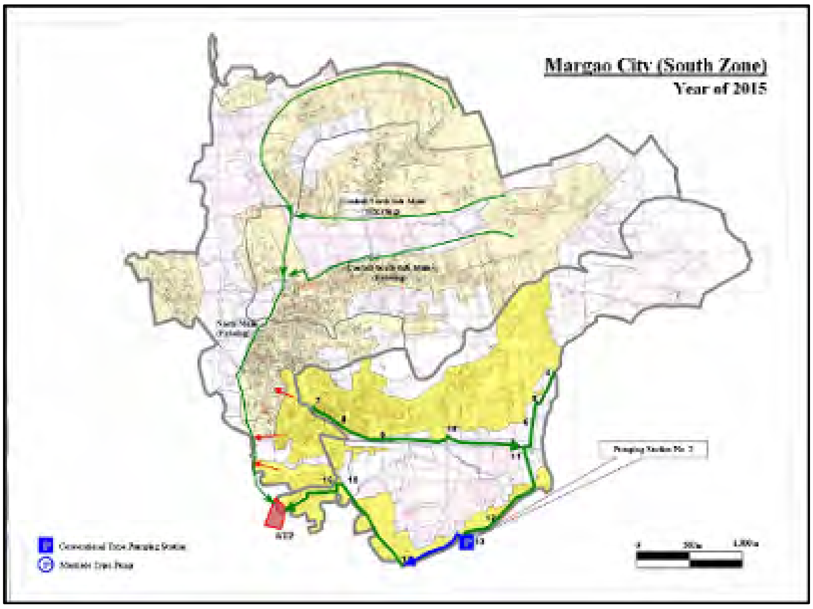


Figure F101.2.5 Priority Project Area of Margao Sewerage Scheme

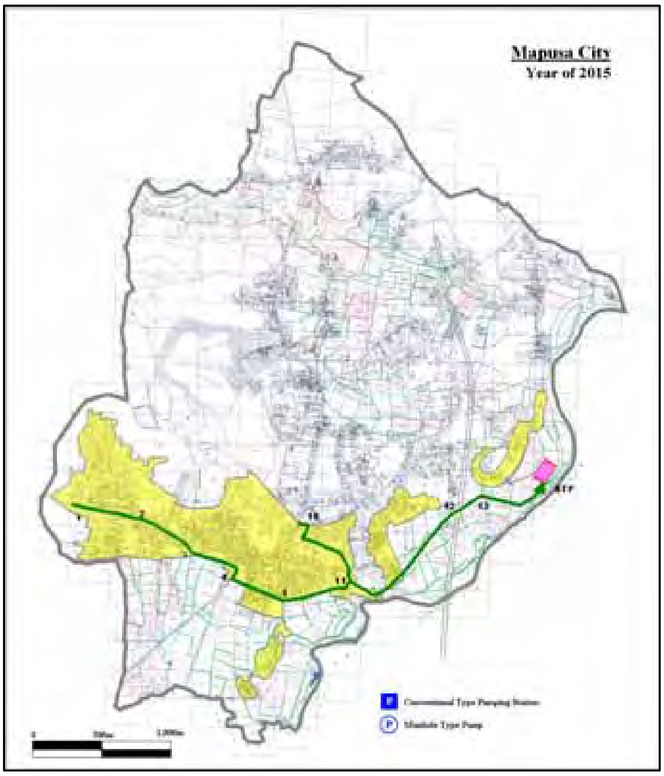


Figure F101.2.6 Priority Project Area of Mapusa Sewerage Scheme

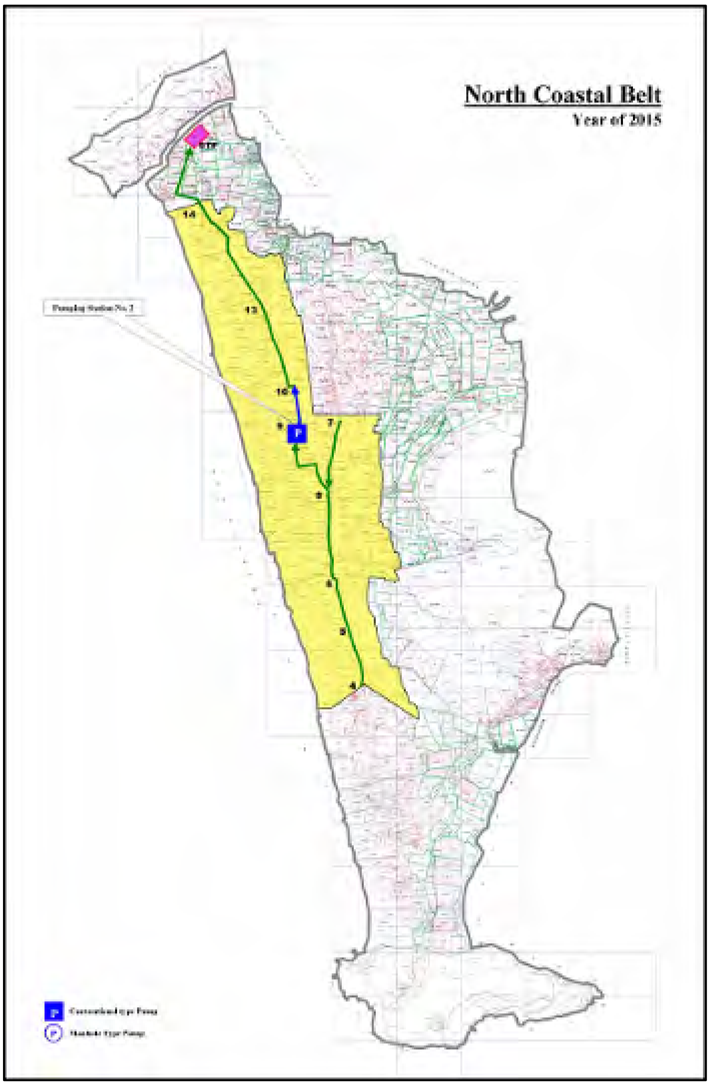


Figure F101.2.7 Priority Project Area of North Coastal Area Sewerage Scheme

PROJECT BENEFITS

- Improvement of water quality in rivers and beaches.
- Improvement of living environment including gutter and local streams.
- Reducing the overflows from existing septic tanks
- Improve sanitary conditions in the city
- Reduce risk of disease and enhance human health
- Nutrient rich sludge from STPs can reuse for horticulture, etc.
- Increase in employment opportunities during construction and O&M stage

PRESUMABLE IMPACTS AND POSSIBLE MITIGATION MEASURES

Table F101.2.4 Presumable Impact and Possible Mitigation Measures for Sewerage Project

Major Item	Impact and Mitigation Measures
Sewage Treatment Plant	
• Resettlement	• STP and pumping station sites are selected to avoid resettlement
• Income loss due to land acquisition	• To be compensated by money or alternative land in accordance with the Land Acquisition Act
• Odour	• Adoption of wastewater and sludge treatment processes causing less odour
• Sludge disposal	• Appropriate reuse or recycle of sludge
• Water contamination in receiving body	• Disinfection with chlorination • Ensuring appropriate O&M of sewerage facilities • Setting up of water quality monitoring
• Noise and vibration causing by construction work	• Adoption of adequate construction method to avoid noise and vibration
Pumping Stations, Trunk Sewers and Branch Sewers	
• Noise and vibration causing by construction work	• Adoption of adequate construction method to avoid noise and vibration
• Traffic delay by construction	• Construction work in night time or intensively

Appendix F102

Results of Rapid – Environmental Impact Assessment

Contents for Appendix F102

REPUBLIC OF INDIA
Government of Goa
PUBLIC WORKS DEPARTMENT

AUGMENTATION OF WATER SUPPLY AND SANITATION FOR THE GOA STATE

FEASIBILITY STUDY

RAPID ENVIRONMENTAL IMPACT ASSESSMENT REPORT

For

the Priority Projects of Study for Augmentation of Water Supply and Sanitation for the Goa State

Final Report Volume V
Appendix F104.1

September 2006

Public Works Department, Government of Goa
in Collaboration with
JICA Study Team

TABLE OF CONTENTS

Rapid Environmental Impact Assessment Report for the Priority Projects of Study for Augmentation of Water Supply and Sanitation for the Goa State

Chapter 1 General Purpose of the EIA Study

1.1 Background of Rapid-EIA Implementation

This Appendix of the Study on Augmentation of Water Supply and Sanitation for the Goa State deals with the Environmental Impact Assessment of the selected Priority Projects. This Appendix was prepared as a part of the Final Report of the Study.

The purpose of performing the Rapid Environmental Impact Assessment (Rapid-EIA) for the *Study for Augmentation of Water Supply and Sanitation for the Goa State* is to identify various environmental factors affected by selected priority projects implementation for the Feasibility Study. The Rapid-EIA undertaken as part of the Goa Water Supply and Sewerage Projects considers the potential and predictable environmental and social impacts on the construction phase and operation & maintenance phase of wastewater due to the Priority Project. Only the Rapid-EIA study of the priority projects needs for a required environmental clearance complying with the Guidelines for Environmental & Social Considerations for international donor agencies. In case of this priority projects, Public Works Department of Goa State is responsible proponent for carrying out the Rapid-EIA study.

In practice, Water Supply and Sewerage Projects are not included targeted sectors for EIA requirement in National level. However, environmental clearance is necessary in relation to any development projects within Goa State. Accordingly, the Rapid-EIA report must submit to the Impact Assessment Wing as soon as practicable to obtain the permission of environmental and social consideration clearance.

1.2 Scoping Study and the Need for an Environmental Impact Assessment

India’s Ministry of Environment, established in 1985, set up the Environmental Appraisal Committee that has the responsibility of scrutinising projects from the environmental point of view and suggesting safeguards to mitigate adverse environmental impacts.

According to the Terms of Reference a separate detailed Rapid-Environmental Impact Assessment (EIA) of the priority project to assist the PWD in making planning and design decisions, in carrying out construction, and in operating the complete facilities in an environmentally sound manner will be undertaken either at the conclusion of this feasibility study or when the physical description of all of the components of the proposed project is substantially clear.

In this report, in addition to the major environmental issues specific to each site, the existing environmental baseline data and socio-economic status of the population in the project area, the maximum environmental benefits, improvement in living conditions and human health that are gained from the investment which will be made, are discussed together with the possible negative impacts and related mitigation measures during the implementation and operation phases of the project. In view of these aspects, the options proposed for each component are assessed from the environmental point of view so as to ensure the sustainability of the Project.

1.3 Background of Water Supply and Sewerage Development

There are seven existing surface water supply schemes in Goa and existing small scale groundwater supply schemes. Water supply service is limited to several hours each day even in the capital city Panaji. Water demand is continuously increasing due to population growth and economic development. This is beginning to constrain socio-economic development in Goa.

Only the cities of Panaji, Vasco, and part of Margao are serviced by conventional sewerage systems. The average coverage ratio is only 13 %, which is lower than the national average. Even where sewer pipelines are installed, the connection ratios remain low (e.g. 30% in Margao and 19% in Vasco). People who are not connected to the sewerage system mainly use on-site sanitation (e.g. pit latrines). During the peak tourism season the populations in coastal areas double and therefore the volume of sewage generated increases. During the rainy season many septic tanks overflow due to rises in the groundwater table.

There is a clear need for additional water supply and sewerage system capacity in Goa, especially for cities, industrial estates and tourism resorts. Therefore, during 2002, the Government of India requested an assistance of the Government of Japan concerning the augmentation of water supply and sanitation for Goa. As requested, the JICA Study Team has been currying out its study work on augmentation of water supply and sewerage/sanitation in the study areas shown in Figures F102.1.1 and F102.1.2.

Figure F102.1.1 Water Supply Study Area

Figure F102.1.2 Sewerage/Sanitation Study Areas

The Master Plan has been formulated in the second phase of the Study by mid-January 2006. The Water Supply Master Plan covers seven water supply schemes. The master plan was developed to solve existing problems, which the PWD and people of Goa currently experience. It was also developed to increase the water supply capacity and to provide an adequate transmission system. The existing supply capacity is not sufficient to meet potential water demand. The sanitation study area covers Margao Municipality; Ponda Municipality; Mapusa Municipality; the South Coastal belt; the North Coastal belt; and Panaji Municipality including its surrounding area (Porvorim, Taleigao, Dona Paula, Caranzalem, St. Cruz, Merces, Ribandar).

Major objectives of the Study are to:

- formulate a Master Plan for augmentation of water supply and sanitation in Goa State based on requirements up to 2025;
- conduct a Feasibility Study for priority project(s) which will be selected from the Master Plan; and.
- pursue technology transfer to the counterpart personnel in the course of the Study.

Chapter 2 Policy, Legal and Administrative Framework

2.1 Institution and Jurisdictions

2.1.1 Environmental Agencies

(1) Ministry of Environment and Forests

Ministry of Environment and Forest (MoEF) is the agency, in the administrative structure of central government, for planning, promotion, co-ordination and overseeing the various environmental protection and forest conservation programmes. The Ministry is responsible for effective implementation of environmental legislation through its various divisions at Central Government level and also through Central Pollution Control Board, State Departments of Environment and Forests, State Pollution Control Boards and Pollution Control Committees in the Union Territories, which serve as implementing agencies of the Ministry. Besides several legislative measures taken by the ministry to protect the wholesomeness of the environment, a National Conservation Strategy and a policy statement on Environment and Development, 1992, National Forest Policy, 1988 and statement on abatement of pollution, 1992 have also been evolved to tackle the environmental protection issues effectively.

The principal activities undertaken by MoEF consist of conservation & survey of flora, fauna, forests and wildlife, prevention and control of pollution, afforestation & regeneration of degraded areas and protection of environment, in the framework of legislations.

The main tools employed for achieving the above objectives include surveys, impact assessment, control of pollution, regeneration programmes, support to organisations, research and development, collection and dissemination of environmental information and creation of environmental awareness among target groups and stake holders at all levels of the country's population. Realizing the need for authoritative statistical data on environment, the work relating to collection, collation and analysis of environmental data and its depiction has been constantly taken-up through various projects.

The main functions of the ministry are:

- Environmental policy planning
- Effective implementation of legislation
- Monitoring and control of pollution
- Eco-development

- Environmental clearances for industrial and development projects
- Environmental research
- Promotion of environmental education, training and awareness
- Coordination with concerned agencies at the national and international levels
- Forest conservation development and wildlife protection
- Biosphere reserve programmes

2.1.2 Other Agencies Strongly Involved in Environment Management

(1) Central Pollution Control Board

The Central Pollution Control Board (CPCB), a statutory organisation, was constituted in September, 1974 under the Water (Prevention and Control of Pollution) Act, 1974. Further, CPCB was entrusted with the powers and functions under the Air (Prevention and Control of Pollution) Act, 1981.

It provides technical services to the MoEF under the provisions of the Environment (Protection) Act, 1986. The principal functions of the CPCB are as given below:

- Advise the central government on any matter concerning prevention and control of water and air pollution and improvement of the quality of air and water.
- Plan and cause to be executed a nation-wide programme for the prevention, control or abatement of water and air pollution;
- Co-ordinate the activities of the State Pollution Control Boards (SPCB) and resolve disputes among them;
- Provide technical assistance and guidance to the SPCB, carry out and sponsor investigation and research relating to problems of water and air pollution, and for their prevention, control or abatement;
- Plan and organise training of persons engaged in programme on the prevention, control or abatement of water and air pollution;
- Organise through mass media, a comprehensive mass awareness programme on the prevention, control or abatement of water and air pollution;
- Collect, compile and publish technical and statistical data relating to water and air pollution and the measures devised for their effective prevention, control or abatement;
- Prepare manuals, codes and guidelines relating to treatment and disposal of sewage and trade effluents as well as for stack gas cleaning devices, stacks and ducts;
- Disseminate information in respect of matters relating to water and air pollution and their prevention and control;
- Lay down, modify or annul, in consultation with the State Governments concerned, the standards for stream or well, and lay down standards for the quality of air; and

- Perform such other function as may be prescribed by the Government of India.

2.2 Legislative and Regulatory Framework

2.2.1 General

The Water (Prevention and Control of Pollution) Act and the Environment Protection Act promulgated in 1974 and 1986 respectively deal with the prevention and control of water pollution. The latter is considered as an umbrella act covering all aspects of the environment, under which the Central Government can take appropriate measures for:

- protecting and improving the quality of the environment, and
- preventing, controlling and abating environmental pollution.

The Pollution Control Boards (PCB) was established under this Act both at the Central Government and also at the State Government level.

The Priority Projects of Study for Augmentation of Water Supply and Sanitation for the Goa State will be executed by the Public Works Department (PWD), State Government of Goa. The PWD will co-ordinate with different government Departments like Revenue Department, Forest Department, Water Resource Department, and State Pollution Control Board at various stages of the implementation of the project and also during the operation phase of the project.

During the construction phase mitigation measures necessary as per Water Pollution Control Act, 1974, Air (Prevention and Control of Pollution) Act, 1981 and Environmental Protection Act, 1986 will be taken. Since the State Pollution Control Board is the enforcing agency for these Acts, the PHED will seek their advice, whenever necessary.

2.2.2 Living Environment

(1) Water Quality

The Central Pollution Control Board and the State Boards initiated the implementation of the Water (Prevention & Control of Pollution) Act enacted in late 1974, from the year 1975. The Water Act is applicable to all Union Territories and has been adopted by all the states, by resolution passed on that behalf under clause (I) of Article 252 of the Constitution. Under the provisions of this Act, no discharge of wastewater can be made into the environment without obtaining prior consent from State Pollution Control Board (from the Central Pollution Control Board, in case of Union Territories). Consent prescribes the volume and quality of wastewater, in terms of concentration of various pollutants, which is permitted for discharge into the environment. The Act allows both the Union Territories and the State Governments and their respective Pollution Control Boards, to make rules implementing the Act. In case of a conflict, however, the Union Government rules prevail.

The standards were stipulated by the Boards for discharge of industrial water depending upon the receiving water body, be it a sewer, nallah, river or other inland surface water body or coastal marine waters. The standards were stipulated also for treated liquid waste disposal on land for irrigation purpose. These standards were updated from time to time.

(2) Air Quality

The Air (Prevention and Control of Pollution) Act, 1981 was formulated by the Central Government to regulate air pollution from various sources. Under this Act, the standards for various pollutants namely SO_2, NO_x, Suspended Particulate Matter, CO, hydrocarbons and several other air pollutants were stipulated by CPCB to protect the ambient air quality. The emissions from various stacks and other elevated sources were also simultaneously regulated as per recommended standards by the State Boards under the guidelines given by the Central Pollution Control Board. These standards were granted by the Boards by way of granting consent to establish and to operate the industry. The noise levels were also regulated by stipulating noise for residential areas and industrial areas.

(3) Environment Protect Act

After implementation of the above mentioned Acts, the Environment Protection Act, 1986 came into practice. This Act has an overriding effect on the other earlier environment Acts. The Ministry of Environment and Forest (MoEF) was established under this Act. The Director of MoEF is the administrative head of this organisation.

The Act is an Omnibus Act subsuming the various pollution control, wildlife, forest conservation acts. The Act therefore links the pollution control and natural resource conservation issues. The Act empowers the Union Government to make rules providing standards in excess of which environmental pollutants shall not be discharged or emitted into the environment. It also empowers the Union Government to make rules regarding handling, storage, manufacture and import of hazardous substances including wastes. Violation of these rules constitutes a crime which is punishable by imprisonment and/or fine.

(4) Forest Act

Much before it became concerned about the negative impacts of pollution on the environment, India became concerned about the diminishing natural resource represented by forests. Initially, forests were perceived as a source of revenue, this perception has recently given way to the concept of forests as a vital link in maintaining the environment and halting its degradation.

In response to the former perception, the Forest Act was enacted in 1927 to consolidate all existing laws relating to forests and control trade in timber and other forest produce. The Act defined “Reserved” and “Protected” forests and laid down the procedure for acquiring land deemed reserved or protected forests under the Land Acquisition Act, 1894. However, measures in this Act proved inadequate to halt the rapid depletion of India’s forests after independence.

This resulted in the Union Government enacting a law, the Forest Conservation Act, in 1980, to control India’s rapid deforestation. It supplements the Forest Act, 1927 by: (1) imposing restrictions on the provision to reserved forests in the Forest Act, 1927; (2) requiring prior approval of the Central Government for diversion of forest areas for non forest purposes; and in case of approval, (3) requiring compensatory afforestation of equivalent area of non forest land. The administrative agency in case of the provisions of the Forest Conservation Act, 1980, is the Union Government. However, as long as it does not involve felling of trees, only limited information needs to be given about the status of the forested area. A compensatory afforestation plan has to be submitted for all activities requiring clearance from the Ministry of Environment and Forests.

(5) Notification of Environmental Impact Assessment

The MoEF enforced the notification in January 1994 for conducting Environmental Impact Assessment (EIA) studies which are obligatory for the establishment of certain categories of industries specified in Schedule I. The Schedule I industries include the fertiliser, petrochemical, pharmaceutical, dyes and paint, iron and steel manufacturing industries, thermal power plants, mining industries and also port and harbour and the river valley projects. The Notification, Schedule I is detailed in Appendix for Master Plan Volume IV M112 Environmental and Social Considerations for Implementation.

The appraisal committees comprising experts, Governmental official and non-government organisations (NGOs) were set up by the MoEF to scrutinise various EIAs prepared for the establishment of such industries and projects. The appraisal committees would accord an environmental clearance to the project in consultation with MoEF after scrutinising the EIA report for the priority projects.

2.2.3 Natural Environment

(1) Biodiversity

India is a Party to the Convention on Biological Diversity (1992). Recognizing the sovereign rights of States to use their own biological resources, the Convention expects the parties to facilitate access to genetic resources by other Parties subject to national legislation and on mutually agreed upon terms (Article 3 and 15 of CBD). Article 8(j) of the Convention on Biological Diversity recognizes contributions of local and indigenous communities to the conservation and sustainable utilization of biological resources through traditional knowledge, practices and innovations and provides for equitable sharing of benefits with such people arising from the utilization of their knowledge, practices and innovations.

Biodiversity is a multi-disciplinary subject involving diverse activities and actions. The stakeholders in biological diversity include the Central Government, State Governments, institutions of local self-governmental organizations, industry, etc. One of the major challenges before India lies in adopting an instrument, which helps realise the objectives of equitable sharing of benefits enshrined in the Convention on Biological Diversity.

The parameters set out in this report are to assist in the identification of specific areas in different regions of India which could be categorized as ecologically fragile or sensitive. They aim to help in ensuring that they are not subjected to environmentally unacceptable activities. Some fragile or sensitive ecosystems are listed. They include ecosystems: with unique properties; with intrinsically low resilience; with high species richness and biological diversity; susceptible to species loss; linking two or more protected ecosystems; with aquifers and water recharge areas of mountain springs; and those with active geological faults and seismic hazards. The parameters are outlined in sections on various ecosystems: deserts, Himalayas, glaciated areas, seismic zones, landslide zones, and watersheds.

(2) Forest Resources

Much before it became concerned about the negative impacts of pollution on the environment, India became concerned about the diminishing natural resource represented by forests. Initially, forests were perceived as a source of revenue, this perception has recently given way to the concept of forests as a vital link in maintaining the environment and halting its degradation.

In response to the former perception, the Forest Act was enacted in 1927 to consolidate all existing laws relating to forests and control trade in timber and other forest produce. The Act defined “Reserved” and “Protected” forests and laid down the procedure for acquiring land deemed reserved or protected forests under the Land Acquisition Act, 1894. However, measures in this Act proved inadequate to halt the rapid depletion of India’s forests after independence.

This resulted in the Union Government enacting a law, the Forest Conservation Act, in 1980, to control India’s rapid deforestation. It supplements the Forest Act, 1927 by: (1) imposing restrictions on the provision to reserved forests in the Forest Act, 1927; (2) requiring prior approval of the Central Government for diversion of forest areas for non forest purposes; and in case of approval, (3) requiring compensatory afforestation of equivalent area of non forest land. The administrative agency in case of the provisions of the Forest Conservation Act, 1980, is the Union Government. However, as long as it does not involve felling of trees, only limited information needs to be given about the status of the forested area. A compensatory afforestation plan has to be submitted for all activities requiring clearance from the Ministry of Environment and Forests.

2.2.4 Public Participation/Awareness

The public has an important role to play in EIA. The concerned persons will be invited through press advertisement to review information and provide their views on the proposed development requiring environmental clearance.

The related law requires that the public must be informed and consulted on a proposed development after the completion of EIA report. Any one likely to be affected by the proposed project is entitled to have access to the Executive Summary of the EIA. The affected persons may include:

- Bona fide local residents;
- Local associations;
- Environmental groups: active in the area
- Any other person located at the project site / sites of displacement

They are to be given an opportunity to make oral/written suggestions to the State Pollution Control Board as per Schedule IV of the EIA Notification.

2.3 Environmental Policies

2.3.1 Local Environment Policy

The Water (Prevention and Control of Pollution) Act and the Environment Protection Act promulgated in 1974 and 1986 respectively deal with the prevention and control of water pollution. The latter is considered as an umbrella act covering all aspects of the environment, under which the Central Government can take appropriate measures for protecting and improving the quality of the environment, and preventing, controlling and abating environmental pollution.

The Pollution Control Board (PCB) was established under this Act both at the Central Government and at the State Government level for each state. The Water Supply and Sanitation projects for the State of Goa will be executed by the PWD, the Government of Goa. The PWD will co-ordinate in regard to performing environmental and social considerations for the projects with different state government departments such as the Forest Department, the Science, Technology & Environmental Department (DST&E), and the State Pollution Control Board at various stages of the implementation of the projects and also during the operation phase of the projects. In fact, Department of Science, Technology and Environment, Goa State is a responsible and Impact Assessment Agency of Environmental Clearance.

2.3.2 National Environment Policy

The MoEF enforced the notification in January 1994 for conducting Environmental Impact Assessment (EIA) studies which are obligatory for the establishment of certain categories of industries specified in Schedule I. The Schedule I industries include the fertilizer, petrochemical, pharmaceutical, dyes and paint, iron and steel manufacturing industries, thermal power plants, mining industries and also port and harbour and the river valley projects. Water supply and Sewage development projects were not listing in Schedule I.

The appraisal committees comprising experts, Governmental official and non-government organizations (NGOs) were set up by the MoEF to scrutinize various EIAs prepared for the establishment of such industries and projects. The appraisal committees would accord an environmental clearance to the project in consultation with MoEF after scrutinizing the EIA report for the proposed project.

2.4 Environmental Conventions Criteria

2.4.1 International Conventions

Related International Agreement and Commitment to Environmental Concerns in the Notification are below:

- Ramsar Convention on Wetlands of International Importance Especially as Waterfowl Habitat (2 February 1971), as amended
- Convention Concerning the Protection of the World Cultural and Natural Heritage (Paris, 12 November 1972)
- Convention on International Trade in Endangered Species in Wild Fauna and Flora (Washington, 3 March 1973)
- Bonn Convention on the Conservation of Migratory Species of Wild Animals (Bonn, 23 June 1979)
- The International Tropical Timber Agreement (Geneva, 18 November 1983)
- International Undertaking on Plant Genetic Resources (Rome, 23 November 1983) as supplemented
- Vienna Convention for the Protection of the Ozone Layer (Vienna, 22 March 1988) and Montreal Protocol on Substances that Deplete the Ozone Layer (Montreal, 16 September 1987)
- International Convention for the Prevention of Pollution from Ships (London, 2 November 1973), as amended
- International Convention for the Regulation of Whaling (Washington, 2 December 1946), as amended
- United Nations General Assembly Resolution 913 (X) Establishing the Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) (3 December 1955)
- Convention on Early Notification of a Nuclear Accident (hereafter Notification Convention), and Convention on Assistance in the Case of a Nuclear Accident or a Radiological Emergency (hereafter Assistance Convention), (Vienna, 26 September 1986)
- The convention concerning the Protection of Workers against Ionising Radiation (ILO Convention 115, Geneva, 22 June 1960) (hereafter, Radiation Protection Convention, 1960);
- The Convention concerning Protection against Hazards of Poisoning Arising from Benzene (ILO Convention 136, Geneva, 23 June 1971) (hereafter, Benzene Convention, 1971);

- The International Convention on Civil Liability for Oil Pollution Damage, Brussels 1969 (CLC)
- The International Convention on the Establishment of an International Fund for Compensation of Oil Pollution Damage, Brussels 1971 (Fund Convention);

2.4.2 Environmental Standards

(1) Water Pollution

In order to protect various water bodies, standards for treated industrial waste / treated domestic waste have been prescribed by the Central Pollution Control Board (CPCB), New Delhi. These standards are different for different types of receiving bodies. Treated effluent / treated sewage to be discharged into any of the following shall meet the relevant standards as prescribed by RPCB:

- into inland surface waters,
- into municipal sewers,
- on land for irrigation,
- into marine coastal waters.

If treated sewage is to be used for irrigation, as is proposed in the sanitation project, upper limits for important parameters will be:

Table F102.1.1 Treated Water Quality for Irrigation

Parameter	Unit	Limits
BOD_5	mg/l	100
Suspended Solids	mg/l	200
Dissolved Solids	mg/l	2100
pH		5.5-9.0
Oil & Grease	mg/l	10
Arsenic	mg/l	0.2
Boron	mg/l	2.0
Cyanide	mg/l	0.2
Chloride	mg/l	600
Sulphate	mg/l	1000

Source: CPCB, Standards for discharge of Industrial/Domestic wastewater

In addition to the standards prescribed by the CPCB, the project proposes to take into account the WHO guidelines for wastewater reuse for irrigation of level B (cereals, industrial and fodder crops, pasture and trees). These guidelines were elaborated by WHO after reviewing epidemiological studies of untreated wastewater reuse. This review led to the conclusion that the danger of infection is:

- high with intestinal nematodes;
- moderate with bacteriological infections and diarrheas;
- minimal with viral infections and diarrheas, and hepatitis A; and
- high to non existent with trematode and cestode infections, schistosomiasis, clonorchiasis, and taenisis, depending on local practices and circumstances.

The WHO guidelines are given in the following table.

Table F102.1.2 Recommended Microbiological Quality Guidelines for Wastewater Use in Agriculture

Category	**Reuse conditions**	**Group exposed**	**Intestinal nematodes (arithmetic mean no of eggs per liter)**	**Fecal coliforms (geometric mean no. per 100ml))**	**Wastewater treatment expected to achieve required microbiological quality**
A	Irrigation of crops likely to be eaten uncooked; sports fields, public parks.	Workers, consumers, public	≤1	≤ 1,000	Series of stabilization ponds designed to achieve the microbiological quality indicated, or equivalent treatment
B	Irrigation of cereal crops, industrial and fodder crops; and pasture and trees.	Workers	≤ 1	No standard recommended	Retention in stabilization ponds for 8-10 days for equivalent helminth and fecal coliform removal
C	Localized irrigation of crops in category B if exposure of workers and the public does not occur.	None	Not applicable	Not applicable	Pretreatment as required by irrigation technology, but not less than primary sedimentation

Source: Health Guidelines for the Use of Wastewater in Agriculture and Aquaculture. Technical Report No.778. WHO, Geneva. 1989

(2) Air Quality

It will be necessary for the project execution agency to maintain air quality within mentioned limits for various parameters. The detailed ambient air quality standards are given in Table F102.1.3

Table F102.1.3 Ambient Air Quality Standards

Pollutant	Time weighted average	Concentration in ambient air as µg/m^3		
		Industrial Areas	Residential and Rural Areas	Sensitive Areas
Sulphur Dioxide	Annual average 24 hours	80 120	60 80	15 30
Oxides of Nitrogen as NO_2	Annual average 24 hours	80 120	60 80	15 30
Suspended particulate matter (SPM)	Annual average 24 hours	360 500	140 200	70 100

(3) Noise

The noise levels at project sites and residential areas nearby should be as per stipulated standards given in Table F102.1.4

Table F102.1.4 Ambient Noise level standards

Area code	Category of Area	Limits in dB(A)	
		Day Time	Night Time
A	Industrial Area	75	70
B	Commercial Area	65	55
C	Residential Area	55	45
D	Silence Zone	50	40

Source : Central Pollution Control Board, Delhi, 1981

Day time is considered as 6.00 AM to 9.00 PM.

Chapter 3 Project Description

3.1 Water Supply Project

3.1.1 Background of the Project

Augmentation of Salaulim Water Supply Scheme was selected as the priority project because it is the most urgent. The first stage of this Scheme is recommended for the priority project, because

- Shortage of water in year 2025 for Salaulim Water Supply Scheme will be the most serious problem among 7 water schemes in Goa.
- Implementation of Salaulim Scheme is most economical comparing with other schemes.
- Salaulim Scheme supplies treated water to the major municipalities, which are Vasco, main port of the Goa State, Verna, the largest industrial area of the Goa State, Margao, the most populated city of Goa State, and part of capital city Panaji.

For other water supply scheme, the PWD is implementing projects for expansion of Assonora (40 MLD), Dabose (10MLD) and Canacona (10MLD).

The project scale was set based on a careful examination of water demand, supply capacity, raw water availability and the PWD's financial capabilities. The priority projects have been selected from the components of Stage 1 of the Salaulim Scheme. The priority projects are described below.

3.1.2 Objectives of the Project

The objectives of priority project in the F/S are to improve water supply situation in Goa,

- Through expanding the existing water supply schemes by constructing new water treatment plants
- Through enhancing the capacities of water transmission and distribution systems of major water supply schemes by rehabilitation of existing facilities, installment of new pipelines and construction of reservoirs, etc. and
- Through the improvement of the operation and maintenance of water supply system.

3.1.3 Component of the Priority Project

- Expansion of Salaulim Water Supply Scheme (for Mormugao, Salcete, Quepem, Sanguem)

- ✧ Expansion of the Salaulim Treatment Plant by 100,000 m^3/day, resulting in a total capacity of 260,000 m^3/day.
- ✧ Rehabilitation and Improvement of the Existing Salaulim Treatment Plant, which has a production capacity of 160,000 m^3/day.
- ✧ Construction of a 20,000 m^3 Master Balancing Reservoir (MBR) in Sirvoi.
- ✧ Installation of approximately 80 km of Transmission Mains.
- ✧ Construction of six Reservoirs.
- ✧ Construction of five Pumping Stations.
- ✧ Replacement of Pumping Equipment at the Verna Pumping Station.

3.1.4 Location map and Proposed Facilities for Priority Project

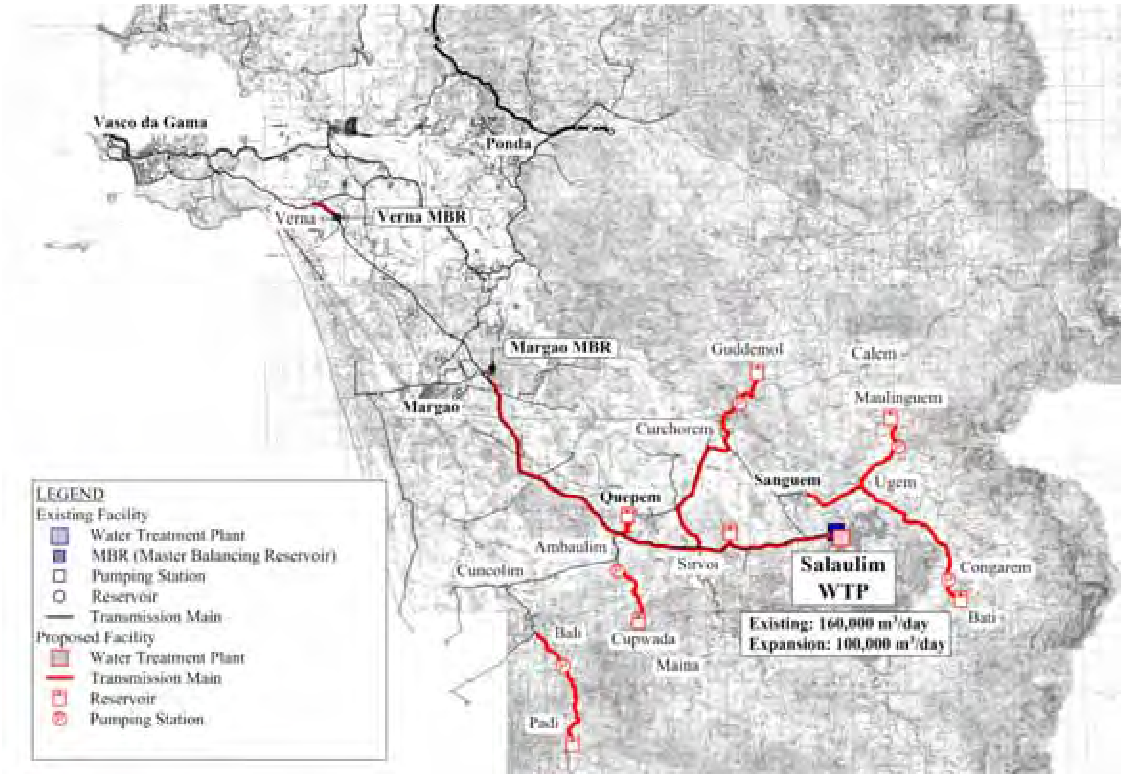


Figure F102.1.3 Location map of priority projects in Salaulim Water Scheme

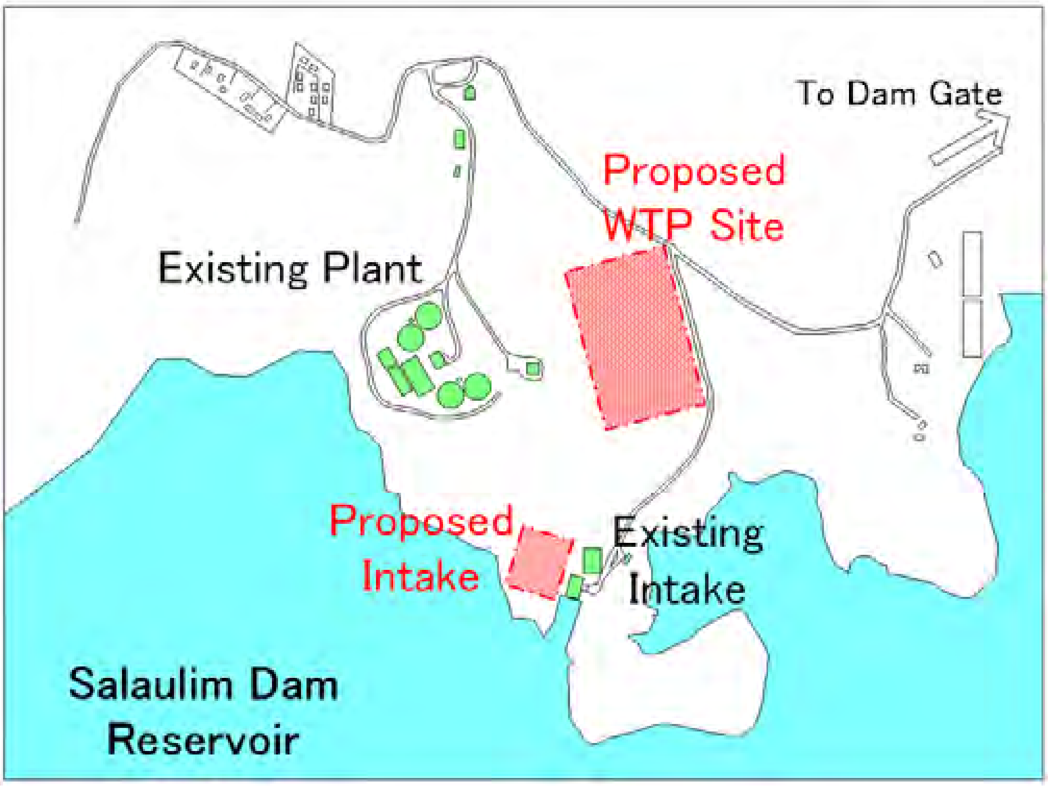


Figure F102.1.4 Proposed site of new Water Treatment Plant in Salaulim

3.2 Sewerage Project

3.2.1 Background of the Project

On the selection of priority projects, each project selected for sewerage was evaluated from the aspect of beneficiary, cost effects, positive impacts and urgency. The evaluation procedures are as follows:

- Resident and tourist population were taken into account as beneficiaries, five (5) points were given for the largest population and points were given proportional to the population, respectively for resident and tourist.
- Unit construction cost and O&M cost per sewage flow were considered for cost effects, five (5) points were given for the lowest value and zero (0) point was given for the highest value, others were calculated proportional to their value.
- The treatment plant capacity was evaluated as a positive impact; five (5) points were given for the largest STP. Points were given proportional to their capacities.
- Urgency was evaluated by the current condition of groundwater contamination (two (2)

points), overflow from soak pit (one (1) point) and dependency on well (two (2) points). The service block with the worst current condition received the maximum point.

The evaluation result is shown in the Table F102.1.5. The result shows that North Coastal Belt received the highest point, and Margao came second. The third is Mapusa and its point is very close to Margao.

Regarding the present situation of the sewerage services in the Study Area, the PWD Goa does not have sufficient institutional setup to run their services, resulted in low house connection rates. Under this situation, it is recommended to limit the number of priority project in order to manage and run sewerage systems at an appropriate level.

Considering above aspects, three (3) projects, namely North Coastal Belt, Margao and Mapusa were selected as priority projects. The Summary of the priority projects is shown Table F102.1.6.

Table F102.1.5 Selection of Priority Project

	Panaji	St. Cruz	Porvorim	Margao	Ponda	Mapusa	Colva	North Coastal Belt	Max Point
Beneficiary:									
Additional Population									
Resident	26,144	16,918	47,848	56,907	19,401	68,255	5,279	39,358	
Point	1.9	1.2	3.5	4.2	1.4	5.0	0.4	2.9	5
Tourist	8,737	0	1,653	2,605	2,097	1,703	5,231	20,261	
Point	2.2	0.0	0.4	0.6	0.5	0.4	1.3	5.0	5
Point for Beneficiary	4.1	1.2	3.9	4.8	1.9	5.4	1.7	7.9	10
Cost Effects									
Cost / Sewage capacity									
Construction cost	394,000	115,000	370,000	513,000	142,000	469,000	111,000	493,000	
Construction cost/Sewage	44.3	44.2	48.1	38.3	40.6	43.4	50.5	44.0	
Point	2.5	2.6	1.0	5.0	4.1	2.9	0.0	2.6	5
OM cost	30,800	7,000	15,300	34,100	7,900	17,100	7,400	17,700	
OM cost/Sewage	3.9	7.4	5.4	4.5	6.2	4.3	9.2	4.3	
Point	5.0	1.7	3.6	4.5	2.9	4.6	0.0	4.6	5
Point for Cost Effects	7.5	4.3	4.6	9.5	6.9	7.5	0.0	7.3	10
Positive Impacts									
Additional STP Capacity	8,900	2,600	7,700	13,400	3,500	10,800	2,200	11,200	
Point for Positive Impacts	3.3	1.0	2.9	5.0	1.3	4.0	0.8	4.2	5
Negative Impacts									
Point for Negative Impacts	0	0	0	0	0	0	0	0	
Urgency									
Groundwater	52%	67%	100%	33%	N.A	83%	N.A	63%	
Contamination									
Point	1.0	1.3	2.0	0.7		1.7		1.3	2
Overflow from Soak pit	18%	12%	12%	35%	31%	73%	18%	14%	
Point	0.2	0.2	0.2	0.5	0.4	1.0	0.2	0.2	1
Dependence on Own Well	N. A.	N. A.	N. A.	N. A.	N. A.	N. A.	7%	43%	
Point							0.3	2.0	2
Point for Urgency	1.2	1.5	2.2	1.2	0.4	2.7	0.5	3.5	5
Total Point	16.1	8.0	13.6	20.5	10.5	19.6	3.0	22.9	30
Rank	4	7	5	2	6	3	8	1	
Priority Project				★		★		★	

Table F102.1.6 Summary of Priority Project

Location	Unit	Margao	Mapusa	North Coastal Belt	Remarks
Population in the Expansion Area	Person	36,779	34,942	22,129	
Trunk Sewer Construction	km	6.0	3.9	6.1	
Branch Sewer Construction	km	44.2	31.5	47.8	
Pumping Station Construction	Nos.	1	0	1	
Treatment Plant Capacity	MLD	(7.5)+6.7	5.4	5.6	(Existing)

3.2.2 Objectives of the Project

The objectives of sewerage projects in the F/S are to improve urban sanitation in Goa,

- Through expanding the existing sewerage systems to areas around south part of Margao.
- Through constructing new sewerage systems in Mapusa and part of North Costal Belt.
- Through the improvement of the operation and maintenance of sewerage.

3.2.3 Component of the Priority Project

(1) Expansion of existing sewerage systems including sewer, pumping station and treatment plants

✧ Expansion of Margao STP (See Figure **F102.1.5** and **F102.1.6)**

✧ South Zone (Trunk sewer, Branch Sewer and 1 Pumping Station)

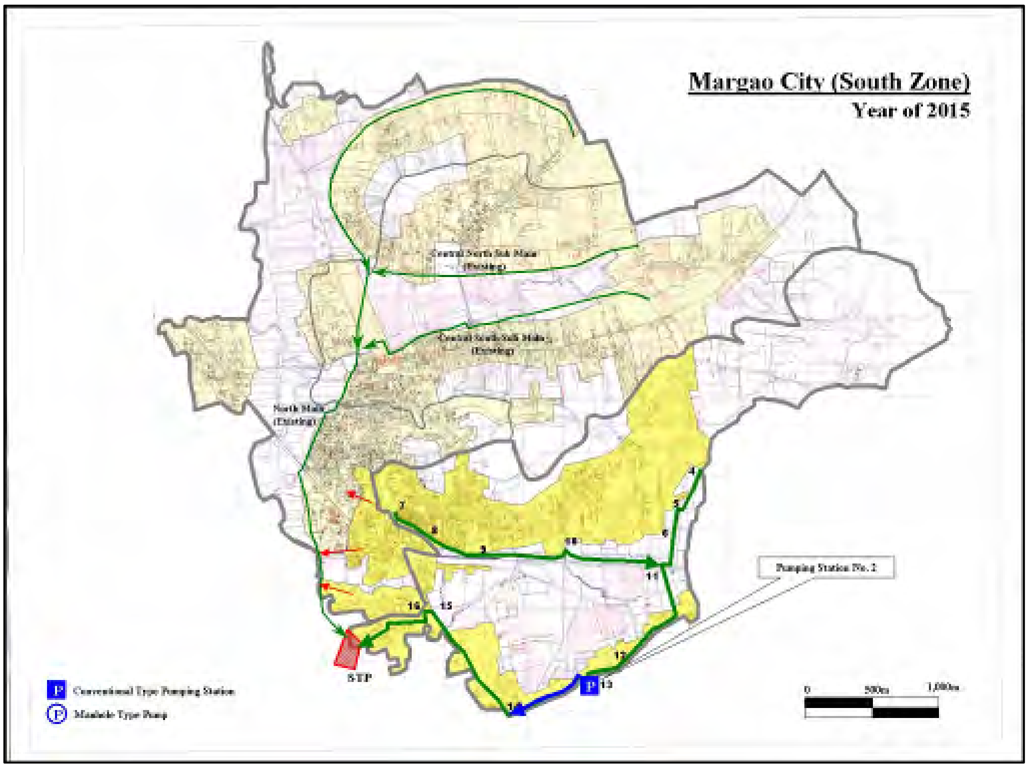


Figure F102.1.5 Location map of priority projects in Margao Scheme

Figure F102.1.6 Proposed site of new pumping station in south Margao

(2) Construction of new sewerage system including sewer, treatment plant and pumping station

- ✧ Mapusa (Mapusa STP, Trunk Sewer, Branch Sewer) (See **Figure F102.1.7 and F102.1.8**)
- ✧ North Coastal Belt (Baga STP, Trunk Sewer, Branch Sewer and 1 Pumping Station) (See **Figure F102.1.9 ~ F102.1.11**)

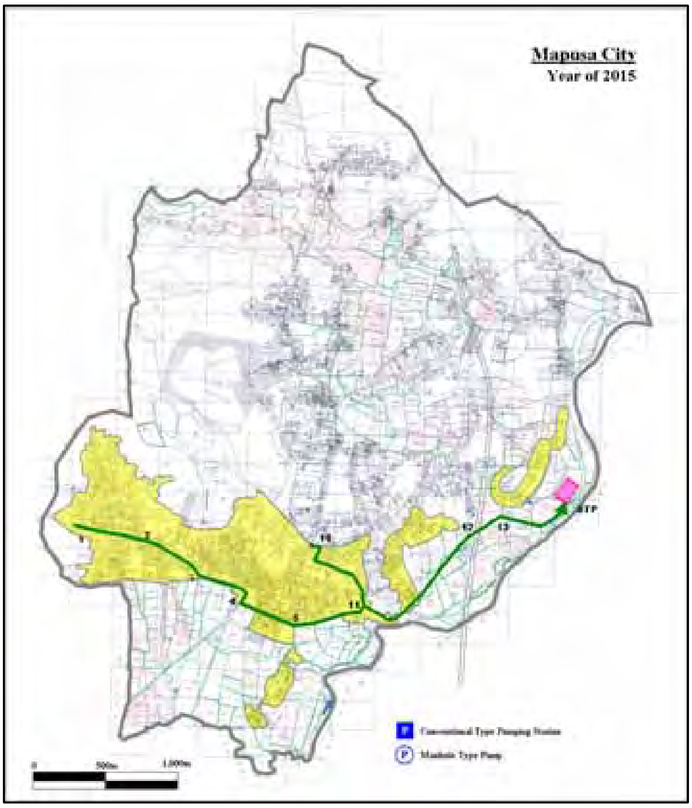


Figure F102.1.7 Location map of priority projects in Mapusa Scheme

Figure F102.1.8 Proposed site of new Sewage Treatment Plant in Mapusa

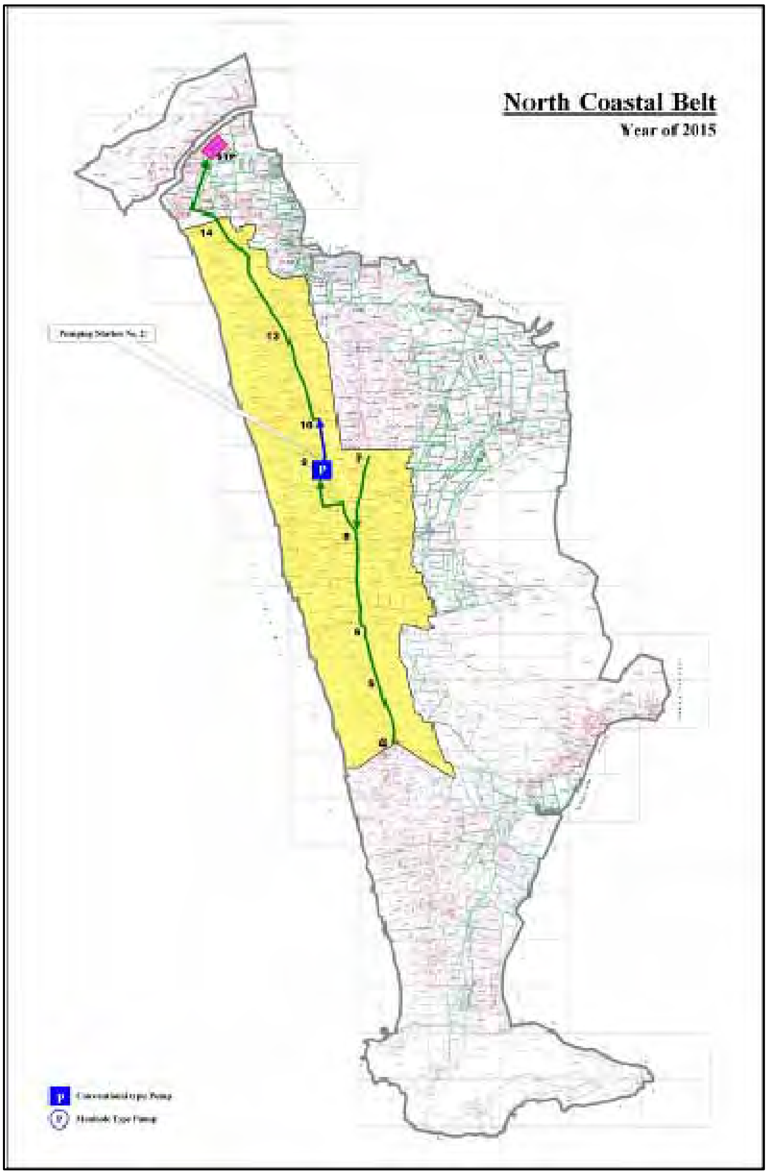


Figure F102.1.9 Location map of priority projects in North Coastal Belt Scheme

Figure F102.1.10 Proposed site of new Sewage Treatment Plant in Baga

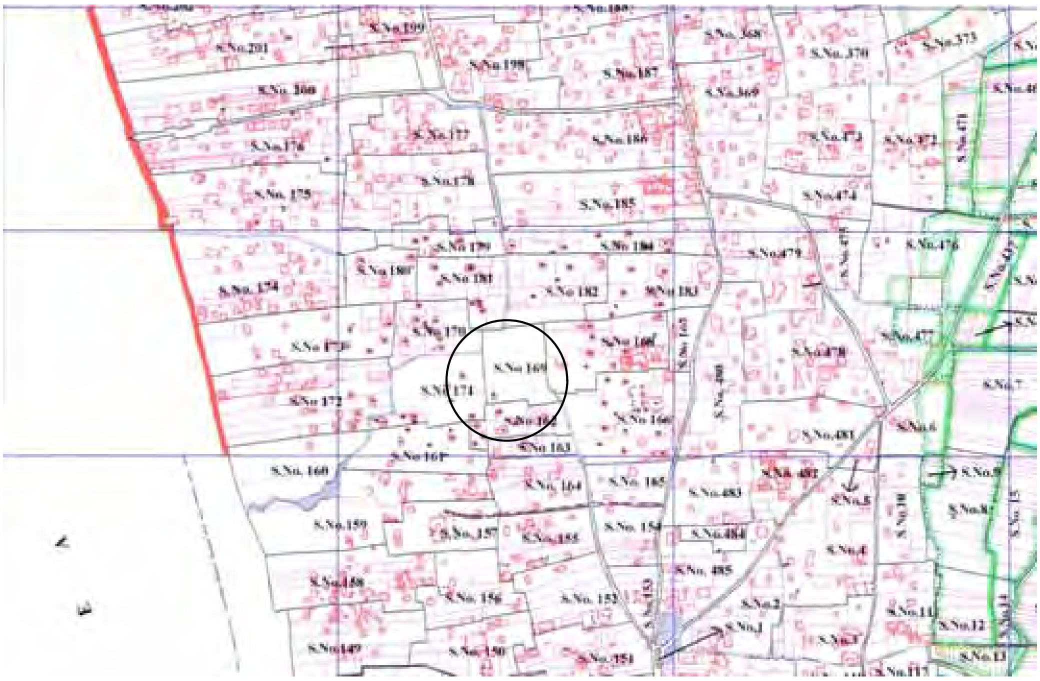


Figure F102.1.11 Proposed site of new Pumping Station in Calangute

(3) Installation of Sewer Cleaning Equipment

- ✧ Mechanized Sewer Cleaning Equipment (Sludge Vacuum vehicle and Pressure Cleaning vehicle)
- ✧ Manual Sewer Cleaning Equipment (Hand Reel Winch Type)

Chapter 4 Baseline Environmental Data

4.1 Study Area

The state of Goa is located on the western seaboard of India, about 600km south of Mumbai. The state is relatively small having an area of 3,702 km^2. Goa has 11 talukas which are divided into the two districts of North Goa and South Goa. The state capital is Panaji and the commercial capital is Margao.

Goa has similar physical features to those of the neighboring states of Karnataka and Maharashtra. Goa has the following three distinct geographical divisions:

(1) The Sahyadris Region

This region is located to the east, is mountainous, covers an area of approximately 600 km^2, and has an average elevation of 600m. The Sahyadris Region is covered by forest and is the catchment area of the rivers.

(2) The Middle Level Plateaus

At the centre of this region there are plateaus, with elevations of between approximately 30m to 100m. Iron-ore mining and cashew and spice plantations are common in this region. Although the soil depths are generally thin in this area, some low-lying areas are cultivated.

(3) The Costal Region

This region consists of the low lying river basins and includes the costal areas and the floodplains/alluvial flats. The Coastal Region has productive agricultural cultivation and therefore has rural agricultural settlements. There are also fishing villages and urban settlements.

4.2 Physical Environment

4.2.1 Topography

The land of Goa is a narrow strip of earth 105 km long and 65 km. Goa is a part of the West Coast region and is similar in physical features to the neighbouring regions of Karnataka and Maharashtra. However, some features contribute the Goan landscape and scenery a distinctive charm of their own.

There are three main physical divisions: the mountainous region of the Sahyadris in the east, the middle level plateaus in the centre and the low-lying river basins with the coastal plains. The most well-known part of Goa is the coastal belt that runs from north to south, while the least known is the Western Ghat region, which also runs from north to south in the barbaric land. Sandwiched in between is the midland region, apparently nondescript, but nevertheless with its own significant ecological and cultural characteristics

4.2.2 Geology and Soil Quality

The political boundaries of Goa correspond quite closely with its natural, geological features. The northern boundary, foe example, runs along the Tiracal River. On the eastern side, the boundary is demarcated by the *Sahyadris*; on the west, by the Arabian Sea. The southern section is closed off by a peak about 111 meters high near Polem.

The principal geological feature of the land is the extensive laterization which occurs because of Goa's position in the tropical moist climate, subject to vast seasonal changes. The laterite caps are extensive over most of the terrain, mountains, plateaus or plains.

4.2.3 Climate and Meteorology

Goa has balmy tropical weather, with temperatures generally ranging between 25℃ to 32℃ (during April-May and October-November the temperature exceeds 30℃ by noon). Goa has torrential monsoon rains between June and September. In Goa, about 90 percent of total rainfall occurs in a short period of 3 to 4 months, during the summer. Actually, the average annual rainfall is approximately 3000 mm, while the average rainfall during the monsoon season (June-September) is approximately 2700mm.

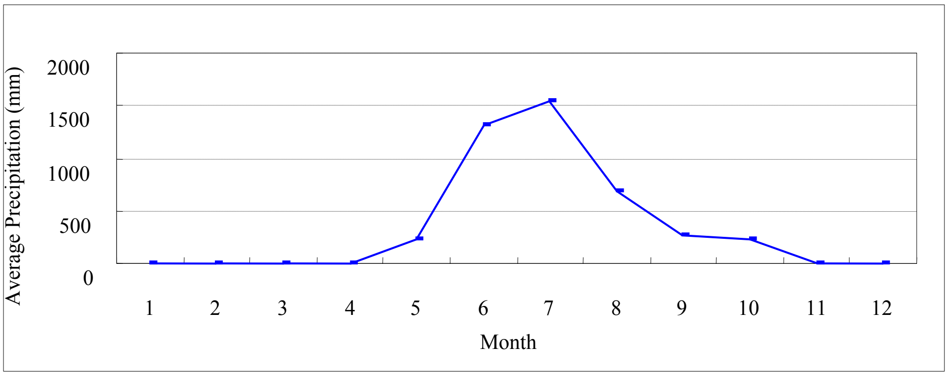


Figure F102.1.12 Average rain fall in each month

This rain occurs in the form of heavy showers with raindrops on the average 10 times bigger than the raindrops of the mid-latitude region. There are two major consequences of this: 7 to

8 months of the year, large tracts of the State are rainless. Part of this is a hot season: March to May in some parts of Goa. So the water that falls during the monsoon period loosens the soil and runs off the surface, filling *nallahs* and channels with valuable silt, and finally through the river system ends in the sea.

Therefore, although the rainfall is more than 1000mm over, about 60 percent of it is wasted as runoff, there being naturally little time for the water to percolate into the ground. In other words, an effective rainfall when not properly harvested or husbanded is only 200mm to 300mm.

4.2.4 River System

Tiracol, Mandovi, Zuari, Colvale, Sal, Talpona, Saleri, Canacona and Galgibaga are the main nine rivers of Goa. Due to the extent of their drainage areas and the human attraction they hold, these nine river and their 42 tributaries are significant. These rivers are not only the source of potable water but also support the Goan ecosystem. The surface water system of Goa is intimately linked up with their development since they provided irrigation facilities for agriculture, produce biotic and mineral resources, transport ore from the mining areas to the port and ferry people and goods to different parts of the state.

Goa’s rivers are tidal and rainfed. The huge volumes of monsoon water fall within the watershed areas and are then drained out through the major rivers to the sea.

Below-mentioned river basins or river systems are deeply-committed to the each selected priority project as water source and discharging watercourses.

(1) Zuari River System (Salaulim Water Supply Scheme)

The Zuari is the southern counterpart of the Mandovi and its sources lies entirely within Sanguem, Quepem, Salcete, Ponda, Mormugao and Tiswadi tulukas. The river has a meandering but entrenched course with wide valley sides abutted by heights, initially simulating high hill landscapes and progressively assuming westwards plateau forms at various levels. The river is also called Sanguem river up to Sanguem. Two major streams, the Uguem and the Guleli, join at Sanguem to form the Zuari river.

(2) Sal River System (Margao Sewerage Scheme)

The Sal originates near Verna and runs southwards to join the Arabian Sea at Betul. The tidal effect is experienced up to Kharebandh. River length is 35km. It has two tributaries, namely Navelim Nallah and Cuncolim Nallah.

(3) Mandovi River System (Mapusa Sewerage Scheme)

The Mandovi rises in the main Sahyadris in the dense forest of Karnataka. The river has the largest drainage basin and the greatest length: 81km. It is subject to tidal interference up to Ganjem village.

The water course is dotted with several islands. After a rather restricted course through the flat-topped range, the river emerges into a more open valley and from Bembol to Pilgao takes a north westerly course for about 17 km. As the tributaries join in, it develops a broad and slow-moving course, swinging towards the west to meet the Arabia Sea. The course is accompanied by remarkable changes in the landscapes and drainage. We see the typical features of a drowned topography with the island of Divar standing prominently in mid-course with its northern counterpart, the island of Chorao, not looking so prominent as an island because it is on the right bank of the Mandovi and encircled by the small but complex network of the Mapusa river drainage. Of the tributaries of the Mandovi, the Mapusa network of drainage and that of Khandepar are most important.

Mapusa Tributary: The tributary emerges from the dense mixed jungles of Dumacem and Amthane and flows southwards joining the Mandovi at Penha de Franca. The river is 26km long. The Mapusa drainage flow to the main river consists of threaded and ill-defined stream in board, flat and in some places marshy levels, skirted by the Nandoli-Porvolim-Mapusa-Assonora-Sirigao Plateau heights, and shows that the whole low level tract is an infilled alluvium, fed by waters as well as debris by the steep down cutting rivulets of the plateaurims, of which the Assonora stream is the longest.

(4) Baga River

The Baga River originates in the dense mixed jungles of Assagao, Bardez. A small stream which comes from the Saligao hilly area joins the river at Arpora. The Baga river is 10km long and flows into the Arabian Sea at Baga village

4.3 Biological Environment in Goa

4.3.1 The Western Ghats Ecosystem in Goa

The Western Ghats are one of the richest reservoirs of diversity in the world. The sections that within Goa (the Sahyadris) and which dominate its ecosystems readily reflect this bewildering complexity in plant, animal and bird life. Official recognition of the ecological value of this area has come in the form of gazette notifications declaring huge areas as sanctuaries or biosphere reserves.

The most important topographic feature of peninsular India is the Western Ghats range extending along its western margin. However, the Western Ghats are acknowledged to be one of 'hot spots' of biological diversity and endemism in the world.

All coastal fisheries on the west coast depend on the nutrient discharge into the coastal seas and subsequent marine productivity. The nutrients originate and are transported by rivers from the Western Ghats.

4.3.2 The Alluvial and Coastal Plains

The district ecological component of the Goa bioregion after the Western Ghat area and the lateritic plateaus is the alluvial lowland. These comprise the stretches of rivers which have over the centuries received the eroded material from higher levels of the Sahyadris.

4.3.3 The Coastal Region

The Goan coastal system is initially connected with the catchments areas of tidal rivers and streams. Theses are the source not only of water, but also of sediments, and hence, play an important part in the formation and maintenance of the coastal topography and ecosystem.

The Goan coastal system has, for instance, over many centuries adapted to inputs from the rivers, particularly the Mandovi and the Zuari. Areas near the river mouths cope with natural fluctuations caused by floods and cyclones.

4.4 Socio-Cultural Environment in Goa

4.4.1 Population

The population census of 2001 estimated the population of Goa to be 1,343,998. Four censuses have been completed for Goa (1971, 1981, 1991 and 2001). The census data shows that that the population growth rate of Goa decreased from 16.08% during 1981-1991 to 14.89% during 1991-2001 as shown in Table 102.1.7.

Table F102.1.7 Population of Goa

Year	Population	Decadal growth rate	Urban Population as percentage of total Population
1971	795,120	-	25.56%
1981	1,007,745	26.74%	32.03%
1991	1,169,793	16.08%	41.01%
2001	1,343,998	14.89%	49.77%

Source: Economic survey 2003-2004

In Goa, half of the total population lives in urban area. The increase in urban population has been occurring for some time, as shown in Table F102.1.7. For example, in 1981 32% of the population lived in urban areas, in 1991 this had grown to 41% and by 2001 49% of the population was living in urban areas. The urbanization in Goa is closely related to the development of the tertiary industry (service sector) in urban area.

4.4.2 Tourism Environment

The packaging Goa as a major international tourist destination is still actively underway. Tourism has come to dominate the economy and landscape of Goan life in a way that no other activity does. Tourism is ubiquitous and except for the fortunate few in the interior talukas, no Goan can live without acknowledging its existence and importance, or being affected by its fallout. Goa now receives more tourists per annum than its total resident population. The strain this places on scarce resources and infrastructure is enormous.

The evidence of pollution and environmental degradation, coupled with a dislocation of social and cultural values could no longer be ignored even by the Government. The sewage, garbage and plastic waste, including discarded plastic mineral water bottles, litter every nook and corner of the coastal villages.

Basic problem of tourism in Goa is that most of the foreign tourists appear during the winter season from November to January. Very few people with visiting Goa during the monsoons; as a result most tourist establishment work for only 6 months in the year (October to April) and are forced to lay off their workers for the remaining 6 months. Tourism in Goa therefore does not provide steady and uninterrupted employment and it is a common experience that after working for a few years in the tourist sector, most people are unable to cope with the interruption and try to move on to the other professions.

The contribution of the tourist industry to the Goan economy has increased substantially and is second only to mining. In 1994 the contribution was 11% to the State GDP, 7% to employment and 7% to total revenues.

4.4.3 Land Use

Figure F102.1.13 shows the current land use types, based on satellite images from the year 1999. The main land use characteristics are as follows:

- Most of the settlement and road development is concentrated in the costal talukas.
- Agricultural areas are located mainly along the rivers or near the coast.
- The areas used exclusively for plantations are located in the midlands, while the plantations that are interspersed with settlements are usually located in coastal areas.

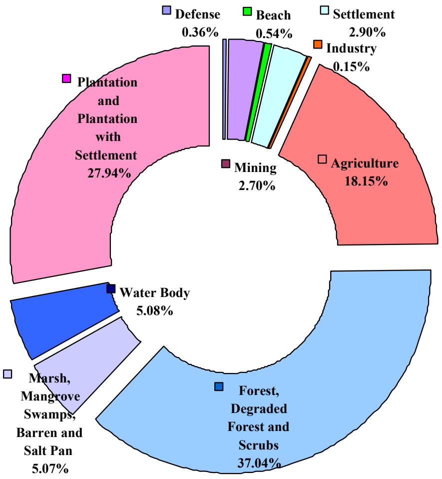


Figure F102.1.13 Existing land use distribution

4.4.4 Public Health

The most serious aspect of environmental hygiene seems to be related to the problem of disposal of sewage and industrial waste by cities, industries and beach resorts into the river and the sea. Modern life is also generating large quantity of garbage which Goans cities and towns are no longer able to cope with, since the bulk of it is non-biodegradable.

Chapter 5 Overall Impact Identification

5.1 General

The first step in Rapid-EIA is to identify the potentially significant impacts. The various aspects considered in impact identification of the project are as follows:

- project components,
- project phases,
- impact generating activities,
- type of impact.

The overall identification of the impacts has been done by using a matrix table which is a common tool to identify and present in a compact way the various impacts of a project. Thereafter the impacts are being described (Description Method) in more detail for the construction phase and the operation phase.

5.2 Impact Identification

In the matrix table, the activities are arranged in columns and environmental parameters in rows (Figure F102.1.14).

The matrix thus *identifies* the environmental factors likely to be affected, and the activities responsible for this. The cells which fall at the junction of an activity and an affected parameter have been shaded. The impacts may be negative or positive. This will be analysed further during the evaluation stage.

The environmental parameters that can be affected are:

- Natural parameters: soil, offensive odour, noise/vibration, water, flora and fauna
- Socio-cultural parameters: waste/sludge, land use, socio-economic, public health, traffic, land acquisition
- Project implementation parameters: worker health

Phases	Construction Phase						Operation Phase				
Parameter	Site Clearance	Excavation	Transportation	Construction	Soil Compaction	Constru. Camps	Energy Utilization	Treatment Plant O&M	Effluent Discharge	Sludge Disposal	Transport
Soil Quality	▨	▨			▨	▨				▨	
Offensive Odour								▨	▨	▨	▨
Noise/Vibration	▨	▨	▨	▨			▨	▨			▨
Water Pollution	▨	▨		▨		▨		▨	▨	▨	
Flora & Fauna	▨								▨		
Waste/Sludge		▨		▨		▨		▨	▨	▨	
Land use	▨	▨			▨					▨	
Socio-Economic			▨	▨		▨		▨			▨
Public Health			▨	▨		▨		▨	▨	▨	▨
Traffic	▨	▨	▨					▨			▨
Land Acquisition	▨										
Worker Health				▨		▨					

Figure F102.1.14 Impact Identification Matrix

A preliminary scrutiny has been made for the two phases of the project:

(1) Construction Phase:

The first activity of the Construction Phase involves site clearance and site access. This activity will have impacts on water, noise, soil, and land use within the project area. Construction of the components of the priority projects will have some negative impacts on air, noise/vibration, water, etc. due to excavation works, civil and related construction works. These impacts will be for short duration. However, green belt and tree plantation development plan to be undertaken during the construction will have positive impacts not only on ecology but also on air and noise quality of the region after the plants come to the desired heights and density. Marginal impacts are anticipated on aesthetics and human interest also.

(2) Operation Phase:

Operation of the system will not affect the quality of air, water noise and soil/land substantially. The generation of fugitive and process dust is minimised. Discharge of untreated water or wastewater will affect the quality of the receiving medium.

The glossary for the impact identification of the following socio-cultural parameters - land use, land acquisition, socio-economic, and population - is as follows:

- The parameter “Land Use” is expected to be affected during the following actions of the project as they involve use of land: site and route identification, site clearance and excavation, soil compaction, sewage treatment, treated water disposal and sludge disposal.
    - In the *site and route identification*, the land is identified as suitable for the project. Preparations are made for acquiring the land before the beginning of the construction. Once the land is acquired, it is cordoned off and is out of bounds for the public.
    - If only the right of way is acquired, the activities such as *site clearance and excavation* temporarily disturb the existing land use which can be restored by adequate *soil compaction*. But once the sewage treatment plant is built, it permanently changes the land use.
    - *Treated water disposal* has been given a special mention since it can make the land suitable for agriculture once again and accommodate year long irrigation and change the cropping pattern.
    - *Sludge disposal*, as manure, again can increase the fertility of the land and help in changing the cropping pattern.

- "Land acquisition" is considered separately. Land acquisition changes land use and it is affected only once, when the land is acquired. It can have positive and/or negative impacts.
- "Socio-economic" parameter should be understood as the income generation and employment opportunities available to the local public in the project area. This parameter is positively affected during each stage of the project.
- "Population" is the number of people or settlements that can be positively or negatively affected by the project. For instance due to the increase of agricultural activities as a result of availability of treated effluent, the population downstream of the treatment plant site can increase.

Chapter 6 Anticipated Environmental Impacts & Mitigation Measures

The following summarizes the results of Rapid-EIA regarding to the impact evaluation and recommended mitigation measures.

6.1 Impacts during Construction Phase

6.1.1 Land acquisition and compensation procedures

Projects sites have been selected avoiding residential, commercial and industrial areas. Therefore, the selected project sites for STPs, WTPs, etc. are vacant lands, woodlands, horticultural lands or open land, which belong to the state government, government agencies, communities (communidade). The land types of the proposed sites are summarized in the following table.

Table F102.1.8 Land Types of the Proposed Site for Priority Projects

Project Component Requiring Land	Capacity of Facility to be Expanded and Newly Constructed	Area Need to Be Acquired	Types of Ownership	Type of Land Use
New Salaulim WTP	20,0000 m^3/d	8ha+2ha(intake)	Government	Woodland
Master Balancing Reservoir at Sirvoi	4,0000 m^3/d	3ha	Government	Woodland
Expansion of Margao STP	13,400 m^3/d	-	Government	Within the premises
Mapusa STP	10,800 m^3/d	15,500 m^2	Community-trust	Open land
Calangute/Candolim STP	11,200 m^3/d	15,800 m^2	Government	Open land

Resettlement of residents and removal of valuable structures are not required for the acquisition of those lands. Moreover, the land types of these sites are not particular in the contexts of surrounding environment, therefore it is unlikely to be difficult to require nearby similar lands by the original land owners of the proposed sites. For these reasons, the level of negative impacts caused by the land acquisitions is considered not to be significant.

The practical and presumable mitigation measures of the impacts caused by the land acquisitions include the provisions of compensation money and substitute land. The following explains the procedures of land acquisition and its compensation.

Land Acquisition Act, 1894 is applied to the acquisition of the lands from communidade and private owners. According to the Land Acquisition Act, a land acquisition plan has to be proposed to the Collector of either North Goa or South Goa to acquire a land in Goa. Then the Collector appoints a land acquisition officer in the region to implement the land acquisition. The PWD have one land acquisition officer in Panaji for their concerned work. According to a land acquisition officer, the normal duration of land acquisition is within 2 years. However, in the case of emergency lands can be acquired within about 6 months.

The following equation is used to calculate the compensation money for land acquisition.

Total Compensation (Rs) =
Land Cost (Rs) × (100% + Additional Compansation: 12% + Solatium Charges: 30%)
+ Cost of Trees and Crops (Rs) + Cost of Structures (Rs)

The appointed land acquisition officer evaluates the land cost based on the recent sells statistics of the lands which are located within 2km in radius from the land to be required. The total cost of trees and crops in the land is evaluated by the Zonal Aquiculture Office of the Forest Department. The cost of existing structures is evaluated by the PWD.

Although the Land Acquisition Act specifies the compensation procedure, there is not regulation for providing substitute land as an alternative of compensation. If substitute land is required instated of providing the compensation money, a proper application letter has to be submitted by the concerned land owner/user to the Revenue Department so that Councilor of Minister can make decision on it.

6.1.2 Observation of the woodlands to be deforested

The sites for New Salaulim WTP located near the Dam and the Master Balancing Reservoir at Sirvoi are presently covered by trees. Part of the proposed routes of new transmission mains also go through woodland. As a result, the deforestation will be required for the construction of these facilities.

Fortunately, those sites and route are neither the lands protected by law such as national parks nor valuable tropical forests for which special considerations are required. It was also observed that the soil type of those sites is hard laterite soil so that land slide is unlikely caused by the impacts of deforestation.

As a mitigation measure of the deforestation, it is recommended to plant trees within the premises of the constructed facilities. However, it would be difficult to completely recover the impacts of deforestation by planting trees in the premises after the construction due to the land limitations. Therefore, it is preferable to try to plant the same amount of trees as that of deforestation in other areas near the sites.

6.1.3 Noise and vibration causing by construction work

During the construction phase, noise and vibration will be expected to generate due to loading of heavy vehicles and operation of light & heavy construction machineries including pneumatic tools (bull dozers, scrapers, concrete mixers, pumps, vibrators, cranes, compressors etc.) that are known to emit sounds with moderate to high decibel value. The construction activity will increase the noise levels up to around 80dB at peak hours. This value is actually exceeding the national standards (see Chapter 2, 2.4.2 Environmental Standards (3) Noise). It can be said generally that installation of sound insulating wall is very effective to reduce the noise level. Noise generated from sources mentioned above will be intermittent and of short duration mostly during daytime. Therefore, no significant impact is anticipated on account of noise generation around the project site. However, the workers are likely to be exposed to high noise levels that may affect them. So ear plug or other ear protector is required to load

6.1.4 Traffic delay by construction

Traffic at a part of the sites of sewerage priority projects, namely Margao, Mapusa and North Coastal Belt are comparatively heavy. During the construction of the trunk sewer lines, traffic congestion will take place, which will have some temporary impact on the social environment. Though the impact will be temporary and of short duration.

Near the railway station in Margao, the road where trunk sewer will be installed is very narrow and there are a lot of small individual retail shops along the street. Therefore, traffic congestion caused by civil works will involve commercial activities during the construction phase both for customers and distributors. Impact will be adverse and of short duration. The construction works at night is highly recommended in order to mitigate this negative impact.

6.2 Impacts during Operation Phase

6.2.1 Disposal of Sludge and Treated Water from STP and WTP

Sludge is composed of by-products collected from the water and sewage treatment process. Especially for sewage sludge, it contains both compounds of agricultural value (including organic matter, nitrogen, phosphorus and potassium, and to a lesser extent, calcium, sulphur and magnesium), and pollutants which usually consist of heavy metals, organic pollutants and pathogens. The characteristics of sludge depend on the original pollution load of the treated water, and also on the technical characteristics of the wastewater and sludge treatments carried out. Sludge is usually treated before disposal or recycling in order to reduce its water content, its fermentation propensity or the presence of pathogens. Several treatment processes exist, such as thickening, dewatering, stabilisation and disinfection, and thermal drying.

Once treated, sludge can be recycled or disposed of using three main routes: recycling to agriculture (landspreading), incineration or landfilling. Other, less developed outlets exist, such as silviculture, land reclamation, and other developing combustion technologies including wet oxidation, pyrolysis and gasification.

Landspreading of sludge partially replaces the use of conventional fertilisers, since it contains compounds of agricultural value. It also contains organic matter, although under a form and at a level below that which would have a significant positive impact on soil physical properties. Composted sludge presents a more stable organic matter due to the addition of a vegetal co-product during the process. However, landspreading also involves the application of the pollutants to the soil. These pollutants undergo different transformations or transfer processes. These processes include leaching to groundwater, runoff, microbial transformation, plant uptake and volatilization and enable transfer of the compounds into the air and water, and their subsequent introduction into the food chain. Therefore, suitable sanitary landfilling is surely required to avoid from outflows to the environment.

There are two possibilities in terms of sludge landfilling: mono-deposits, where only sludge is disposed of, and mixed-deposits (most commonly observed), when the landfill is also used for municipal wastes. The inputs of landfilling are the waste and additional resources required for the operation of the landfill site, such as fuel for vehicles, electricity, and additional materials when leachate is treated on-site. Landfill operation, therefore, generates emissions into the air, and into the soil and water at dumpsites (various compounds such as ions, heavy metals, organic compounds and microorganisms in leachate). The operation of a landfill also generates other impacts in terms of noise and dust from the delivery vehicles, as well as odours, land use, disturbance of vegetation and the landscape.

Forestry and silviculture refer to different kinds of tree plantation and use. The term forestry is mainly used when considering amenity forests. On the contrary, silviculture is more specifically used when referring to intensive production. From the both agricultural and environmental point of view, differences exist in terms of the impact of landspreading as compared to the use of sludge in forestry, relating to such factors as the plant species grown, the fauna and flora involved, and the soil types.

When considering the risks to humans associated with the presence of heavy metals in sludge, it is assumed that these are lower than those associated with spreading on agricultural land, as forest products represent only a very small part of the human diet. However, some risks may still exist due to the transfer of heavy metals to game or edible mushroom species, and in a general manner to wild fauna and flora.

There is limited information available on how sewage sludge application can influence soil microbial and bio-chemical characteristics with respect to maintaining soil quality. The effects of heavy metals on the soil microbial community, with emphasis on specific microbial activities, have been reported. Generally, the application of low metal sludge had beneficial effects on microbial biomass. It has been reported that sewage sludge applications at recommended rates increased microbial activity in soil. The availability of metals in sludge depends upon the concentration of heavy metals present in the sewage sludge and the nature of the sludge itself. More information is needed concerning other routes for sludge recycling, such as land reclamation or use in forestry and silviculture. Research should be carried out to precisely identify the agricultural benefits of sewage sludge spreading and its environmental and sanitary impacts (especially concerning organic pollutants for which no data is currently available).

Major developed countries already have original guidelines set to detect heavy metals and toxins in sewage sludge by measuring and ensuring allowable maximum levels aren't surpassed. Some guidelines require that each field on which sludge fertilizer is to be spread must be approved and monitored to ensure the mandated nitrogen to heavy metal ratio is not exceeded. Accordingly, continuous monitoring of those parameters is essential in India.

On the other hand, the Environmental Protection Agency of United States of America has made a final decision not to regulate dioxins in land-applied sewage sludge. After five years of study, including outside peer review, the Agency has determined that dioxins from this source do not pose a significant risk to human health or the environment. The most highly exposed people, theoretically, are those people who apply sewage sludge as a fertilizer to their crops and animal feed.

Currently, the sludge is treated on sludge drying beds in the existing STP. The PWD sometimes provides the dried sludge to village farmers around the STPs without charge. Based on the prepared Master Plan, the volume of wet sludge to be generated will be around 50m^3/d. In the future, sludge should be sold to farmers and fertilizer industry in an organized manner.

However, the reuse of sludge is recommended only if the amount of heavy metals contained in the sludge does not depredate the soil conditions of agricultural lands significantly in terms of heavy metal contents. It is also recommended to take into account the contents of heavy metals already present in the land and the pH of the soil. In practice, the recommended reuse of sludge would face some technical and social difficulties. The sludge needs to be stored properly. While the sludge will be produced all year round, but the demand of sludge would be limited to one or two seasons in a year. Furthermore, there are no norms accepted in Goa yet to control the amount of sludge reuse for each agricultural land.

Treated wastewaters and sludge can also be used for the irrigation of forest and farmland areas for the cultivation of different plant species. The back wash water from some of the existing WTP such as Canacona WTP is already used for the irrigation of nearby plantation during the dry season.

6.2.2 Water quality observation

The following table shows the discharge points of the sewerages based upon the Master Plan.

Table F102.1.9 Proposed Discharge Point of Treated Effluent

Sewage Treatment Plant	Discharge Point
Margao STP	Small stream connecting to Sal River
Mapusa STP	Tributary of Mandovi River
Baga (Calangute North Coastal Belt) STP	Baga River

As a result of the environmental scoping, it was found that only Margao STP currently discharges/will continuously discharges its treated water into a small stream. The designed discharged points of the other proposed STPs of the priority projects are rivers which have enough flow to significantly dilute the effluent discharged from the STPs so that any occurrence of significant environmental and social impacts of the effluent are not expected.

In the Master Plan Study period, the JICA Study Team has conducted visual observation and geological investigation to evaluate the impacts of the effluent for Margao STP by walking along the stream from the existing discharge point to the confluence of the stream with Sal River which has lager flow. In the dry season the flow of the stream are almost as much as the volume of the effluent from the STP. However, the water quality of the stream was in good condition because the wastewater was well treated before being discharged into the stream. The surround environment of the stream is paddy fields of good conditions, which are not degraded by the effluent from the STP. It is also presumed that the effluent have positive impacts on the paddy fields as a provider of rich nutrients.

It was also found that the confluence with Sal River is about 400m away from the discharge point. The surrounding environment of the confluence is also not actively used for riverside activities. Therefore it was concluded the environmental impacts of the effluent from Margao STP is not significant and will not be significant even after the proposed expansion of Margao STP. It was also concluded that the installment of discharge pipe from the STP to Sal River is not required as a mitigation measure.

The earlier water quality investigation at the existing STPs conducted by the Study Team in the Reconnaissance Survey also shows that the water quality of the treated effluent from the Margao STP meets the effluent Standards (BOD and SS) of India in both dry and rainy seasons as shown in Table F102.1.10.

This water quality investigation also indicated that the STP can reduce the number of coliform during both seasons. However, continuous water quality monitoring is indispensable to check the functional treatment capability of the sewerage facilities.

It is also required to continuously operate and maintain the proposed STPs in order to avoid the inflow of untreated sewage into the rivers and sounding environments even during power cuts. As mitigating measures to reduce this risk, the installment of emergency power generator at each proposed STP should be considered in addition to the preparation and implementation of sustainable operation and maintain plan for the proposed STPs.

Table F102.1.10 Water Quality of the Effluent and Discharge Point at Margao STP

STP	Season	Water Quality Parameter	Raw sewage	Water Quality of Effluent		Water Quality of the Stream receiving the Effluent	
				Measured Value	Effluent Standard[1]	Measured Value	Environment Standard[2]
Margao	Rainy Season	BOD (mg/L)	6.0 mg/L	3.0	50	2.2	30
		SS (mg/L)	8.0 mg/L	2.0	100	1.5	100
		Coliform (MPN)	4,600,000	46,000	-	110,000	No standard Recommended[3]
	Dry Season	BOD (mg/L)	30.5 mg/L	13.0	50	22.5	30
		SS (mg/L)	28.0 mg/L	9.5	100	22.0	100
		Coliform (MPN)	11,000,000	460,000	-	240,000	No standard recommended

1) Central Pollution Control Board (July 2002), Environmental Standards for Ambient Air, Automobile, Industries and Noise, p55
2) Schedule-VI Part-A, General Standards for discharge of Environmental pollutants in Inland Surface waters, The Environmental Protection Rules, 1986
3) Health Guidelines for Use of Wastewater in Agriculture and Aquaculture, TP No.788. WHO, 1989

6.2.3 Effects of odour from STPs.

In the Reconnaissance Survey, stakeholder interviews were conducted to 20 residents around the existing STPs of Panaji and Margao to gain an understanding of the environmental and social considerations required for sewerage projects. In the interviews, perception on the seriousness of the odour from the STPs was asked as a question and its result is shown in the Table M102.1.11. This table indicates that about a quarter of the residents around the existing STPs consider the odour from STP as a serious problem.

Table F102.1.11 Perception on the seriousness of the odour from the STPs

Level of Seriousness of the Odour	Percentage of Respondents
1. Very serious	25%
2. Serious	37%
3. Not very serious	38%

Margao STP is currently operated at far below its treatment capacity and the pollution load of the raw wastewater is thin due to groundwater intrusion into sewers. Therefore, the current odour level in Margao STP is usually very low. Accordingly, problem of offensive odour is not remarkable impact at present. Because most of the proposed sites for the new STPs are set apart from residential areas, the odour seems not to have significant impacts. However, it is easily predicted that residential areas have been developed around not only Margao STP but also new planned STP after its construction.

Therefore, mitigation measures to reduce the offensive odour are especially required for the further expansion of the existing STPs and for the construction of new STPs. Recommended main mitigation measure is the application of appropriate wastewater and sludge treatment technologies which cause less odour such as Oxidation Ditch. The installment of air sealing cover on wastewater and sludge treatment facilities is also possible mitigation measure. Another mitigation measure is to design the facility layout of STP in the way odour causing facilities are located at the far side of nearby residential areas as possible.

The application of these mitigation measures will be considered in the basic design of the wastewater and sludge treatment facilities in the Detailed Design for the projects.

Chapter 7 Analysis of Alternatives

7.1 General

The various alternatives have been already presented and are compared below in more detail. The suggested integrated approach aims at recommending the most likely preferred option according to the following criteria:

- Environmental constraints regarding water quality, offensive odour, sludge disposal, public health should be minimised.
- Social impacts should be reduced and careful management is needed to do so. The acceptance of the project by the community is required in order to allow its smooth implementation and prevent negative reactions from local residents.

7.2 With and Without Priority Project

Technical aspects of with/without project scenarios of the water supply scheme and the sewerage scheme are compared by the JICA Study Team in the Main Report, Volume II Chapter 5 Water Supply Master Plan and Chapter 6.Master Plan for Sanitation

If the project are implemented with the scenario, sewage/night soil discharged to the rivers at present will be treated in 2020 while if the projects are not implemented without the project scenario), no sewage is treated and all the sewage discharged finds its way to the major rivers which finally flow into the sea degrading seriously its water quality and environment.

When an effluent with high BOD load is discharged in a natural river/stream, the BOD value of receiving water increases considerably which, in turn, results in the fall in DO value in the water. Therefore, it will be shown that the BOD value will be deteriorated dramatically at any water environment without the project in proportion as growth in population. Meanwhile, the BOD value will be expected to decrease with totally covering of the project. Consequently, the projects can leave irreplaceable water environment to posterity.

7.3 Alternative Water Supply Facilities Locations

This environmental scoping identified the following as a likely significant impact regarding to the selected water supply scheme.

7.3.1 Deforestation for the construction of WTPs and reservoirs

The acquisition of water right for the proposed water supply project was permitted by the Water Resource Department of the Goa state at the end of the formulation of Master Plan.

The alternative analysis for each set of proposed project sites was conducted through the rapid-EIA scooping process to select better project components and sites. The following shows the results of alternative analyses regarding to the proposed water supply projects.

7.3.2 Salaulim Water Supply Scheme

Only Salaulim Water Supply Scheme (WSS) is selected as priority project. Salaulim Dam is the only water source that can meet the increasing water demand in the future. Therefore, there is no possible alternative to the expansion of Salaulim Water Supply Scheme.

It was already agreed in a written form that the land ownership of 6 ha (out of the area around the existing Salaulim Water Treatment Plan) will be transferred from the Forest Department of the State Government to the PWD for the new WTP after the boundary of the site is finalized.

The site that the PWD previously proposed for the construction of new WTP was close to the lakefront of Salaulim Dam, which is a good condition for water intake. However, during site visits for the preparation of Master Plan, it was found that there was one household living within the trees of that area and that the original proposed site was close to an archeological site, namely Mahadev Temple. This temple was relocated to this location to avoid being submerged at the bottom of the Dam after construction of the Salaulim Dam. It was also found that a sign board of Archaeological Survey of India at the temple says that within 100 meter from the protected limits, no construction work is allowed and prior approval should be obtained from Archaeological Survey of India for construction and excavation work within 200 m from the protected limits. The site previously proposed by the PWD was too close to the archaeological site. It was also found that the site did not have enough flat land space to accommodate the new WTP of 200,000m^3/d (Based on Master Plan up to 2025).

Therefore, during the formulation of Master Plan, the new alternative sites for the new WTP were sought within the area around the existing Salaulim WTP. By conducting site investigation, it was found that there are other available areas whose sizes are enough to accommodate the new WTP. However, the exact boundary of the new site for the new WTP could not have been finalized during the formulation of Master Plan due to the time constraint. The exact boundary of the new site was finalized at the resulting of the Feasibility Study.

Although its exact boundary is not finalized, the new site is considered to have less negative social impacts. Since there are only very scattered and limited households around the area, the boundary of new site was set avoiding any households and the vicinity of the archaeological protected site. Possible major impact of its construction would be only the deforestation at the site.

The other major project components of Salaulim Water Supply Scheme are the constructions of another transmission pipeline from Salaulim to Margao and new master balancing reservoir on the hill at Sirvoi (the largest master balancing reservoir to be constructed) which will perform as a relay point between Salaulim and Margao.

The both project components don’t have alternative sites. The new transmission pipeline will be installed along with the existing transmission lines in the road already constructed and owned by the PWD especially for water supply transmission. The road goes mainly through rural areas where households are very scattered and there is enough space to install another transmission pipeline at its road shoulder. Therefore, its construction is considered not to have any major environmental and social impacts.

The proposed site for the new Master Balancing Reservoir is located along the road constructed for water transmission pipelines and is on the hill at Sirvoi which is the best and only suitable place for the new master balancing reservoir in terms of hydraulic conditions. Fortunately, there is no resident living on the hill. Possible major impact of its construction would be only the deforestation for the construction at the site.

In the operational stage of the projects, the water quality of the public water bodies within the service area of Salaulim Water Supply Scheme may decline because the volume of sewage in the area will significantly increase as a result of the water supply project. However, improvements to sewerage facilities are being considered for populated areas within the service area such as Margao as part of the Priority Project. The expansion of sewerage in the populated areas will be carried out along with the increase of on-site sanitation facilities in rural areas.

7.4 Alternative Sewerage Facilities Locations

This environmental scoping identified some likely significant impacts regarding to selected sewerage projects. The identified key impacts include:

- Wastewater discharge from Sewage Treatment Plants (STPs);
- Offensive odour from STPs;
- Acquisition of lands currently used for agriculture and horticulture; and
- Disposal of sludge.

These impacts mainly depend on the location of the STPs in relation to nearby residential areas and rivers. Therefore, appropriate sites for the STPs were well considered through alternative analysis and most suitable sites have been identified through the Master Plan Study. To conduct better alternative analysis, new sets of alternative sites have been specified during the formulation of Master Plan, which were added to the sites previously proposed by the PWD. The most suitable site for each STP was presented in the second stakeholder meeting with some of the other alternative sites to confirm the most suitable site and its possible negative impacts.

The following shows the results of alternative analysis on each set of alternative sites for the selected sewerage projects, which were conducted through the rapid-EIA scooping process.

7.4.1 Expansion of Margao STP

Margao has an existing STP, which is surrounded by paddy fields and some residential areas. The existing STP has enough land to accommodate future expansion within the own premises. Installation of a new STP in the separate place may be impractical plan in respect of all evaluation parameters like cost efficiency, technical aspect and also environmental aspects. The existing inflow of sewerage is currently well below the treatment plant's design capacity because only small proportion of Margao's population have connected to the sewers. However, the inflow is expected to increase significantly after the expansion of its service area to the South Zone of Margao by the priority project and after the increase of household connections.

The existing STP discharges its treated water to the adjacent small stream. The stream passes through nearby paddy field about 400m before joining tributary of Sal River. There is a potential risk of discharging untreated sewage into the small stream if there are power cuts or in case of the facility breaks down. This risk would increase if the volume of sewage being treated rises.

Although the current odour level at Margao STP is not significant because raw sewage is significantly diluted by ground water intruding into sewers and the current inflow is well below the designed inflow volume of the facilities. However, the planned increase of the inflow has potential to cause significant odour problem especially during the dry season. After the construction of the expended STP, a closely-spaced residential area has been developed at the east side of the STP. The boundary of the residential areas is now reaching the STP. The offensive odour from the STP has presumable significant impact on the residential area.

7.4.2 Construction of Mapusa STP

The results of the public awareness survey by the JICA Study Team and the first stakeholder meeting have indicated that the overflow of effluent from septic tanks often annoys local residents especially in Mapusa. The underlying geology in Mapusa is a key reason for the overflows. Installation of new sewerage systems in Mapusa is therefore prior to be developed.

The selected site for Mapusa STP, which was proposed by the PWD, is far from the populated area of Mapusa and is next to a river that has a relatively large flow. It is difficult to find alternative land as large as proposed site due to geographical and technical disadvantages. The site is a part of "communidade", which is community land and is supposed to be used for public purposes such as STPs and other essential infrastructures. This community land is currently being temporally rented to locals as paddy fields. Therefore appropriate compensation or substitute paddy fields will need to be considered for the loss of the economic opportunity that the farmers currently enjoy. The possibility that the area surrounding the site could be used for urban development in the future is considered to be low based on the site investigation and available land use plan.

7.4.3 Construction of a STP in North Coastal Belt

The PWD previously proposed new sewerage schemes covering most of North Coastal Belt. Several sites were previously proposed for the STP in North Coastal Belt by the PWD in past study reports. However during the Reconnaissance Study, it was found that these sites are not suitable in terms of social impacts on the surrounding areas. Therefore more suitable alternative sites are sought by the PWD and the Study Team in collaboration.

Two alternative sites for the STP covering Calangute and Candolim were newly attempted, for the two alternative sewerage plans of separated and integrated sewerage systems, at the north end of Calangute Panchayat (Baga) and at the south end of Candolim Panchayat.

While only the site few hundreds meters behind Baga Beach is to be used for the integrated sewerage system, both alternative sites are to be used in the separated sewerage system which covers the two areas separately by the separate sewerage facilities. Judging from the environmental point of view, the site in Baga, which is open area at the moment, is more suitable for STP, because the alternative site in Candolim is limited in space, currently used as paddy field, and rather close to a residential area.

As results of the alternative analysis from different aspects by Feasibility Study, the separate sewage system is selected for Calangute. Accordingly, the site in Baga is selected for the separate sewerage system. The selected site is a large area apart from residential areas. The STP site is around 700m away from the CRZ. A stream goes nearby the site into the right side of Baga Beach

Chapter 8 Environmental Mitigation Plan

8.1 General

The objective of preparing an Environmental Mitigation Plan (EMP) is to formulate measures, whose implementation will:

- mitigate adverse effects on various environmental components and resources as have been identified in the EIA study;
- protect environmental resources wherever possible and
- enhance the value of the environmental component wherever possible.

The EMP is enable evaluation of the success or failure of environmental management measures and reorientation of the plan if found necessary. The mitigation measures to be adopted cover both the construction phase and the operation phase. These measures normally are short term during the construction phase and long term during the operation phase.

It should be noted that individual mitigation measures implemented bit by bit, may only be partially effective. It is recommended, therefore, that the undertaking contractors are required to produce an environmental management plan for all the proposed operations.

The community must be informed in advance about the benefits of the project and possible inconvenience to them. The implementing agency must seek co-operation of the local authorities, and execute the project effectively and efficiently. Success of the project depends upon participation and support of the community. Efforts need to be made to involve the population at different stages of project execution and in subsequent maintenance. The construction work should be carefully planned and managed in order to cause minimum disturbances to people.

The consolidated mitigation measures are presented in Table F102.1.12. It contains details for both the construction and operation phase of the facilities. Some details are also given for the Detailed Engineering Phase. The main considerations are summarised below.

8.2 General Mitigation Measures

8.2.1 Detailed Design Phase

During the detail design stage, attention should be paid to the following aspects:

- Route selection should be made to minimise land acquisitions, to avoid rehabilitation and resettlement, damage to historical or cultural properties, damage to existing infrastructure, indiscriminate felling of avenue trees, etc.

- Safety measures will be taken care of by following relevant codes of practice.
- Clearly sort out land acquisition issues to avoid delay in implementation of the project due to disruptions by public. Realistic monetary compensations should be made for private land acquisitions.

8.2.2 Construction Phase

The construction phase impacts have been outlined in **Chapter 6, 6.1**. All these adverse impacts have been taken into consideration. Following measures should be adopted in general for all activities:

- Minimum damage to existing flora and fauna, structures, electricity and telephone cables.
- Minimum disturbance to the local activities and business should be ensured.
- The sewer pipes should be stacked properly in a pre determined location and should not be cluttered around blocking the pedestrian area alongside the roads.
- Excavated earth should be prevented from getting washed into drainage channels, rivers and canals.
- Surplus excavated earth should be disposed of immediately.
- Measures should be taken to prevent direct discharge of polluted waters from construction activities into lake, rivers and irrigation canals.
- Dust pollution should be controlled with the measures outlined in the **Table F102.1.12**.
- Pavements and roads should be repaired immediately following the construction activity and the project and surrounding area should be restored to as near as possible pre-project conditions.
- Adequate measures should be taken to minimise construction related noise.
- Proper precautions should be taken against risk of accidents.

8.2.3 Operation Phase

The operation phase impacts have been outlined in **Chapter 6, 6.2**. All these adverse impacts have been taken into consideration. The following measures should be adopted in general for all activities:

- The treated water quality should be maintained as per the requirements at all times.
- Air and noise quality should be monitored and corrective action taken in case it exceeds applicable norms.
- Proper precautions should be taken for the good health of the operatives and the population.

8.3 Mitigation Measures for Sewerage and Water Distribution System

Selection of route for sewers and transmission mains is one of the most important activities in the pre-construction phase. In order to minimise negative environmental impacts and land acquisitions, to avoid involuntary resettlement and rehabilitation problems and in general, from a social point of view, to minimise severance and other problems due to pipe laying activities, the sewers and transmission mains will be laid along the roads.

Pumps and associated equipment form generally the weakest point in the system. In addition, sewage and water pumping is always a management problem. It results in environmental impact of noise and odour and there are significant environmental risks associated with the failure of pumping stations.

Construction of the sewerage system and water distribution network will comprise: carrying the pipes to the site, excavation, laying the sewer and water pipeline, making good of the site after laying the pipeline, disposal of spoil/excavated material. All relevant codes of practice should be followed during detail engineering and construction phases to ensure pipelines safety and protection against corrosion.

The risk of accidents should be minimised by taking all the proper precautions during the sewer and transmission mains laying activity. In some narrow roads and busy crossings, care must be taken for proper diversions of the traffic with the help of the traffic police. Care should also be taken to avoid damaging existing infrastructure, telephone and power supply electric cabling, poles etc. and minimising the construction level impacts.

8.4 Mitigation Measures for Sewage Treatment Plant

8.4.1 Water Quality of Effluent

First and foremost, care should be taken to ensure adequate treatment to meet the discharge effluent standards. Since it is recommended that the treated water should meet the required standards for irrigation re-use and be conveyed upstream of an area that can be irrigated. Treated water quality should be monitored carefully so as to meet the discharge standards effectively.

8.4.2 Sludge Disposal

The sludge from the WTP and STP should be disposed of in an environmentally acceptable manner. The sludge should be dewatered in sludge drying beds and the dried sludge is proposed to be used as fertiliser since it is biological in nature and has soil quality enhancing properties. However, the following precautions should be taken in the treatment, handling and disposal of the sludge:

- to facilitate proper drainage to avoid standing water leading to mosquito breeding,
- to develop a green / planting belt all around treatment plant, especially around sludge drying bed to reduce odour nuisance,
- to take care that the operatives handling the sludge are properly clothed with gloves and gum boots and will not handle the sludge with bare hands.

8.4.3 Worker's Health

The workers' health should be monitored with medical check-ups at the time of joining and thereafter annually. In between, in case of any complaints, respiratory ailments, accidental chlorine leakage etc., medical check-up should be conducted.

All the workers should be trained in first aid and emergency medical health should be available round the clock. It is also recommended from the safety point of view that one officer of the managerial cadre is available on duty at all times.

Table F102.1.12 Environmental Mitigation Plan

	Environmental Issues	Adverse Impact	Nature of Impact	Proposed Mitigation Measures	Implementing Authority
1. DETAILED ENGINEERING PHASE					
1.1	**Route Selection for Trunk Sewers and Transmission Mains**	• Land acquisition leading to resettlement with unrealistic compensation • Improper right of way selection temporarily affecting telecommunication/ electricity • Reckless felling of avenue trees	Significant and permanent	The trunk sewer right of way has been selected or to be selected: • to minimise land acquisition, damage to cultural properties • to minimise road/river/canal crossings • to avoid water transmission lines, felling of avenue trees	Consultant/ PWD
1.2	**Corrosion of Sewers / Transmission Mains**	• Short life of trunk mains • Rampant corrosion can lead to public health problems due to leakage of untreated sewage	Significant	• To propose proper design and construction of sewers, with adequate ventilation, and, if needed, an effective protective lining • Proper precaution to be taken to control mixing of industrial wastewater with domestic sewage	Consultant/ PWD
1.3	**Safety of Sewers / Transmission Mains**	• Unsafe sewers can lead to public health problems and cause general nuisance to public	Significant	• Relevant codes of practice to be followed during design and construction stages	Consultant/ PWD
1.4	**Misuse of Sewers for Storm water**	• Leads to blockages of the sewers and overflows • Leading to potential public health problems and causing general nuisance	Significant	• Completely separate sewerage and storm water drain is not possible; misuse should be prevented	Consultant/ PWD

	Environmental Issues	Adverse Impact	Nature of Impact	Proposed Mitigation Measures	Implementing Authority

2. CONSTRUCTION PHASE

2.1	**Soil Quality**	• Due to excavation and earthwork: soil erosion, loss of top soil, silting and blocking of drainage/ nallahs, which can cause slush; damage to existing structures • Due to compacting: loss of original quality, reduction in fertility	Significant and Permanent	• Stabilise all slopes with provision of benches/pitching • Avoid earthwork during monsoon • Provide adequate cross drainage facilities • Preserve top soil to be replaced after the completion of construction activity; avoid wet soils • Dispose of surplus earth after raising levels and refilling trenches, in low lying areas with proper compacting and planting of surfaces • Plant shrubs/trees on exposed slopes and surfaces	Contractor/ PWD
2.2	**Air Quality**	• Localised increase in dust due to excavation & earthwork • Temporary increase in the levels of SO_2/NO_x, from construction equipment and vehicles	Significant and Temporality	• Dust control through sprinkling / washing of construction sites and access roads particularly in congested areas • Use of dust cover over construction material • Dust collectors should be used in all drilling operations • Construction material trucks to be covered to minimise spills • Construction requiring heavy traffic street closing/ diversion to be carried out during night time	Contractor
2.3	**Noise Pollution**	• Increase in noise levels due to construction work, transport of construction materials etc.	Significant and Temporality	• Equipment emitting noise over 90 dB should be avoided • Where residences are located within 200 m and in sensitive areas like hospitals, schools, zoos, noisy construction work should be carried out in day time only • Equipment maintenance strengthened to keep them low noise • Sound barriers should be installed if needed	Contractor

	Environmental Issues	Adverse Impact	Nature of Impact	Proposed Mitigation Measures	Implementing Authority

2. CONSTRUCTION PHASE

2.4	**Water Quality/ Drainage**	• Increase in turbidity affecting surface water quality • Sanitary pollution	Significant	• Ensure steps to prevent earth and stone from silting up the nallahs and drainage systems • Control run off and soil erosion through proper drainage channels and structures; improve existing cross drainage and provide extra cross drainage works wherever necessary • Provide adequate sanitation facilities to construction site workers	Contractor/ PWD
2.5	**Traffic**	• Traffic jams, bottlenecks, delays and inconveniences to general public • Serious disruptions of vehicular traffic, pedestrian access and commerce	Significant and Temporary	• Co-ordinate and plan all activities in advance • Adequate actions to direct traffic in consultation with highway and traffic police • Minimise vehicle movements • Preference for unused or low traffic roads • Construction of temporary roads and diversion of traffic • Use local construction materials to avoid long distance transportation, especially of earth and stones • Seek public co-operation through public awareness	Contractor/ PWD/ Traffic Police
2.6	**Risk of Accidents**	• Endangering lives of people/workers during construction due to inadequate safety measures	Significant	• Adequate traffic control measures should be taken • Sign board warning presence of open sewer trench • Guard rails to protect pedestrians • Strong safety policy for workers; protective helmets to be provided	Contractor/ PWD
2.7	**Aesthetic Conditions**	• Visually anaesthetic conditions due to cluttering of waste, and spoils, dug up roads and pavements	Significant and Temporary	• Enhance aesthetics through proper housekeeping of construction site • Disposal of construction wastes at the approved sites quickly • Repair pavements and roads after sewer laying work is completed • Completing the construction activity by removing all spoils	Contractor

	Environmental Issues	Adverse Impact	Nature of Impact	Proposed Mitigation Measures	Implementing Authority

2. CONSTRUCTION PHASE

2.8	**Land Acquisition**	• Inadequate compensation • Inadequate utilities in the rehabilitation area • Relocation trauma and infections and other diseases in the new location	Significant and Permanent	• Minimise relocation • Advance realistic payments to be made to relocated (estimation for compensation for land and property should be made on the prevailing market rates) • Provision of clean drinking water to national potable water standards, sanitation, proper drainage at new locations	PWD/
2.9	**Construction Camps**	• Prevalence of unsanitary conditions and practices like open air defecation • Possibilities of public health problems • Piling of garbage from workers	Significant and Temporary	• Adequate measures such as provision of septic tanks/pit latrines around the construction camp sites • Provision of clean drinking water to potable water standards • Collection of garbage in garbage cans in fixed places and disposal of it regularly	Contractor
2.10	**Public and Workers' Health**	• Adverse health of workers due to unsanitary practices and spreading of diseases from vectors	Significant and Temporary	• Workers are the immediately affected people • Proper sanitation and drinking water should be provided • Medical facilities to be provided to prevent communicable diseases	Contractor/ PWD

	Environmental Issues	Adverse Impact	Nature of Impact	Proposed Mitigation Measures	Implementing Authority
3. OPERATION PHASE					
3.1	**Air Quality**	• Problems of bad odour from the treatment plant	Significant	• Some bad odour from sewage treatment plant is unavoidable; however, steps should be taken to minimise odour by proper maintenance and housekeeping of the treatment plant	PWD/ Operator
3.2	**Water Quality**	• Overflow of sewers and breakdown of treatment plant leading to failure in meeting the requisite standards • Poor performance will affect the proposed reuse for irrigation, and also the receiving water body	Significant	• Preventive maintenance of all components should be performed regularly • Relevant standby equipment and spare parts should be provided; standby power generation should be provided at pumping stations, if any • Proper response plan must be prepared	PWD/ Operator
3.3	**Sludge Treatment & Disposal**	• Improper treatment of sludge could lead to putrefaction and other related problems such as bad odour, health effects etc.	Significant	• Sludge should be treated properly and dewatered • Dried sludge should be given for land application to farmers, if it can be handled properly by them	PWD/ Operator
3.4	**Offensive Odour**	• Raw sewage and excess sludge lead to generation of offensive odour	Significant	• Appropriate wastewater and sludge treatment technologies which cause less odour such as Oxidation Ditch • The installment of air sealing cover on wastewater and sludge treatment facilities	
3.5	**Public Health**	• Mixing of sewage with drinking water • Outbreak of waterborne diseases • Unhealthy conditions: mosquito breeding over sludge drying beds, etc.	Significant	• Any such health risk to public should be minimised by proper maintenance and operation of sewers, pumping stations, treatment plant etc. • In case of failure, inform relevant authorities to alert public at risk so that precautions might be taken	PWD/ Operator
3.6	**Workers Health & Safety**	• Workers may be inflicted by endemic & other diseases such as malaria or respiratory ailments • Accidents and loss of lives may occur during sewer cleaning & maintenance • Non availability of emergency medical facilities at all times during day & night	Significant and Permanent	• Proper house keeping of the plant to prevent unsanitary conditions • Regular medical check ups and immediate treatment of affected workers • Maintenance personnel should not perform dangerous tasks when alone, enter the manholes without checking for gas and without proper protective clothing, enter the manholes without ropes and harnesses firmly tied • Manholes should not be left open especially in busy roads, near schools and residential areas	Operator/ PWD

Chapter 9 Environmental Management, Training, and Monitoring Plan

9.1 General

Mitigation measures are implemented and their effectiveness should be monitored description of administrative aspects of ensuring. The success of the Environmental Monitoring Programme depends on the efficiency of the organisational / institution set up responsible for the implementation of the programme.

For a water supply & sewerage projects of proposed capacity, the Environmental Management Plan needs to be entrusted, in both the construction and the operation phases, to an Environmental Management Group, and regular monitoring of various environmental parameters is also necessary to evaluate the effectiveness of the management programme so that necessary corrective measures could be taken in case there are some drawbacks in the proposed programme.

The Environmental Management Plan has to consist in:

- setting up an Environmental Management Group to implement the mitigation measures in operation phase;
- ensuring a proper operation and maintenance of the treatment works;
- ensuring a proper maintenance of the sludge drying beds and the disposal of dry sludge with a proper treatment;
- monitoring the treated water quality;
- monitoring the built in pollution control equipment, for vehicles and equipment;
- maintaining tree plantations around the STP facilities and the periphery of the water treatment plant.

Details of the Management Group and the monitoring requirements needed to ensure that construction and operation follow best environmental practices are given in this section.

9.2 Environmental Management Group

The Environmental Management Group (EMG) will be part of the staff in charge of the operation and maintenance of the water supply facilities. However, this staff will be in charge of the overall management of the environmental aspects of the Projects.

The staff will be provided by the operator of the Water Treatment Plant, Sewage Treatment Plant and Pumping Station. Under the supervision of an Environmental Engineer, the EMG will comprise an Environmental Scientist, a Chemist and a Biologist, plus three assistants, as shown on the following organisation chart. The environmental Engineer would report directly to an Environment Assessment Wing.

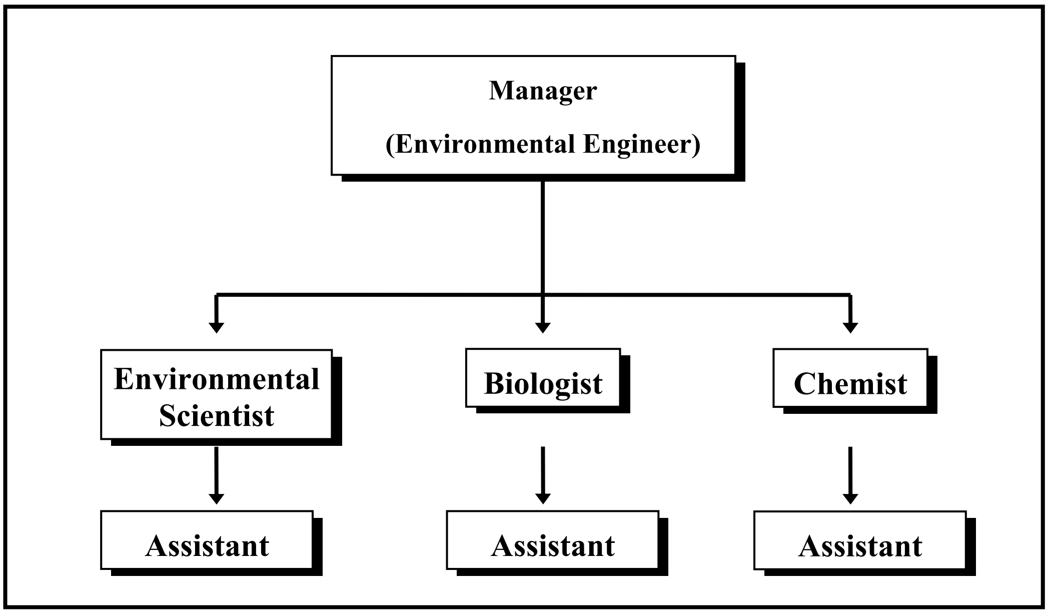


Figure F102.1.15 Model Organisation of Environmental Management Group

The main functions of the Environmental Management Group will be:

- Collecting environmental index samples (water, air, soil and sludge)
- Analysing the samples collected or getting analysis done from outside sources;
- Preparing and updating a database of environmental parameters;
- Implementing the environmental control and protective measures;
- Collecting statistics of health of workers and the population of surrounding areas;
- Monitoring the progress of implementation of Environmental Management Programme;
- Co-ordinating the environment related activities within the project as well as with outside agencies.

9.3 Monitoring Plan

To make an evaluation the effectiveness of the Environmental Management Plan, regular monitoring of the important environmental parameters will be taken up by PWD themselves with / without the help of outside agencies.

9.3.1 Water Quality

The sampling of various inlets and outlets will be carried out for analysis of relevant parameters. The analysis will be done at least once in a month both at the inlet and outlet of the STP & WTP (if any). Some of the parameters will be tested daily if possible. This routine practice would help PWD evaluate the performance of individual units of the sewage treatment plant and take corrective measures if the results are not satisfactory.

9.3.2 Air Quality

Ambient air quality should be monitored for SO_2, NO_x, SPM, etc. At the STP, H_2S and CH_4 should be monitored. Instruments like high volume air samplers and other monitoring kits should be used for the purpose of air quality monitoring. For the operation period, monitoring points should be fixed in consultation with the Pollution Control Board in Goa.

9.3.3 Noise Monitoring

Noise levels should be monitored in working space and main noise producing sources such as the equipment using motors, pumping stations, over the boundary and around the sewage treatment plant.

9.4 Environmental Testing Laboratory

A well equipped laboratory for routine analysis of raw water / sewage and treated water as well as for ambient air quality and sludge analysis should be provided at the sewage treatment plant site. The biological testing facility should be provided in the laboratory in addition to chemical analysis of water. The record of analyses should be maintained at the plant on-site for all the parameters mentioned in the Monitoring Programme.

The cost of the installation of the laboratory and carrying out of the various analyses will be included in the investment and operation cost of the sewage treatment plant. This is the normal practice and all major sewage treatment works have such a facility and the same is recommended to be applied for this project as well.

9.5 Environmental Training

The environmental monitoring programme will be successful only if it is implemented by trained and skilled staff. The training of the qualified staff should be necessary not only in day to day operation and maintenance of the treatment plant, but also in environmental aspects. National Environmental Engineering Research Institute, NEERI and Pollution Central Boards conduct training courses for environmental management which will increase the capabilities of the staff in the Environmental Management Group to execute independent plans for environmental management.

It will be essential to involve the staff who will be responsible for the execution of the Environmental Management Plan, in the construction phase, as well as to train the staff in practising the mitigation actions.

The training should include:

- Concepts of pollution control techniques in the various methods of sewage treatment,
- Operation and maintenance of the sewage treatment plant,
- Emergency preparedness to handle adverse situations,
- Principles of water quality analysis,

This training is different from the mandatory training required for operation and maintenance of the water treatment plant.

Chapter 10 Risk Analysis & Contingency Plan

10.1 General

The components of selected water supply and sewerage project are sewer and transmission laying, construction of treatment plant and reservoirs, installation of pumping station and their operation. The risk involved in laying the sewers and transmission mains are mainly for pipelines of DN 600mm and larger which require lifting by cranes. The risk of mechanical equipment failure and thereby occurrence of accidents cannot be overlooked.

Contingency measures plans have been prepared for:

- water treatment works and sewage treatment works that could reasonably be expected to cause significant environmental impacts as a consequence of operational disruption (i.e. maintenance, etc. or breakdown);
- accidents which may occur while laying pipelines or during construction of the treatment works;
- discharge of sub-standard wastewater into the environment from treatment plant which could cause a significant public health impact, and which therefore requires a continuous system of influent/effluent monitoring to identify potential problems as and when they arise.

In the preparation of the contingency measures:

- the most likely causes of process disruption/breakdown have been identified;
- an attempt has been made to estimate their probability of occurrence;
- the possible resultant environmental adverse impacts are presented;
- the recommended courses of action to minimise the severity of the impacts have been highlighted;
- the responsible agency who will act in case of emergencies has been indicated.

Table F102.1.13 gives the potential risks due to construction, operation and maintenance and corrective actions. The major risks which can result in breakdowns and disruptions are described below.

10.2 Power Supply

One of the main reasons for disruption during the operation phase of the treatment works is very likely to be power cuts due to a transmission line problem and energy shortage. Power cuts and the reasons for them should be monitored in advance so as to set a reliability analysis at the new treatment plant.

It is recommended that the new treatment plant influent pumping station is equipped with a branched connection to ensure continuity of operation in case one line remains out-of-order. It also suggested that standby power generators are provided to ensure at least minimum services in case of prolonged power cuts.

Table F102.1.13 Risk Assessment and Contingency Plan

	Works	Risks	Impact	Corrective Action Plan	Responsibility
1. Accidents related to Construction					
1.1	**Sewerage/ Water Supply Works**	• Accidents due to pedestrians falling into the open trenches	Significant	• Excavated trenches should be provided with adequate barricades • Signboards in bold letters to be displayed in prominent places • Solid planks with guard rails should be provided across the trenches for crossing	Contractor
		• Accidents due to vehicular traffic and risk to pedestrians, workers, vehicle drivers	Significant	• Traffic diversions and signboards should be displayed prominently • Proper lighting should be provided at night time • Co-ordination with traffic police in managing traffic	Contractor/ PWD
		• Accidents due to failure of machinery such as cranes	Significant	• Workers to be trained on contingency management • Emergency medical help should be available immediately • The contractor should have a proper safety policy issued to workers and should strictly comply with all the safety regulations	Contractor
		• Accidents due to carelessness of workers	Significant	• Workers should be provided with protective clothing and helmets • Workers should not be allowed to work when alone • Workers should be trained on first aid • Emergency medical help should be available immediately	Contractor
		• Breakage's of water supply pipes and services connections	Significant	• Inform public in advance about works • Make temporary arrangements for not disturbing water supply in case some pipes have to be displaced	Contractor/ PWD
1.2	**Treatment Plant & Pumping Stations**	• Risk of accidents and loss of limb and life	Significant	• During construction effective safety and warning measures including all the above mentioned safety precautions should be followed by the contractor and PHED should insist on compliance by contractor • Lighting of construction site and safety signs to be installed	Contractor/ PWD

	Works	Risks	Impact	Corrective Action Plan	Responsibility
2. ACCIDENTS RELATED TO OPERATION & MAINTENANCE					
2.1	**Sewers/ Transmission Mains**	• Accidents to operator/PWD personnel	Significant	• Operators should not enter the manholes when alone • Operators should check for gases before entering the manholes • Operators should wear protective clothing, helmets and masks • Operators should enter the manhole by lowering themselves with a rope or a harness tied safely above • Manhole covers should be lifted using proper lifting keys • At least one person of Manager level should be on duty at all times	Operator/ PWD
2.2	**Water/Sewage Treatment Plant**	• Breakdown of sewage treatment units (or overall poor condition)	Not Significant	• The treatment plant will require regular maintenance (preventive maintenance rather than reactive maintenance should be insisted upon)	Operator/ PWD
		• Breakdown of mechanical equipment	Not Significant	• Adequate standby for pumps and motors should be provided • Adequate quantities of reliable spare parts should be available on site • All standby equipment should be regularly checked to ensure full working order	Operator/ PWD
		Maintenance of sludge drying beds: • risks of perpetuation of mosquitoes and other vectors • risk of bad odours • risk of groundwater pollution.	Not Significant	• Sludge drying should be maintained properly • Wet sludge should be raked frequently and dry sludge should be removed and stored/disposed off • Ensure proper drainage • Operator should ensure that there is no standing water on the SDB	Operator

	Works	Risks	Impact	Corrective Action Plan	Responsibility
2.3	**Treatment Plant (continued)**	• Failure of biological process due to toxicity, poor maintenance, etc. (contamination of the effluent with toxic industrial effluents is the major reason for failure of biological treatment systems)	Significant	• All relevant authorities should be informed on potential health risk to public • The biological process should be revived • Inoculation or addition of nutrients should be carried out, if needed	Operator
2.4	**Pumping Stations**	• Breakdown of pumping stations leading to flooding and consequent public health problems as well as general nuisance to public	Significant	• Pumping stations should be avoided as far as possible and in cases where it is not possible, their numbers should be minimised • All pumps should be wear resistant • Standby pumps should be provided and they should be regularly checked to ensure full working condition when needed • Safety overflow should be provided at all pumping stations leading to a ditch or preferable a drain. These emergency overflows should be designed to ensure minimum environmental nuisance, in case of use	Contractor/ Operator/ PWD
		• Power failure leading to flooding of sewage on streets and other problems	Significant	• Standby diesel generators should be provided to cater for a minimum of 1.5 times the average dry weather flow so as to avoid flooding	Contractor/ Operator/ PWD

Chapter 11 Public Consultation

11.1 Objective and Holding of Stakeholder Meeting

Stakeholder participation has been incorporated into this project from an early stage. The participation has focused on the consideration of a wide range of environmental and social impacts. It is important to consult with the stakeholders to generate support for the projects. Figure F102.1.16 shows the continuous process of public consultation. The consultation has been carried out in three stages inline with the three phases of the Study by the PWD, in cooperation with the JICA Study Team. This figure was used at the first stakeholder meeting on 23 August 2005 to explain the public consultation approach that was being adopted. As shown in the figure, the consultation process started even before the master plan was developed. A detailed list of the invitees and attendants, record of discussion is provided in Volume IV Appendix M111.1 Note of Discussion from and Attendance Sheet of the First Workshop and Stakeholder Meeting.

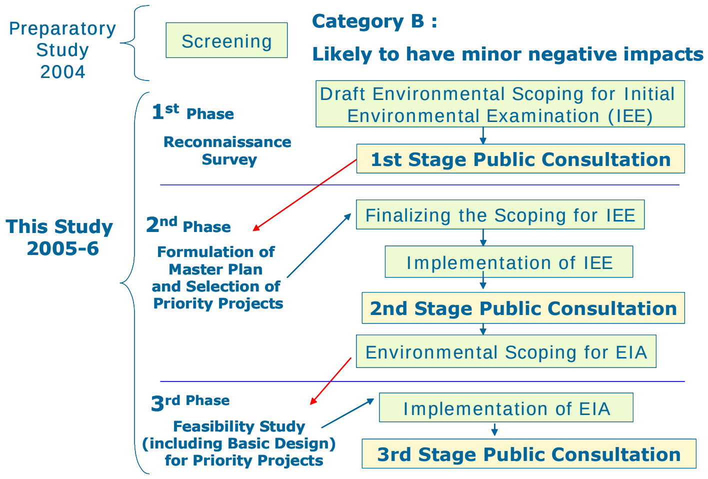


Figure F102.1.16 Process of Continuous Public Consultation

Some of the main results of public awareness survey were explained directly to the stakeholders during the second stakeholder meeting that was held on 23 December 2005. Also, some of the results from the stakeholder interviews with the residents living near the existing STPs were used to assess the potential negative impacts of the proposed sewerage projects as part of the IEE.

The note of discussion of the each stakeholder meetings was disclosed to the public through the notice boards of PWD's head quarter and regional offices. Three local newspaper publishers (Herald, Navhind Times, Gomantak) were asked by the PWD to inform the public that the not of discussion was on the notice boards and two of them put the article in their newspaper before PWD sent the invitations cards of the stakeholder meeting to selected stakeholders.

A discussion paper for the first stakeholder meeting was provided to the public by posting it on the notice boards in the PWD's head office and regional offices. The discussion paper is attached in Volume IV Appendix for Master Plan M111.1 Note of Discussion from and Attendance Sheet of the First Workshop and Stakeholder Meeting. Two local newspapers (Herald and Navhind Times) were requested to run advertisements to inform the public that the discussion paper was available on the notice boards.

The second and the third stakeholder meetings were held by the PWD in cooperation with the JICA Study Team on December 2005 and July 2006 respectively. More than 50 stakeholders were attended. A detailed list of the invitees and attendants, record of discussion is provided in Volume IV Appendix for Master Plan M111.2 Note of Discussion From and Attendance Sheet of the Second Stakeholder Meeting and Volume V Appendix for Feasibility Study F101.1 Note of Discussion From and Attendance Sheet of the Third Stakeholder Meeting.

Chapter 12 Evaluation and Conclusion of the Rapid-EIA Study

12.1 Project Benefits and Positive Impacts

12.1.1 Environmental Aspect

Objective of implementation of the water supply and sewerage schemes are to improve the public health and hygiene, lead to improvement in quality of living and gaining economic growth. Therefore, implementation of each scheme will be brought about following benefits and positive impacts:

- The collection and treatment of untreated sewage before entering the rivers will improve water quality of the rivers.
- Proper collection, treatment and disposal system of sewage will reduce the risks of parasitic infections, incident of various water-borne diseases.
- A proper sewage handling and disposal arrangement will minimize the chances of contamination of ground and surface water.
- Such provisions assist to maintain ecological balance by reducing damages to flora and fauna.
- Controlled reuse of sewage sludge may be enhanced agricultural activities and development and also sustenance of environmental protection.
- Improvement in the existing sewerage system will help a function of urban drainage to reduce the nuisance in streets and road blockages that set up floods.
- Nutrient rich treated water and dried sludge can be used for irrigation, as a material of cement.

Especially sewerage schemes, implementation of project can make significant contributions to improve living environment, sanitary conditions for populations and to conserve irreplaceable natural environment. Moreover, the local residents have a right to receive fairly governmental public services, like a water supply as essential utilities.

12.1.2 Social Aspect

The proposed water supply and sewerage systems are social infrastructures and will mainly benefit the local residents directly and indirectly through environmental improvement.

The expected positive impacts of the proposed water supply projects include:

- increase in the population supplied with safe piped water,

- improvement of supplied water quality,
- continuous water supply,
- reduction of waterborne diseases,
- improvement of financial situation by NRW pilot project implementation,
- more water supply available to tourist facilities,
- more water supply available to industries, etc.

Currently, many water consumers have complains about water shortage, limited and irregular timing of water supply, risk of water supply to be contaminated by sewage, improper costumer services such as broken water meters. These problems will expectedly solved by the implementation of the Priority Projects which include the improvement of water supply facilities, information management system, and costumer services.

The priority project covers the increase of water demand necessary up to 2012 in Goa. At a domestic level, convenience of water supply will be significantly had access to 24 hours-7days water supply in widely areas. Large water consumers such as hotels and factories will also be provided with sufficient water. From a viewpoint of fairness, the regional gap in water supply service, between towns near WTPs and tail-end towns of water transmission will also be significantly reduced by the increase of water supply

The expected positive impacts of the sewerage priority projects include:

- improvement of water quality in rivers and beaches,
- improvement of living environment including gutter and local streams,
- reduction of the overflows from existing septic tanks,
- improvement of the sanitary conditions and images of towns and costal areas,
- reduction of the risk of disease and enhancement of human health,
- improvement of socio-economic conditions to attract more tourists especially in tourism destinations,

Currently, many residents have complains about overflows from their septic tanks, unsanitary living environment due to open defecation, etc. These problems will expectedly be solved by the implementation of the priority projects which includes a basic plan to expansion of existing sewerage facilities in Margao as well as development of new sewerage systems. The priority projects also address the importance to enhance the public awareness on sanitation for the effective use of the proposed sewerages. The awareness enhancement will be carried out in the Total Sanitation Campaign subsidized by the central government of India.

In the above, the social benefits of the priority projects are evaluated qualitatively. The expected level of environmental improvement by the sewerage projects is qualitatively evaluated more detailed in Volume II Chapter 13.4 Environmental Aspects. Moreover, the benefit of saving time and medical cost by the reduction of water-borne diseases and the benefit of water environment preservation for truism are qualitatively evaluated in the economical evaluation of the Feasibility Study (see Volume III Chapter 9 Economic and Financial evaluation).

12.2 Minimization Negative Environmental & Social Impacts

12.2.1 Environmental Aspect

In planning network of sewerage system, the points such as site location and space availability for sewage treatment plant, early start of treatment, initial and O&M cost etc. are considered;

In the former F/S study taken by PWD, locations of some new sewage treatment plants (STP) were close to the township and populated area. In this plan, there are some negative impacts not only transmigration/land acquisition but also urban environmental nuisance such as noise, vibration and destroy the scenery. However, proposed sites of the priority projects are in the empty lots avoiding from the residential and commercial areas of objective cities.

12.2.2 Social Aspect

The minimization of presumable negative social and environmental impacts caused by the priority projects has been considered through the process of environmental and social considerations while implementing the Feasibility Study (see Volume III Chapter 10 Social Considerations and Environmental Impact Assessment). The following summarizes the level of negative social impacts after their recommended mitigation measures are appropriately applied.

The following two items are identified as presumable negative social impacts of the priority projects through the environment scoping of the Rapid-EIA.

- The offensive odour from STPs
- The acquisition of lands currently used for agriculture and horticulture for the proposed new STPs and WTPs

The odour from STPs can be reduced significantly by the appropriate selection of sewage and sludge treatment technologies. The selection of most suitable technologies for each STP was conducted in the phase of Feasibility Study along with considering the other mitigation measures.

The negative impacts of the land acquisition of agricultural and horticultural lands will be minimized thorough the compensation measure. Concerned residents living or working around the proposed STP and WTP sites have been already invited to the stakeholder meetings. The compensation measure will be explained to more residents around the sites to reduce the social impact by early notification.