3.1.6 Sanquelim Water Supply Scheme

(1) Outline of the Scheme

The Sanquelim Water Supply Scheme (WSS) has two WTPs, as follows:

- Podocem WTP, which has a capacity of 40 MLD; and
- Sanquelim WTP, which has a capacity of 12 MLD.

The scheme supplies treated water to Bicholim Taluka (as shown on Figure 31.33) and transmits raw water and treated water to the Assonora WTP (acting as a supplementary water source for the Assonora WSS).

(2) Treatment Plants

The plant schematic is shown in Figure 31.34. Detailed asset data for the plant are attached to Volume IV Appendix M31.5 Sanquelim Water Supply Scheme.

(3) Transmission and Distribution System

The components of the Sanquelim WSS's transmission and distribution system are listed in Table 31.6.

Table 31.6 Details of Sanquelim WSS's Transmission and Distribution System

a. Length of Transmission Mains	151,666 m
- Ductile Iron, 100mm – 750mm	41,566 m
- Cast Iron, 50mm – 600mm	68,850 m
- Others	41,250 m
b. Number of Distribution Reservoirs	30
c. Capacity of Reservoirs	16,950 m^3
d. Length of Distribution Mains	159,900 m
- Cast Iron, 100mm	5,500 m
- Ductile Iron, 150mm	300 m
- A.C., 50mm – 200mm	26,100 m
- PVC, 63mm – 110mm	126,500 m
- G.I., 100mm	1,500 m

Source: Sector Status Study – WSS Goa, 2004, (Data was confirmed to the PWD in 2005)

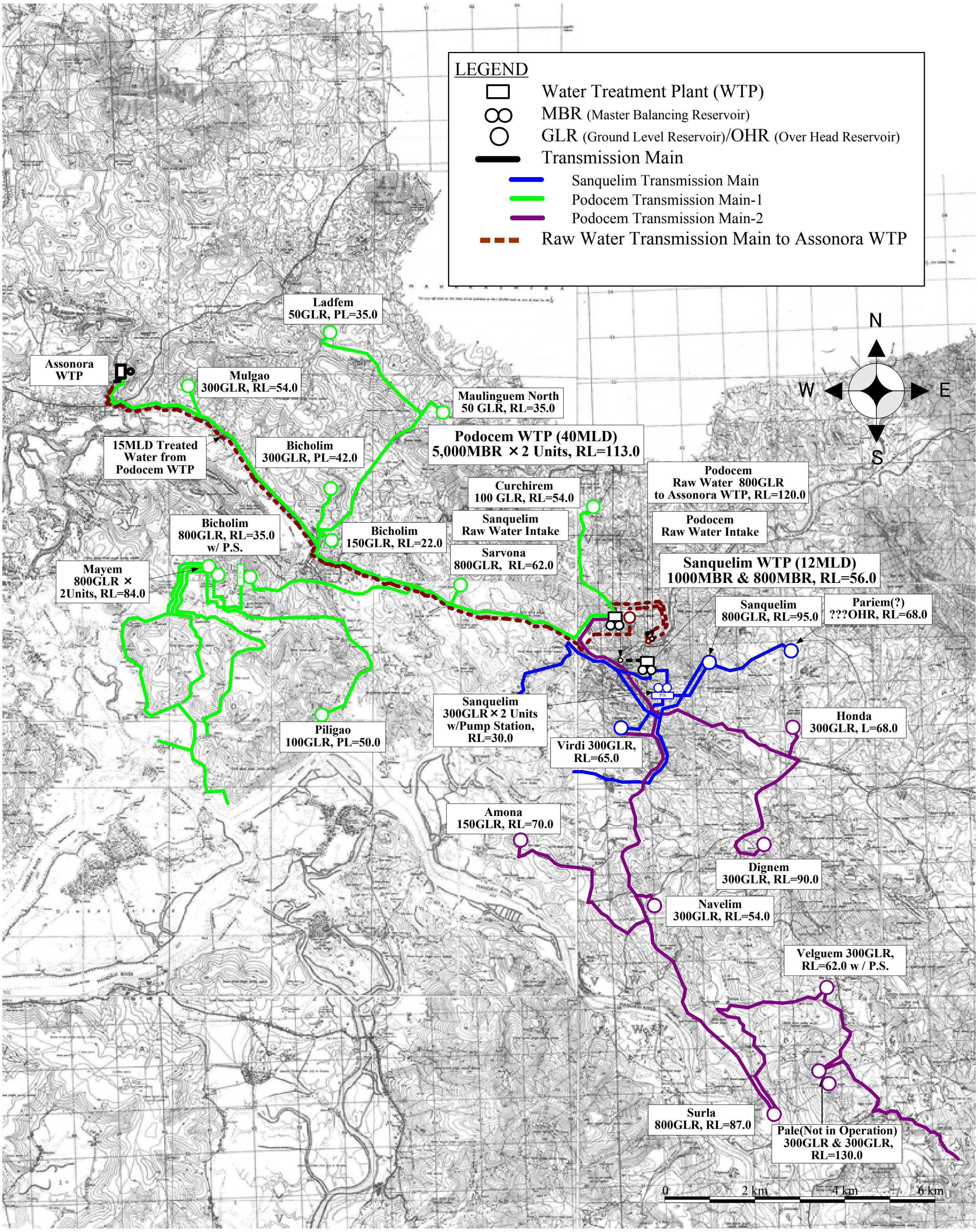

Figure 31.33 Sanquelim Water Supply Scheme

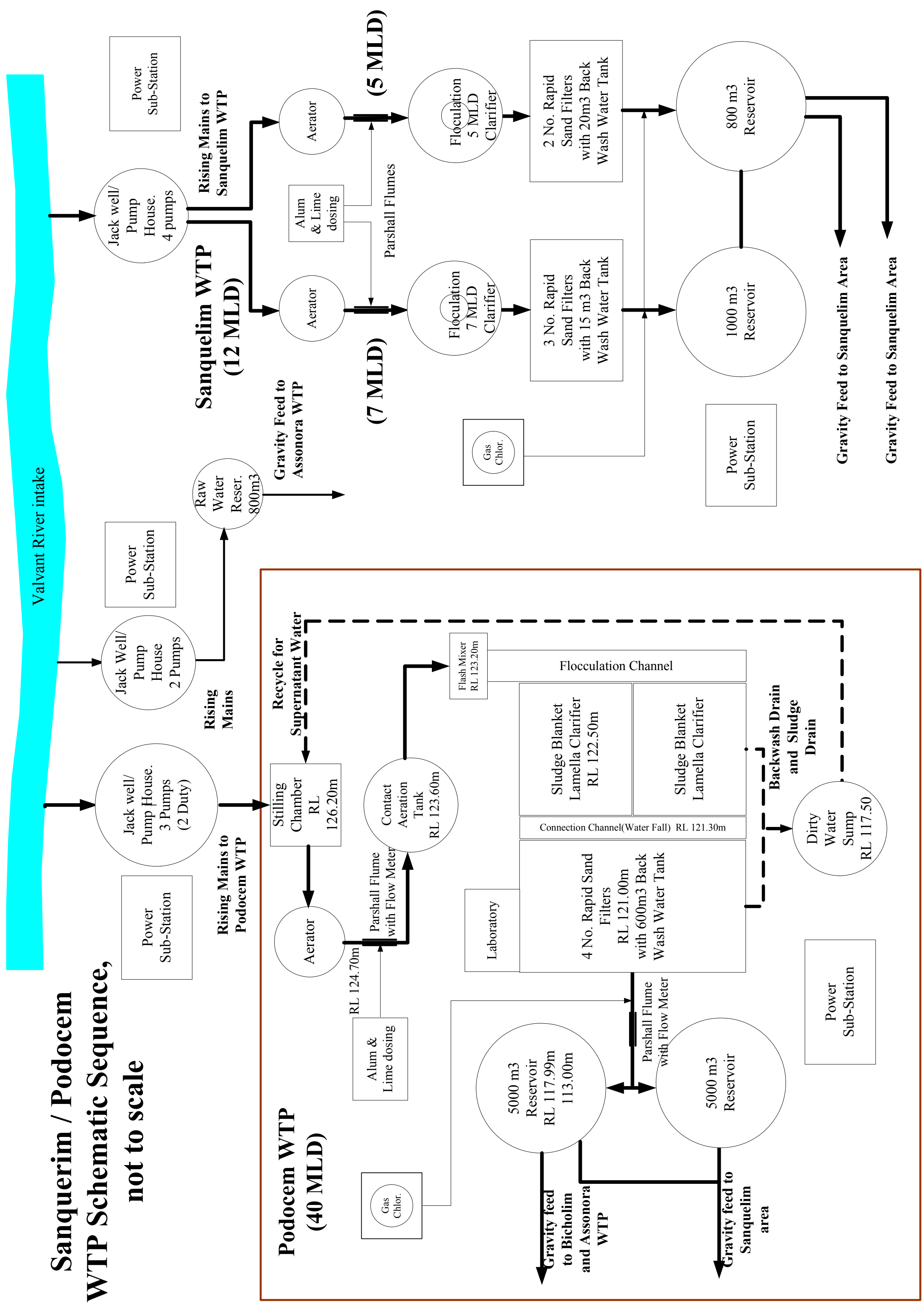

Figure 31.34 Schematic Diagram of the Podocem/Sanquelim WTP

(4) Water Quality

Water qualities of raw and treated water are monitored at water treatment plant and parameters are pH, turbidity, alkalinity, hardness, chloride ion, manganese iron, DO and residual chlorine. These parameters are rather for operation of the plant but not for confirmation of safety of the treated water. Detailed records of water quality are shown in Volume IV Appendix M31 Existing Water Supply System.

Figure 31.35 shows the turbidity levels of the raw water taken from the Valvant River prior to it entering the Podocem WTP (40 MLD).

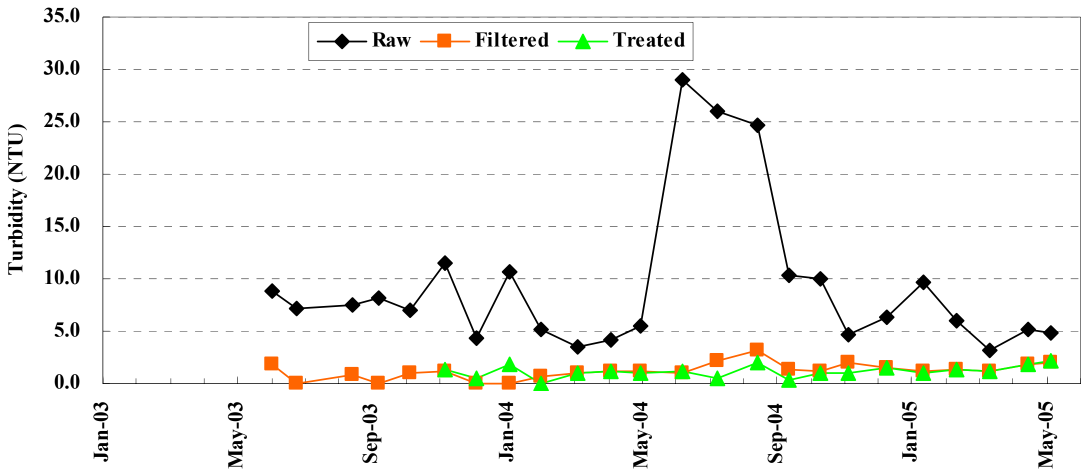

Figure 31.35 Turbidity of Raw Water at the Podocem WTP (40 MLD)

The test results show that the turbidity of the raw water from the Valvant River fluctuates, particularly during the wet season (May to October) when turbidity levels increase as a result of rainfall runoff. The turbidity levels of the raw water at the Podocem WTP were found to be very similar to those at the Sanquelim WTP (12 MLD). This would be because the water for these two plants is sourced from the same river.

Figure 31.36 shows the concentration of iron (Fe) in the raw water at the Podocem WTP from 2003 to present. The results indicate that the concentration of iron occasionally increases.

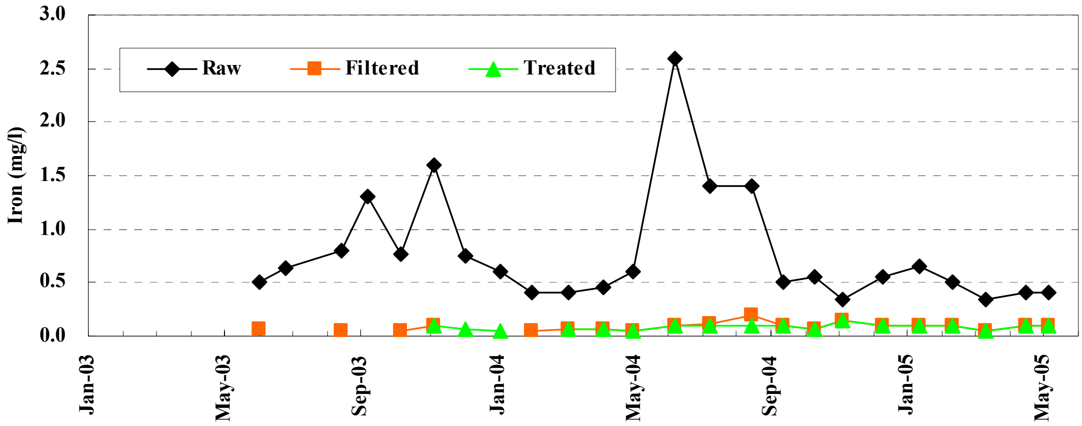

Figure 31.36 Iron Concentration in the Raw Water at the Podocem WTP

During this study, residual chlorine concentrations in the water at consumers' taps was tested at Bicholim. The tests were completed using simple water quality analysis kits. Residual chlorine was detected, therefore it is assumed that the chlorination systems at the plant and/or the reservoirs are functioning properly. Section 3.1.11 presents more detailed results of the residual chlorine analysis.

(5) Operation and Maintenance

Situations of operation and maintenance are very similar to one of Salaulim WTP previously discussed. Specific problems concerning Sanquelim WTPs are described in following (6).

(6) Problems Identified

The following problems were identified with the Sanquelim WSS during the Reconnaissance Survey, as part of Phase I of this project:

1) Lack of flow measurement and flow control systems

Flow metres are not available at the water treatment plant. Therefore the flow rates for intake and transmission are estimated based on the pump capacities and hours of operation. Since flow rates are not accurately known, appropriate chemical dosage is difficult. Also, the transmission flow rates at major points along the transmission mains are not measured. Therefore, appropriate flow control is not possible.

2) Ineffective coagulation

Figure 31.37 presents the aluminium concentration in the treated water. The presence of aluminium in the treated water indicates that chemical dosing is not managed properly or that the mixing is not sufficient.

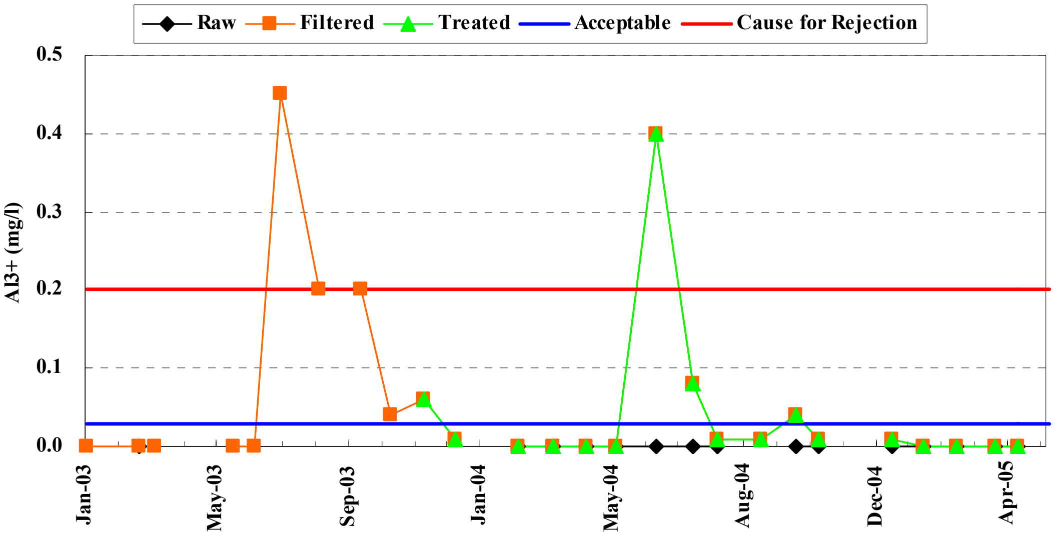

Figure 31.37 Aluminium Concentration in Treated Water at the Sanquelim WTP (12 MLD)

3) Insufficient backwashing

The field investigation found the filter sands contain a lot of mud, the filter media layers are not uniform (see Photo 31.11) and water discharged from the filter, just after it has been backwashed, is turbid. This means that backwashing may not be sufficient because the duration of backwashing is not sufficient and that there may be a structural problem of the filter basin.

Photo 31.10 Filter Media of Podocem Plant

4) Electrical Power Outages

On average, power outages interrupt the WTP operation for 25 - 50 minutes each day during the dry season and 60 - 90 minutes each day during the wet season. To protect against the problems associated with power outages, the following measures should be considered:

- surge control should be installed to protect against water hammer;
- a standby generator should be installed; and
- reservoirs should have sufficient capacity to store water.

5) Lack of operation and maintenance manuals and plans

There are no standard operation and maintenance manuals or plans for the treatment plant, transmission system or distribution system. This means appropriate operation and proactive maintenance is not possible.

6) Lack of asset drawings, asset data and process data

Current asset drawings and data are not available, meaning:

- performance evaluation is difficult;
- operation and maintenance is inadequate because basic facility information is unavailable; and
- responses to problems/emergencies are inadequate or delayed.

3.1.7 Dabose Water Supply Scheme

(1) Outline of the Scheme

Dobose Water Supply Scheme (WSS) has one WTP, which has a capacity of 5 MLD. The WSS supplies Satari Taluka as shown in Figure 31.38.

(2) Treatment Plants

The scheme consists of a 5 MLD plant, which was commissioned around 1992. The plant is currently running at 7 MLD to help meet demand.

Figure 31.39 shows the plant schematic. Detailed asset data for the plant are included with Volume IV Appendix M31.6 Dabose Water Supply Scheme.

(3) Transmission and Distribution System

Table 31.7 lists the components of the transmission and distribution system at the Dabose WSS.

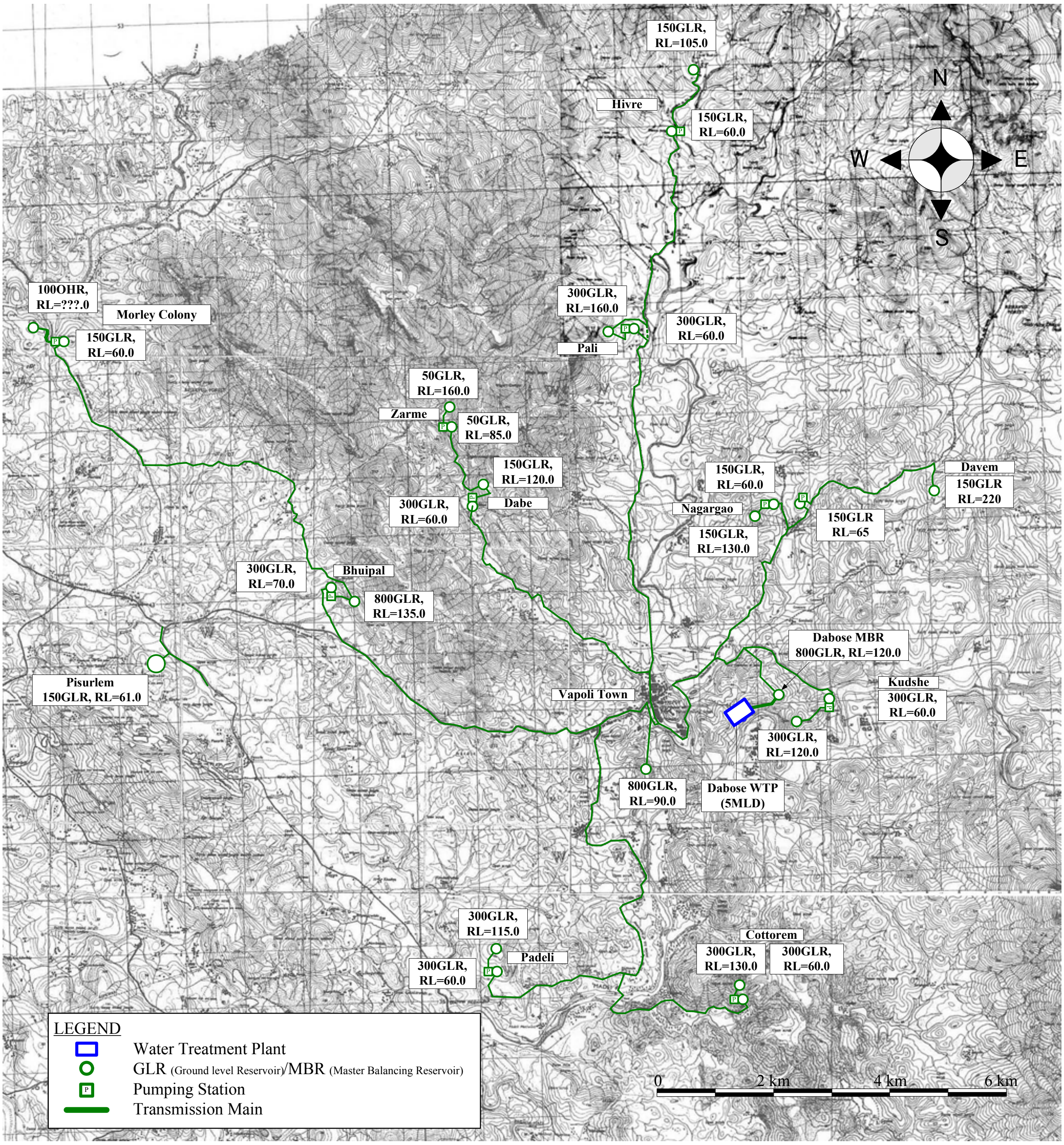

Figure 31.38 Dabose Water Supply Scheme

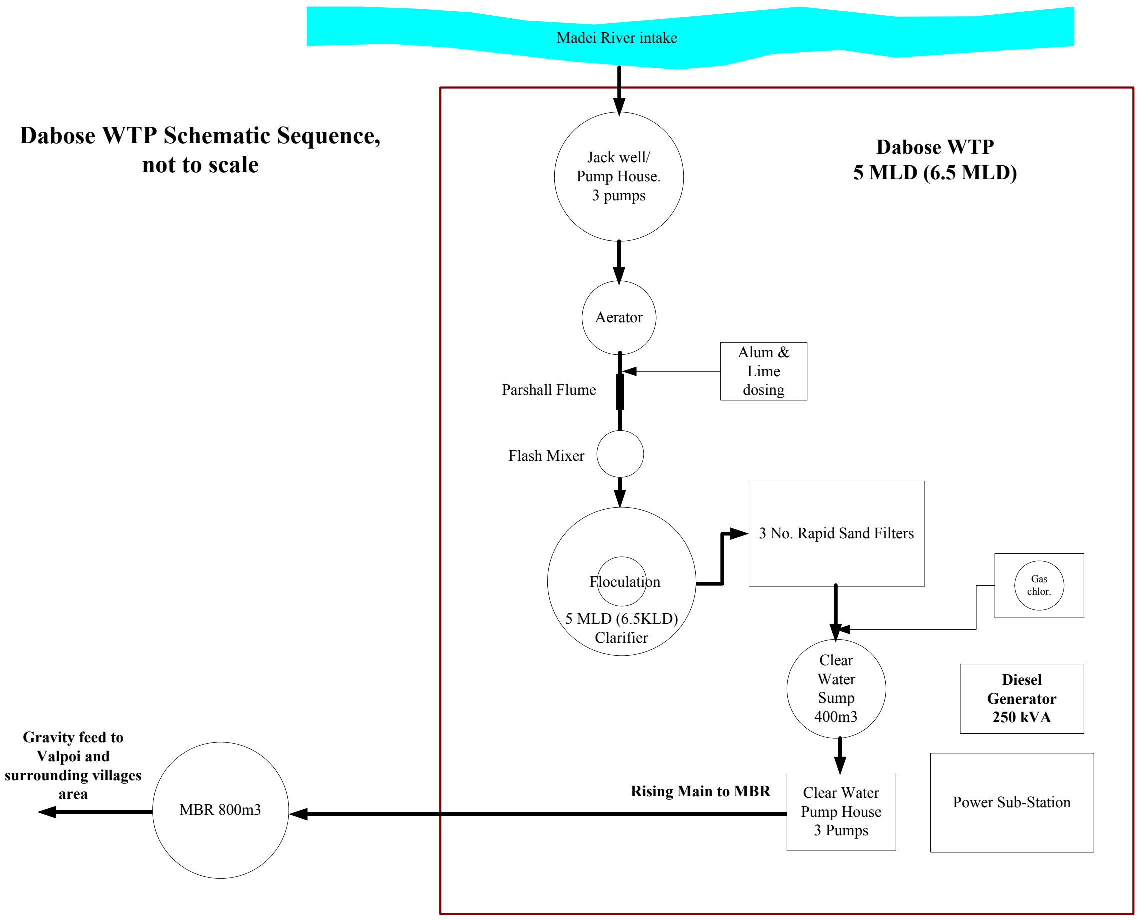

Figure 31.39 Schematic Diagram of the Dabose WTP

Table 31.7 Details of Dabose WSS's Transmission and Distribution System

a. Length of Transmission Mains	65,150 m
- Ductile Iron, 100mm – 200mm	14,300 m
- Cast Iron, 150mm – 350mm	10,850 m
- Others	40,000 m
b. Number of Distribution Reservoirs	26
c. Capacity of Reservoirs	6,400 m^3
d. Length of Distribution Mains	183,500 m
- A.C., 100mm – 150mm	30,000 m
- PVC, 63mm – 150mm	153,500 m

Source: Sector Status Study – WSS Goa, 2004, (Data was confirmed to the PWD in 2005)

(4) Water Quality

Water qualities of raw and treated water are monitored at water treatment plant and parameters are pH, turbidity, alkalinity, hardness, chloride ion, manganese iron, DO and residual chlorine.

These parameters are rather for operation of the plant but not for confirmation of safety of the treated water. Detailed records of water quality are shown in Volume IV Appendix M31 Existing Water Supply System.

Figure 31.40 presents the turbidity levels in the raw water taken from the Madei River.

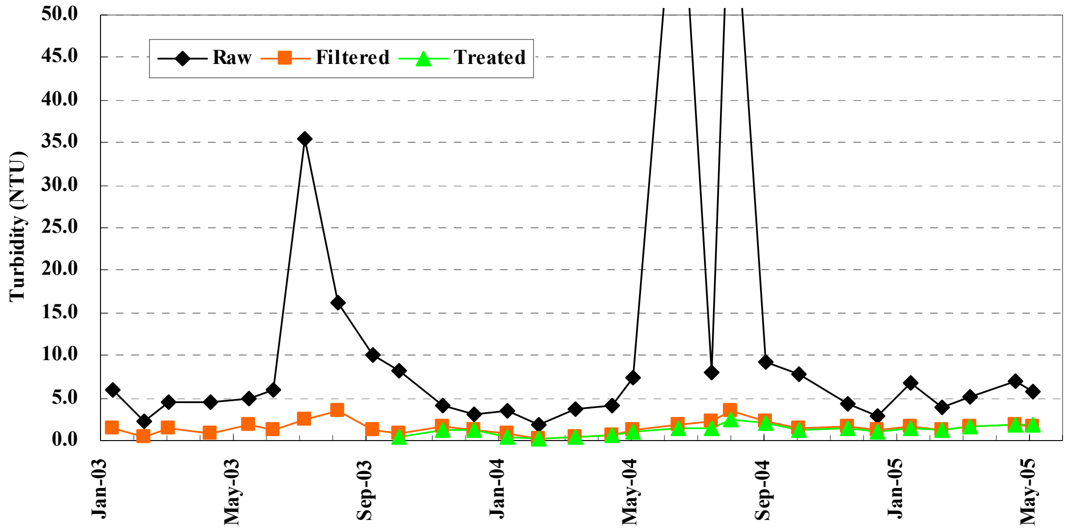

Figure 31.40 Turbidity of Raw Water from the Madei River

The results show that the turbidity levels in the raw water taken from the Madei River fluctuate, particularly during the wet season (May to October), as a result of rainfall runoff.

Figure 31.41 shows the concentration of iron (Fe) in the raw water from 2003 to present. The results indicate that the concentration of iron occasionally increases.

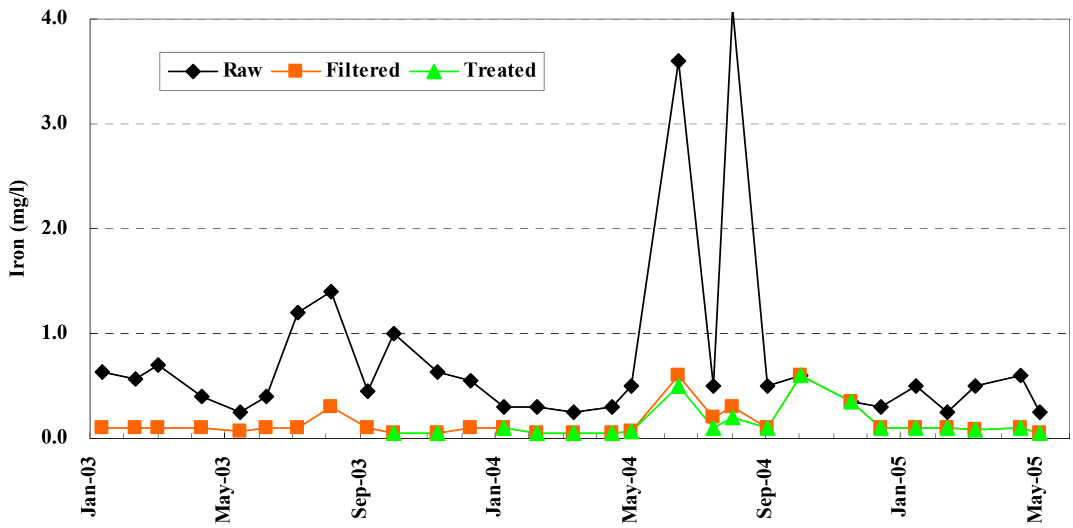

Figure 31.41 Iron Concentration in the Raw Water at the Dabose WTP

Residual chlorine concentrations in the water at consumers' taps was checked during the study at Valpoi and detected residual chlorine. It is therefore assumed that the chlorination systems at the plant and/or the reservoirs are functioning properly. Section 3.1.11 presents more detailed results of the residual chlorine analysis.

(5) Operation and Maintenance

Situations of operation and maintenance are very similar to one of Salaulim WTP previously discussed. Specific problems concerning Dabose WTP are described in following (6).

(6) Problems Identified

The following problems were identified with the Dabose WSS during the Reconnaissance Survey, which was undertaken as part of Phase I of this project:

1) Lack of flow measurement and flow control systems

Flow meters are not available at the water treatment plant. Therefore the intake and transmission flow rates are estimated based on the pump capacities and hours of operation. Lack of flow measurement means that accurate chemical dosage is difficult. Also, the transmission flow rates at major points along the transmission mains are not measured, therefore adequate flow control is not possible.

2) Ineffective coagulation

The aluminium concentration in the filtered and treated water is shown in Figure 31.42. The presence of aluminium in the treated water indicates that chemical dosing is not managed properly or that the mixing is not sufficient.

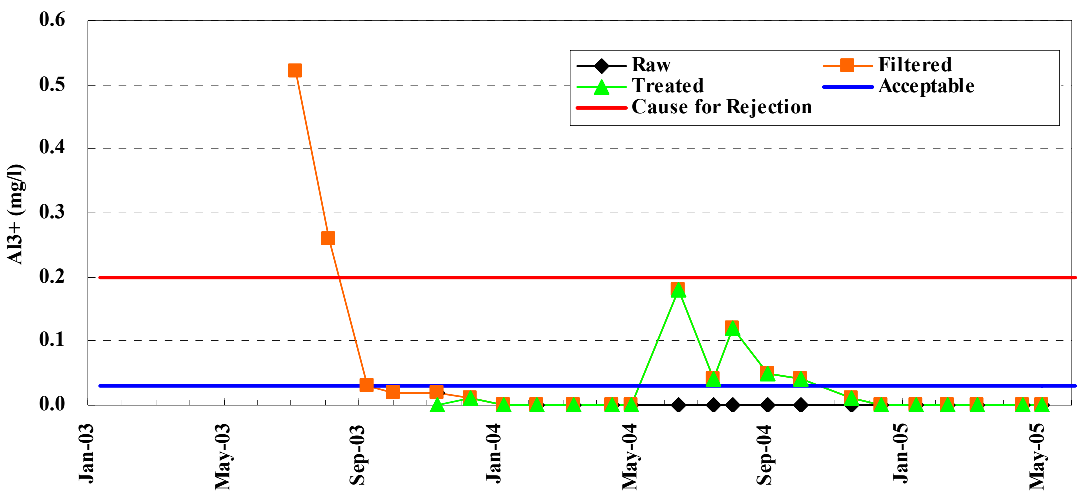

Figure 31.42 Aluminium Concentration in Treated Water at Dabose WTP

3) Insufficient backwashing

The field investigation found that the water coming out of the filter is turbid. This means that backwashing may not be sufficient because the duration of backwashing is not sufficient and that there may be a structural problem of the filter basin.

4) Lack of operation and maintenance manuals and plans

There are no standard operation and maintenance manuals and plans for the treatment plant, transmission system or distribution system. Therefore appropriate operation and proactive maintenance is not possible.

5) Lack of asset drawings, asset data and process data

Current asset drawings and data are not available meaning:

- performance evaluation is difficult;
- operation and maintenance is adequate due to lack of basic facility information; and
- responses to problems/emergencies are inadequate and delayed.

3.1.8 Canacona Water Supply Scheme

(1) Outline of the Scheme

Canacona Water Supply Scheme (WSS) has one WTP, which has a capacity of 5 MLD. The WSS supplies treated water to Canacona Taluka, as shown in Figure 31.43.

(2) Treatment Plants

The Canacona WTP consists of a 5 MLD plant, which was commissioned in 1983. Raw water is sourced from the Tapona River, and since 1997 from the Chapoli Dam. The river intake has a jack well with three pumps. The Dam intake pump house is equipped with three number 100HP pumps and a small submersible pump. The rising main to the plant is approximately 8.5km long.

The plant schematic is shown in Figure 31.44. Detailed asset data for the plant are attached to Volume IV Appendix M31.7 Canacona Water Supply Scheme.

(3) Transmission and Distribution System

Table 31.8 lists the components of the Canacona WSS transmission and distribution system.

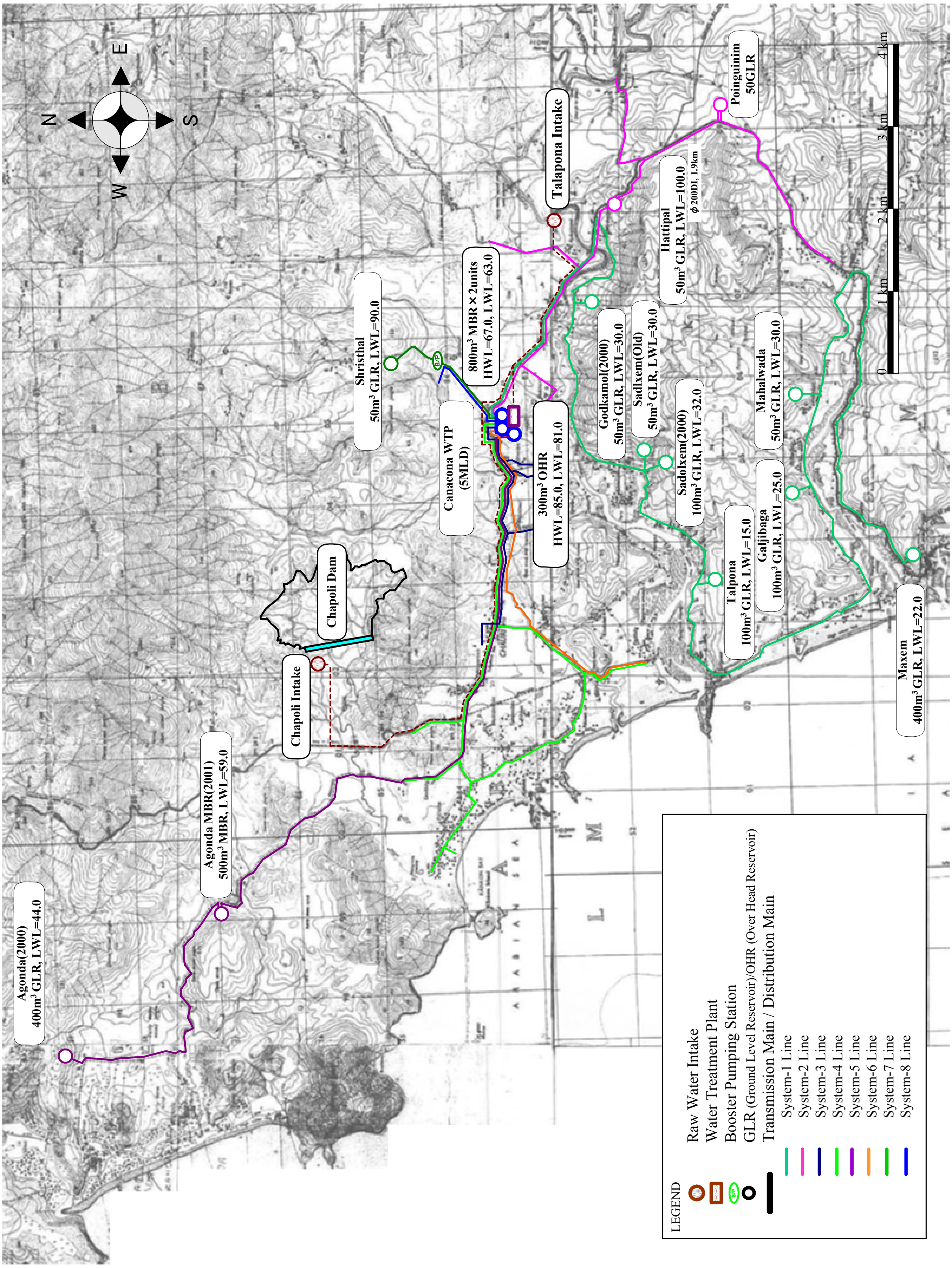

Figure 31.43 Canacona Water Supply Scheme

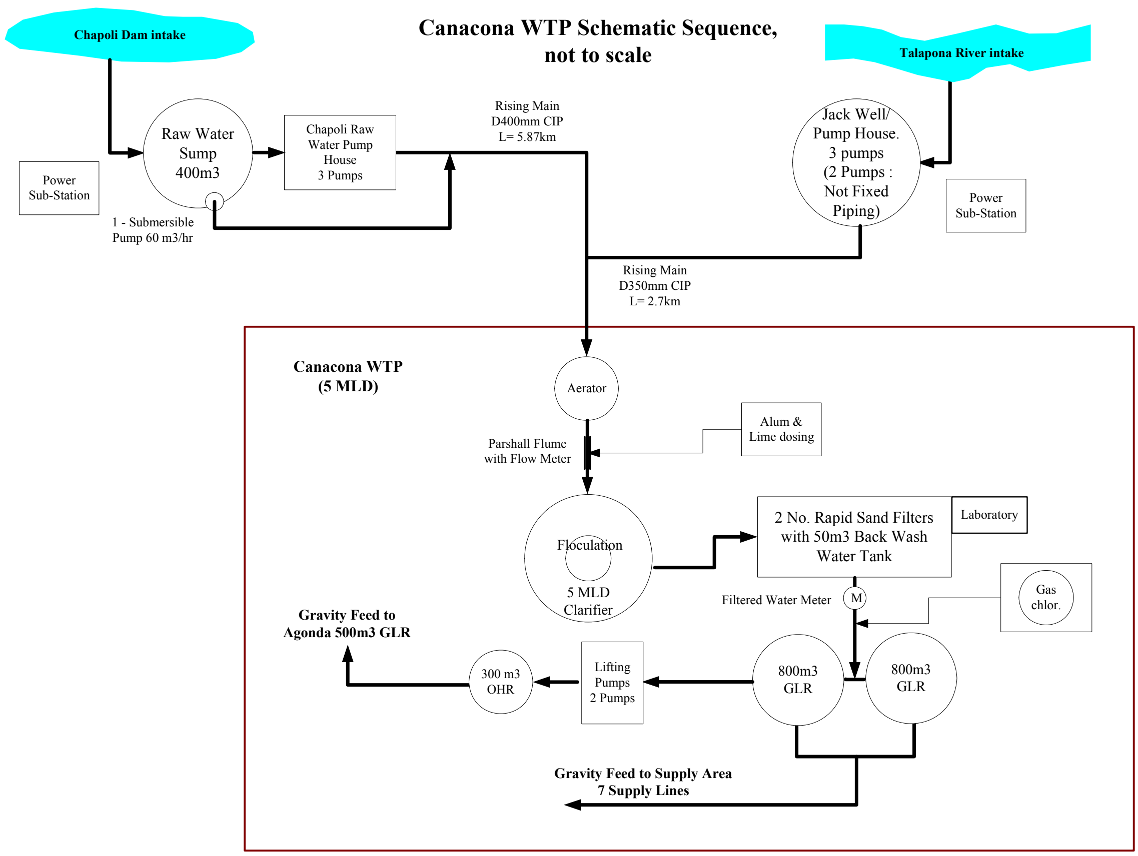

Figure 31.44 Schematic Diagram for the Canacona WTP

Table 31.8 Details of Canacona WSS's Transmission and Distribution System

a. Length of Transmission Mains	60,273 m
- Ductile Iron, 300mm	17,270 m
- Cast Iron, 125mm – 400mm	14,255 m
- A.C., 80mm – 200mm	28,748 m
b. Number of Distribution Reservoirs	15
c. Capacity of Reservoirs	3,700 m^3
d. Length of Distribution Mains	48,085 m
- Cast Iron, 125mm – 250mm	5,685 m
- Ductile Iron, 300mm	17,270 m
- A.C., 80mm – 200mm	16,630 m
- PVC, 63mm – 90mm	8,500 m

Source: Sector Status Study – WSS Goa, 2004, (Data was confirmed to the PWD in 2005)

(4) Water Quality

Water qualities of raw and treated water are monitored at water treatment plant and parameters are pH, turbidity, alkalinity, hardness, chloride ion, manganese iron, DO and residual chlorine. These parameters are rather for operation of the plant but not for confirmation of safety of the treated water. Detailed records of water quality are shown in Volume IV Appendix M31 Existing Water Supply System.

Figure 31.45 presents the turbidity levels in the raw water at the Canacona WTP.

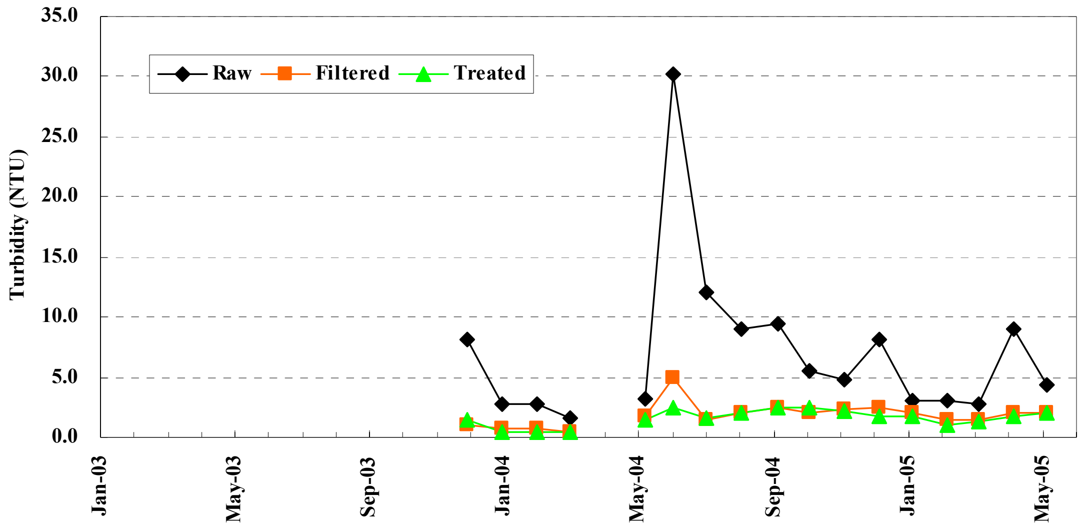

Figure 31.45 Turbidity Levels in the Raw Water at the Canacona WTP

The results indicate that the turbidity of the raw water fluctuates, particularly during the wet season in response to rainfall runoff.

Figure 31.46 shows the concentration of iron (Fe) in the raw water from 2003 to present. The results show that the concentration of iron occasionally increases.

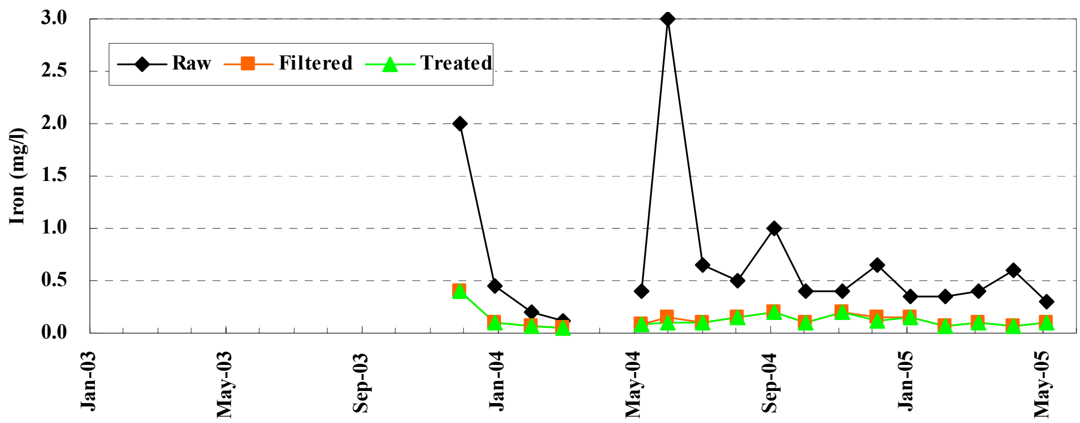

Figure 31.46 Iron Concentration in the Raw Water at the Canacona WTP

The concentration of residual chlorine in the water delivered to consumers' taps was tested during the study at Nagorcem. Residual chlorine was detected in the tap water. It is therefore assumed that the chlorination systems at the plant and/or the reservoirs are functioning properly. Section 3.1.11 provides more detailed results of the residual chlorine analysis.

(5) Operation and Maintenance

Situations of operation and maintenance are very similar to one of Salaulim WTP previously discussed. Specific problems concerning Canacona WTP are described in following (6).

(6) Problems Identified

The problems discussed below were identified during the Reconnaissance Survey as part of Phase I of this study:

1) Lack of flow measurement and flow control systems

Flow metres are not installed at the water treatment plant. Therefore, the flow rate at the intake point and the transmission flow rates are estimated based on the pump capacities and hours of operation. The lack of flow measurement means chemical dosage is inaccurate. Since the transmission flow rates are not measured flow control is poorly implemented.

2) Insufficient backwashing

The field investigation indicated that the backwashing is insufficient because the duration of backwashing is inadequate and there may be a structural problem of the filter basin.

3) Electric Power Outages

Power outages interrupt plant operation on average six hours each day. The following measures are required to manage the resulting problems:

- surge control should be installed to manage the effects of water hammer;
- a standby generator should be installed; and
- reservoirs should have sufficient capacity to store water.

4) Lack of operation and maintenance manuals and plans

There are no standard operation and maintenance manuals or plans for the treatment plant, transmission system or distribution system. Therefore appropriate operation and proactive maintenance is difficult.

5) Lack of asset drawings, asset data and process data

Current asset drawings and data are not available, meaning:

- performance evaluation is difficult;
- operation and maintenance is inadequate because basic facility information is unavailable; and
- responses to problems/emergencies are inadequate and delayed.

3.1.9 Small Scale Water Supply System

The PWD has indicated that in 4 of the 11 Talukas in Goa (Bardez, Bicholim, Marmugao and Salcete), all the cities, towns and villages are serviced by regional water supply schemes (although the water supply conditions may be lacking). The remaining 7 Talukas have small scale water supply systems (rural water supply schemes) which mainly depend on groundwater. Volume IV Appendix M31.8 Rural Water Supply Scheme lists the small scale water supply schemes in each Taluka.

Recently a number of existing rural water supply schemes have been incorporated into the regional surface water supply schemes. Some of the rural schemes serve to augment the regional scheme at times of peak demand.

3.1.10 Water Consumption and Connections

(1) Data Source

Basic data, such as the number of connections and water consumption, was collected (with the assistance of the PWD), to help evaluate the existing water supply situation in Goa. Data collection was difficult because the PWD head office does not collect these basic types of data. For northern Goa the data had to be sourced from the individual divisional and sub-divisional offices. For southern Goa the data was sourced from the private companies that the PHE subcontracts to do the billing work (e.g. calculation of water consumption and water charges, printing and sending of bills to customers).

The source of the data that was used to assess the existing water supply situation is shown in Table 31.9. These data provided by PWD Goa is shown in Volume IV Appendix M32 Data Concerning Number of Conection and Water Consumption Provided by PWD Goa.

Table 31.9 Data Source of Number of Connection and Water Consumption

Taluka	Data Source
Pernem	Sub-Divisional office II of Divisional office XVII, data from October 2004 to June 2005
Bardez	Divisional office XVII, data of June 2005
Tiswadi	Sub Divisional office I of Divisional office III, data of average in 2004
Bicholim	Divisional office XVII , data of June 2005
Satari	Divisional office XVII , data from March to April 2006
Ponda	Divisional office III, data of July 2005
Mormugao	Private Firm (Megasoft), data of 2004
Salcete	Private Firm (Megasoft), data of 2004
Quepem	Private Firm (Megasoft), data of 2004
Sanguem	Private Firm (Megasoft), data of 2004
Canacona	Private Firm (Megasoft), data of 2004

(2) Number of Connections

1) Domestic Connections

The number of domestic connections in each taluka is shown in Table 31.10 and Figure 31.47.

Table 31.10 Number of Domestic Connections in Each Taluka

	Pernem	Bardez	Tiswadi	Bicholim	Satari	Ponda	Mormugao	Salcete
Urban	1,310	26,228	18,880	5,123	1,082	8,137	13,868	26,681
Rural	6,690	16,020	8,348	6,100	5,029	8,334	2,019	16,728
Total	8,000	42,248	27,228	11,223	6,111	16,471	15,887	43,409

	Quepem	Sanguem	Canacona	Total
Urban	5,390	1,294	1,605	109,596
Rural	5,152	1,294	1,641	77,357
Total	10,542	2,588	3,246	186,953

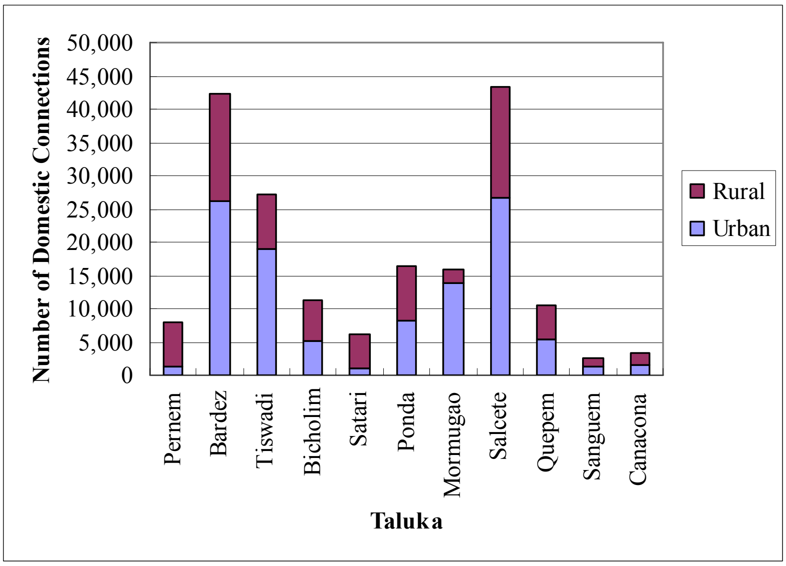

Figure 31.47 Number of Domestic Connections in Each Taluka

The above table and figure show the number of urban and rural domestic connections for each taluka. These calculations used the service ratio for urban and rural areas.

Table 31.11 and Figure 31.48 show the number of domestic connections for north and south Goa.

Table 31.11 Number of Domestic Connections in North and South Goa

	North Goa	South Goa	Total Goa
Urban	60,759	48,837	109,596
Rural	50,522	26,835	77,357
Total	111,281	75,672	186,953

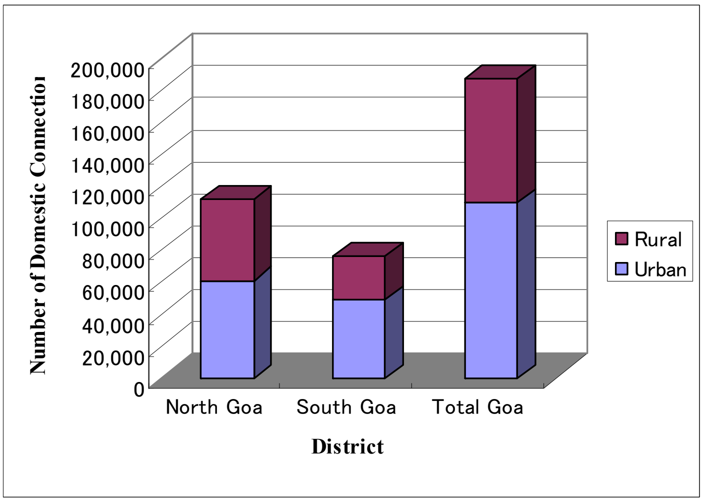

Figure 31.48 Number of Domestic Connections in North and South Goa

2) Number of Non-Domestic Connections

Table 31.12 shows the number of domestic and non-domestic connections in each taluka.

Table 31.12 Number of Connections in Each Taluka

Category	Pernem	Bardez	Tiswadi	Bicholim	Satari	Ponda	Mormugao	Salcete
Domestic	8,000	42,248	27,228	11,223	6,111	16471	15,887	43,409
Commercial	55	739	575	270	72	344	261	349
Government	0	141	270	28	126	110	134	481
Industries	3	17	12	9	13	59	298	544
Municipality	0	0	29	33	5	6	5	3
V. Panchayat	0	0	0	15	19	0	0	0
Defense	0	1	14	0	0	0	12	3
Temporary Sup.	0	5	0	65	0	0	14	85
Total	8,058	43,151	28,128	11,643	6,346	16,990	16,611	44,874

Category	Quepem	Sanguem	Canacona	Total	Ratio
Domestic	10,542	2,588	3,246	186,953	97.00%
Commercial	108	17	90	2,880	1.49%
Government	74	16	56	1,436	0.75%
Industries	78	6	16	1,055	0.55%
Municipality	0	1	0	82	0.04%
V. Panchayat	0	0	0	34	0.02%
Defense	0	0	0	30	0.02%
Temporary Sup.	12	3	3	272	0.14%
Total	10,814	2,631	3,411	192,742	100%

The above table shows that domestic connections represent more than 97 % of the total number of connections. The number of commercial connections (including hotels, restaurants, etc) is high in the talukas of Bardez, Tiswadi, Ponda, and Salcete because these talukas have high levels of tourism. The talukas of Mormugao and Salcete have the highest number of industrial connections.

(3) Population Serviced and the Service Ratio

1) Population Serviced

The number of people served by the water supply system was calculated using the number of domestic connections and the average household size. The average household size was sourced from the census data. However, because many households share their water connection with their neighbours the household size from the census data was multiplied by 1.5. This multiplication factor was recommended by the PWD. The number of people served in each taluka is shown in Table 31.13 and Figure 31.49.

Table 31.13 Number of People Served in Each Taluka

	Pernem	Bardez	Tiswadi	Bicholim	Satari	Ponda	Mormugao	Salcete
Urban	9,435	138,483	101,950	36,882	7,952	49,434	93,607	149,147
Rural	49,169	86,508	46,083	45,754	36,963	55,128	13,327	97,858
Total	58,604	224,992	148,033	82,636	44,916	104,562	106,934	247,006

	Quepem	Sanguem	Canacona	Total
Urban	33,201	8,733	11,072	639,897
Rural	34,623	9,125	12,064	486,602
Total	67,824	17,857	23,136	1,126,499

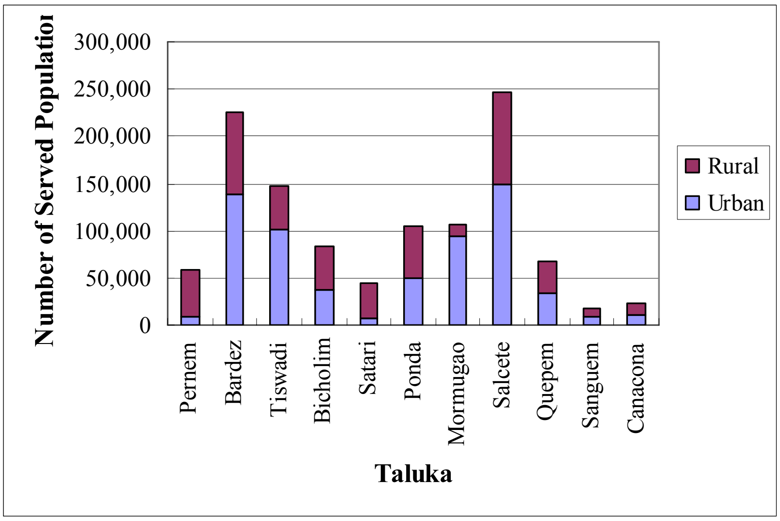

Figure 31.49 Number of People Served in Each Taluka

2) Service Ratio

The service ratio was calculated comparing the size of the population serviced (as described above) to the total population. Table 31.14 and Figure 31.50 show the resulting service ratios.

Table 31.14 Service Ratio for Each Taluka

	Pernem	Bardez	Tiswadi	Bicholim	Satari	Ponda	Mormugao	Salcete
Urban	93%	95%	95%	93%	95%	94%	73%	95%
Rural	75%	87%	80%	82%	66%	52%	52%	85%
Average	78%	92%	90%	86%	70%	66%	69%	91%

	Quepem	Sanguem	Canacona	Average
Urban	95%	77%	91%	90%
Rural	83%	16%	36%	68%
Average	88%	27%	51%	79%

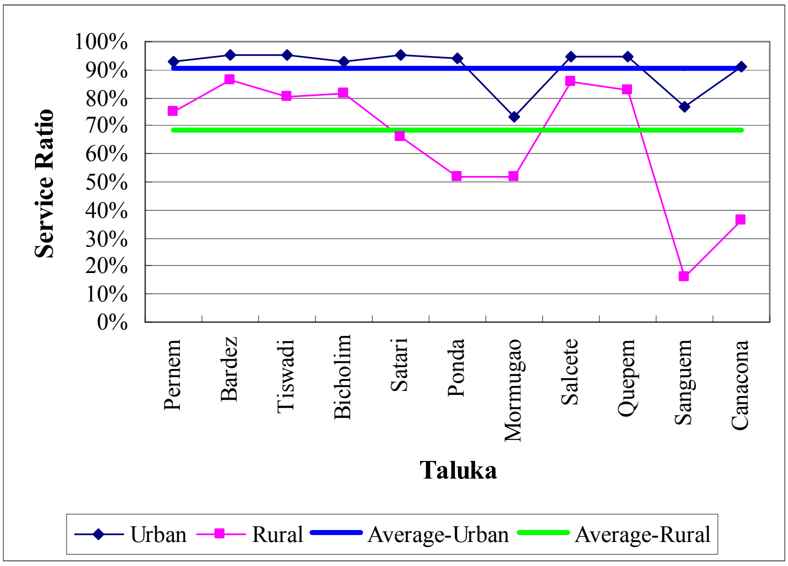

Figure 31.50 Service Ratio for Each Taluka

The above table and figure show that the service ratio in urban areas is relatively high, having an average of 90%. However, the service ratio in rural areas can be much lower, and varies from 16 % in the Sanguem taluka to 87 % in the Bardez taluka. The average rural service ratio is 68%. The talukas that have service ratios below this rural average are Pernem, Satari, Ponda, Mormugao, Sanguem and Canacona.

(4) Water Consumption by Category

Table 31.15 and Figure 31.51 show water consumption categorized by type and by taluka.

Table 31.15 Water Consumption in Each Taluka(m^3/day)

Category	Pernem	Bardez	Tiswadi	Bicholim	Satari	Ponda	North Goa
Domestic	2,761	27,904	19,705	9,578	3,657	10,325	73,931
Tour/Com	41	1,594	1,148	516	58	245	3,601
Industry	54	475	1,387	229	97	1,544	3,785
Institutions	59	95	143	314	215	230	1,057
Defence	0	0	933	0	0	0	933
Total	2,915	30,068	23,316	10,636	4,027	12,344	83,307

Category	Mormugao	Salcete	Quepem	Sanguem	Canacona	South Goa	Goa
Domestic	13,804	33,820	6,855	1,670	2,109	58,258	132,188
Tour/Com	722	2,574	110	21	85	3,511	7,112
Industry	18,294	2,202	165	9	21	20,690	24,476
Institutions	681	2,051	231	18	71	3,052	4,109
Defense	358	1,859	0	0	0	2,218	3,151
Total	33,859	42,506	7,361	1,718	2,286	87,729	171,036

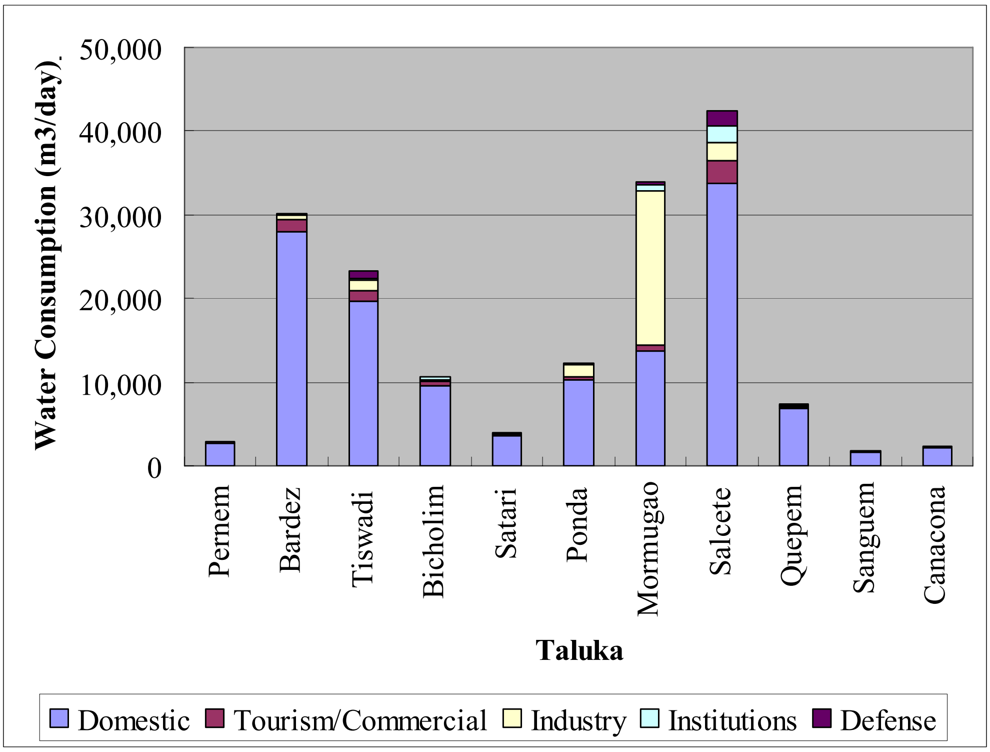

Figure 31.51 Water Consumption in each Taluka (m^3/day)

Due to the presence of a huge industrial estate, the industrial water consumption in the Mormugao taluka represents more than 50% of the total consumption for the taluka..

Figure 31.52 shows the proportion of each type of water consumed in Goa. This figure shows that domestic water consumption is the largest proportion of the total (78%) and industrial consumption is the second largest proportion (14 %).

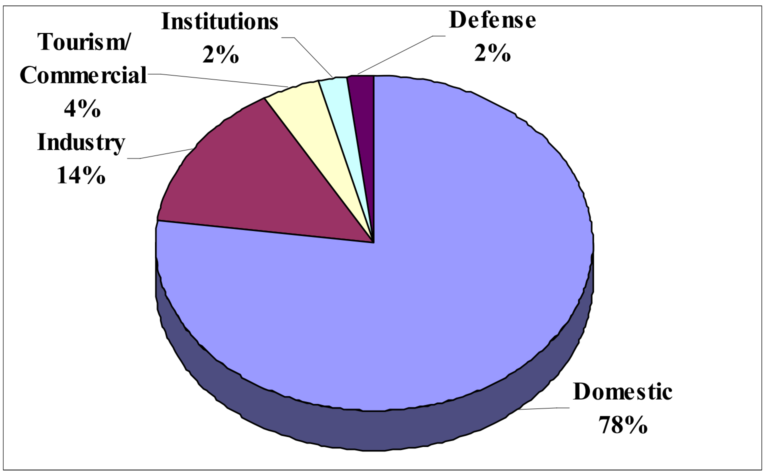

Figure 31.52 Proportion of Each Type of Water Consumed

(5) Domestic Per Capita Water Consumption

Domestic per capita water consumption was calculated dividing the total domestic water consumption by the number of people served by the water supply system. Table 31.16 and Figure 31.53 show the per capita water consumption for each taluka. The average per capita water consumption for urban areas is 143 lpcd and for rural areas it is 84 lpcd.

Table 31.16 Domestic Per Capita Water Consumption (liter per capita per day: lpcd)

	Pernem	Bardez	Tiswadi	Bicholim	Satari	Ponda	Mormugao	Salcete
Urban	70	151	151	148	115	130	138	159
Rural	43	85	99	93	76	73	80	108
Average	54	125	134	116	85	102	134	139

	Quepem	Sanguem	Canacona	Average
Urban	128	96	112	143
Rural	85	71	75	84
Average	105	95	93	117

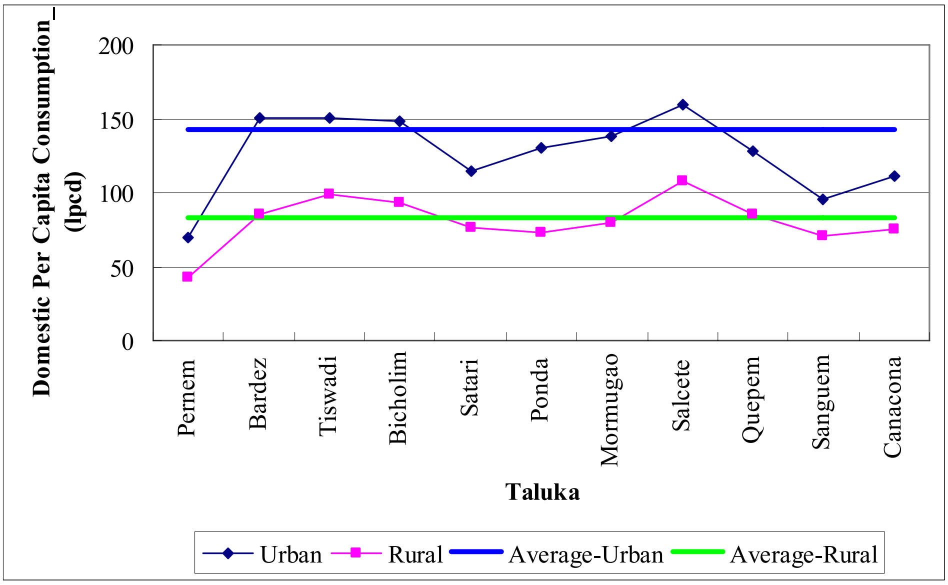

Figure 31.53 Domestic Per Capita Water Consumption (litter per capita per day: lpcd)

The per capita water consumption is lowest in the talukas of Pernem and Satari. Figure 31.54 shows a comparison of the average per capita water consumption in Goa compared to the standard per capita water consumption which is presented in the CPHEEO manual. The CPHEEO standard per capita water consumption for urban areas is 135 lpcd and for rural areas it is 70 lpcd. Figure 31.54 shows that the average per capita water consumption in Goa is already higher than the CPHEEO consumption figures.

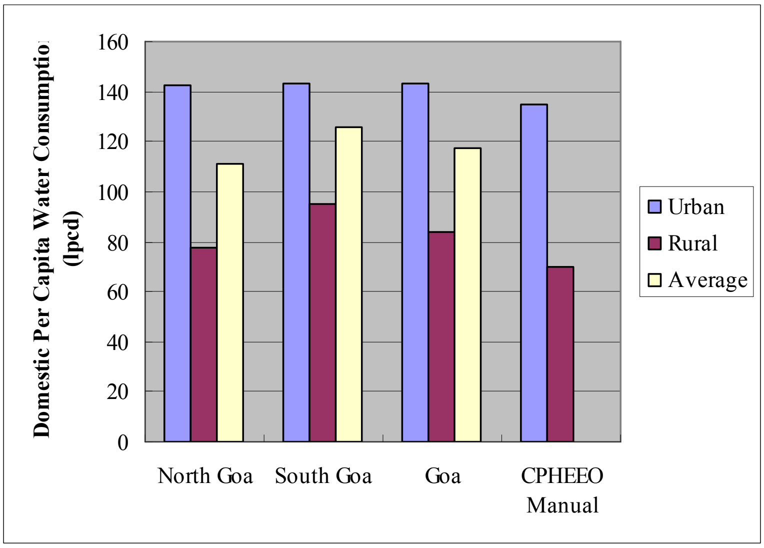

Figure 31.54 Average Per Capita Water Consumption (lpcd)

3.1.11 Water Quality Analysis for Water Supply

(1) General

Water quality analysis was undertaken to confirm the safety of the water supply. Salaulim Dam and 15 other wells were investigated as part of this study.

There are many iron and manganese mines throughout Goa. Spoil from these mining operations is sometimes discharged onto riverbanks. During the rainy season these deposits can be washed into the water sources when the water level in the rivers rises. Although iron and manganese do not present a significant problem for water purification, other chemicals such as arsenic associated with the mine spoil could cause health problems. The raw water quality was therefore analyzed on 34 chemicals including arsenic, iron and manganese etc. at PWD water quality analysis laboratory during both the dry and rainy seasons.

It was also important to confirm the safety of the supplied water (e.g. tap water). Residual chlorine was used as the indicator of tap water quality. The investigation was completed using simple water quality analysis kits.

Table 31.17 shows the number of samples. Results of all water quality analysis are shown in Volume IV M33 Water Quality Analysis for Water Supply System.

Table 31.17 Water Quality Analysis for the Water Supply System

Sampling Point	Number of Samples	Parameter
Salaulim Dam	2 dry season samples. 1 from the surface and 1 from the bottom layer.	34 parameters required by Indian Dinking Water guidelines[2)]
	2 rainy season samples. 1 from the surface and 1 from the bottom layer：	34 parameters required by Indian Dinking Water guidelines[2)]
Water Supply Wells	1 dry season sample from each water supply well (i.e. 15 samples in total).	34 parameters required by Indian Dinking Water guidelines[2)]
	1 rainy season sample from each water supply well (i.e. 15 samples in total).	34 parameters required by Indian Dinking Water guidelines[2)]
Tap Water (seven schemes)	11 [1)]dry season samples：	Residual chlorine, standard plate count bacteria, coliform[3)]
	11 [1)]rainy season：	Residual chlorine, standard plate count bacteria, coliform[3)]

1) Tap Water Quality Sample Points
   - Chandel Scheme: Permem
   - Assonora Scheme: Mapusa
   - Sanquelim Scheme: Bicholim
   - Dabose Scheme: Valpoi
   - Opa Scheme: Orgao, Panaji, Ponda（3 points）
   - Salaulim Scheme: Vasco, Margao, Quepem（3 points）
   - Canacona Scheme: Nagorcem

2) Source: The Government of India, Manual on Water Supply and Treatment Third Edition, 1999 May

3) When residual chlorine was detected the tests for standard plate count bacteria and coliform were not conducted.

(2) Evaluation of Water Quality for Water Supply

The water quality for water supply was evaluated on ‘Acceptable’ values of 12 parameters in ‘Recommended Guidelines’ presented on ‘Manual on Water Supply and Treatment Third Edition, The Government of India, 1999 May’.

The Indian ‘Recommended Guidelines’ propose 34 parameters for drinking water quality and for each parameter, two values such as ‘Acceptable’ value and ‘The cause of rejection’ value are defined. According to ‘Guidelines for Drinking-water Quality, Third Edition, WHO 2004’ (hereinafter ‘WHO Guidelines’), these Indian 34 parameters are categorized as ‘health significance’ aspects and ‘acceptability’ aspects. The ‘health significance’ aspects mean that parameters cause adverse health effects in humans. ‘Acceptability’ aspects mean that the appearance, taste and odor and these threshold concentrations of drinking water should be acceptance to consumer.

Among the Indian ‘Recommended Guidelines’, 12 parameters, such as E.coli, arsenic, chromium, fluoride, manganese, selenium, cadmium, cynide, mercury, nitrate, copper and lead, are categorized as health significance aspects. Since the purpose of water quality analysis is to confirm the safety of water, the water quality of water supply was evaluated on these 12 parameters categorized as ‘health significance’ aspects.

There are two values in 'Recommended Guidelines'. One is 'Acceptable' values and the other is 'the cause for rejection' values. 'Acceptable' values mean that the figures are the limits upto which water is generally acceptable to the consumers. 'The cause for rejection' values mean that water should be rejected if chemical concentrations are exceed the figures. 'Acceptable' figures are stricter than 'the cause for Rejection' figures. Acceptable values in 'Recommended Guidelines' therefore were used in the evaluation to confirm the safety of water.

Taking account of situation surrounding the sampling points, the most of parameters concerning chemicals from industry and agriculture were excluded from analysis. Cadmium and lead on 'WHO Guidelines' have stricter values than Indian 'Recommended Guidelines'. The parameters also were referred to WHO guidelines.

(3) Results of Water Quality Analysis

1) Salaulim Dam

Water quality of Salaulim dam was investigated. All parameters were satisfied with 'Recommended Guidelines' values during both seasons. Cadmium and Lead was also satisfied with 'WHO Guidelines'. Because E.coli was found in Salaulim dam, disinfection should be necessary for drinking water supply.

2) Water Supply Wells and Springs

Fifteen samples were investigated. Two samples collected from Curca and Siroda were satisfied with 'Recommended Guidelines'. Other thirteen samples were satisfied with 'Recommended Guidelines' except for E.coli. Cadmium and lead were also investigated and these were also satisfied with 'WHO Guidelines'.

3) Tap Water

Tap water was tested for residual chlorine at 11 locations, across 7 schemes. Two points in each place were selected as sampling sites. It is reported that iron and manganese were found in raw water but treated water in WTPs was satisfied with 'Recommended Guidelines'. Then, only residual chlorine of tap water was investigated.

Residual chlorine was detected in all the tap water samples during both the dry and rainy seasons. The average chlorine concentration was approximately 0.3 mg/L in both the dry and rainy seasons. Tap water in Bicholim (which is in the Sanquelim scheme) had the highest average chlorine concentration during both the dry and rainy seasons. Tap water in

Nagorecem (which is in the Canacona scheme) had the lowest average chlorine concentration.

3.1.12 Results of Leakage Survey

The extent of leakage in the PWD piped water service area was surveyed during the first phase of the study, from May to July 2005, by carrying out leakage surveys in the selected pilot areas. Details of the results of the leakage survey are shown in Volume IV M34 Results of Leakage Survey.

Leakage surveys were conducted using the following steps:

1. Selection of survey areas
2. Household survey
3. Mapping
4. Flow measurement, pressure measurement and house meter reading
5. Leakage Detection
6. Evaluation of Leakage Reduction

Survey areas were selected through consultation with the PWD offices. As each survey area contains around 100 to 200 households, survey areas were generally selected from urban areas. Features of the five selected survey areas are as shown in Table 31.18.

Table 31.18 Features of Survey Areas

	Taluka	Name of Town	Name of Survey Area	Hours of Water Supply	Distribution Pipe Length (m)	Number of Household
1	Bicholim	Bicholim	Lamgao	24 hours	2,140	192
2	Bardez	Mapusa	Marod	6 hours (from 4 am to 10 am)	1,130	121
3	Ponda	Ponda	Khadpabandh	22 hours	1,780	173
4	Salcete	Margao	Fatorda	24 hours	1,310	116
5	Tiswadi	Panaji	Althino	3 hours (from 7 pm to 10 pm)	1.480	168

Results of the leakage survey are summarized as follows.

- In the five leakage survey areas, several leaking points were found and the UFW ratio varied from 13 to 74 %. After these leak points were repaired, the UFW ratio decreased in several survey areas.
- Leakage points were found not only on house connections but also on distribution pipelines. Leaks on distribution pipelines were usually from pipe joints and deteriorated ACP pipelines.
- There were several visible (above ground) leakage points.

- Attention should be paid to water meter maintenance. The percentage of good working meters in the survey areas ranges from 42% to 85 %. Meter calibration is not conducted periodically, therefore water consumption data may contain a percentage of metering error.

Based on the results obtained from the leakage survey, a "NRW Reduction Pilot Project (NRPP)" was planned and conducted during the 3rd Phase of the Study. The results of the NRPP is shown in Volume III Main Report: Feasibility Study.

3.1.13 Summary of Existing Conditions

The PWD is currently facing a number of technical problems across Goa's water supply schemes, extending from the water source to service connections. The assessment completed as part of this study identified the following key problems:

(1) Raw Water Quality

Manganese and iron was present in the raw water for almost all the plants in Goa. In particular, relatively high concentration of manganese was present in Salaulim Dam which is the raw water source for the Salaulim WSS (as shown in Figure 31.7). It is therefore recommended that manganese and iron treatment (such as pre-chlorination, aeration and manganese sand filtration) is considered for future plants.

(2) Tap Water Quality

Residual chlorine concentrations in the water at consumers' taps were tested during the study at the following eleven locations (Pernem, Mapusa, Bicholim, Valpoi, Panaji, Orgao, Ponda, Vasco da Gama, Mergao, Quepem and Nagorce). Residual chlorine was detected at all points. Therefore it can be assumed that the chlorination systems at the plants and/or the reservoirs are functioning properly. It is, however, recommended that the PWD observe the tap water quality hereafter because the intermittent water supply and leakages become the cause of water pollution.

(3) Lack of Flow Measurement and Flow Control Systems

The flow rates of intake and transmission are not directly measured using flow meters. Therefore, the flow rates are estimated from the pump capacity and hours of operation. Lack of flow measurement means accurate chemical dosage is not possible. Also, the transmission flow rates along the transmission mains are not measured. This means flow control cannot be carried out properly.

(4) Ineffective Coagulation, Sedimentation and Filtration

The sedimentation basins do not remove the majority of turbidity because coagulation and sedimentation might be ineffective. Therefore the turbidity of the water entering the filtration basin is large, which means the filters need to be backwashed more frequently. The field investigation indicated that the backwashing is not sufficient because the duration of the backwashing process is not long enough or there is a structural problem of the filter basin.

Also, the treated water was found to contain aluminium. Aluminium is not contained in the raw water. It is therefore concluded that the aluminium in the treated water comes from the chemical dosing rates are not well controlled or the mixing is not sufficient.

Photos 31.12 and 31.13 show the inadequate chemical storage conditions at the Assonora WTP and the Dabose WTP, respectively. The other WTPs have similar poor storage conditions.

Photo 31.11 Chemical Storage at the Assonora WTP

Photo 31.12 Chemical Storage Room at the Dabose WTP

(5) Safety Provision

Safety related to the chlorination systems at all the WTPs was very poor. For example:

- there are no facilities for adequately detecting or containing gas leaks;
- personal breathing apparatus is available in the laboratories at some WTPs but is not used or maintained;
- combinations of small bore PVC and flexible plastic hoses are used to connect the cylinders to the chlorinators, instead of copper pipes.

There appeared to be a lack of general safety awareness with regards to chlorine usage.

(6) Electric Power Outages

Operation of the Salaulim WTP and the Opa WTP, was interrupted for around 3,170 minutes and 1,600 minutes respectively during 2004, as a result of power outages. Power failure means the water supply stops and the water supply facilities can be damaged. To prevent intermittent water supplies and the damage to the facilities resulting from the effects of water hammers, the following measures should be considered:

- surge control should be installed to protect from water hammer;
- standby generators should be installed; and
- reservoirs should have sufficient capacity to store water.

(7) Visible leaks along the transmission mains

There are many visible leaks at the air and scour valves located along the transmission mains. It is recommended that a system of reactive leak control be established to repair all visible leaks.

(8) Lack of operation and maintenance manuals and plans

There are no standard operation and maintenance manuals or plans for the treatment plants, transmission systems or distribution systems. This means appropriate operation and proactive maintenance is difficult.

(9) Lack of asset drawings, asset data and process data

The PWD does not have current drawings of the water supply facilities (such as treatment plants, transmission mains, distribution reservoirs, distribution mains and booster pumping stations) or maps that cover all the water supply areas. Also, records and data for the operation and maintenance of the schemes are not maintained. Some drawings and data are maintained by individuals, but this is not available for management of the system as a whole.

The lack of current asset drawings and data means:

- performance evaluation is difficult;
- operation and maintenance is inadequate because basic facility information is unavailable; and
- response to problems/emergencies is inadequate or delayed.

3.2 Sanitation/Sewerage System

3.2.1 General

The present water quality of Mandovi and Zuari rivers ranges 3 - 6 mg/L BOD and North and South Coastal Area ranges 7 - 9 mg/L BOD. They exceed water quality standard of 3 mg/L BOD. However, pH of every survey results was within the standard. A coliform is not applied in the standard, 1.1×10^5 (MPN/100ml) was detected at the Zuari river in rainy season at large. The details are presented in sub-section 3.2.5. Some pollutants may be derived from human activities. To improve water quality, countermeasures including sewerage are recommended.

An appropriate sewerage system is essential for improving public health and quality of life in urban areas and for attracting tourism development. Most of Goa does not have sewerage system. According to the Census in India, only 13 % of Goa's urban population is served by sewerage system, much lower than the all India average of 28%, the neighbouring states of Maharastra (40 %) and Karnataka (38 %). Of the five principal municipalities in Goa, Panaji, Vasco and Margao have sewerage system. Although the cities of Mapusa and Ponda are the hub of the tourists and pilgrim traffic in addition to fast growing urban population, there are no sewerage systems in two cities. These two municipalities and tourism development at the Calangute beach adjoining Mapusa and at the Colva beach adjoining Margao require appropriate sewerage/sanitation systems. The two beaches are most important tourist attractions of the coastal belt of North and South Goa, which require environmental protection.

According to the Census 2001, 51.8% of the rural population and 30.8% of the urban population had no latrine despite the continuous efforts of the State Government in the last 20 years to increase sanitation coverage. Percentage of latrine ownership for each Taluka is summarized in Table 32.1.

Table 32.1 Summary of Distribution by Different Types of Latrines

Taluka	Rural Area (%)			Urban Area (%)		
	Pit latrine	Water closet latrine	No latrine	Pit latrine	Water closet latrine	No latrine
Pernem	9.3	17.1	70.9	4.1	30.7	63.8
Bardez	19.6	42.7	36.6	18.6	43.9	34.6
Tiswadi	15.5	28.7	39.4	17.4	43.6	24.8
Bicholim	10.8	9.4	75.9	14.5	30.0	44.4
Satari	13.9	11.4	72.3	27.9	27.5	36.6
Ponda	22.3	17.5	53.6	21.9	34.1	27.8
Mormugao	32.4	13.6	38.2	10.9	32.0	38.2
Salcete	27.6	23.3	27.8	20.8	45.6	20.8
Quepem	15.2	13.0	66.5	32.3	27.4	29.8

Sanguem	16.6	10.6	66.9	52.1	19.0	28.0
Canacona	16.7	14.2	63.9	13.6	32.1	45.9
Total	**18.9**	**20.8**	**51.8**	**18.7**	**38.9**	**30.8**

Source: Sector Status Study, Water and Sanitation, Goa, August 2004

From the above, it is observed that in rural areas of Pernem, Bicholim, Satari, Quepem, Sanguem, and Canacona high percentages of households do not have latrines in 2001.

In order to improve the hygienic conditions in rural areas and to provide sanitation facilities, total 72,165 single seat low cost pour latrines have been constructed by the Sulabh International Social Service Organization since 1985 as shown in Table 32.2.

Table 32.2 Constructed Single Seat Pour Flush Latrine (1985 – 2004)

Year	North Goa	South Goa	Total
1985 – 1990	1,287	925	2,212
1990 – 1995	4,535	2,470	7,005
1995 - 2000	12,985	10,026	23,011
2000 - 2001	7,139	4,727	11,866
2001 – 2002	3,066	2,684	5,750
2002 - 2003	5,278	3,973	9,251
2003 - 2004	4,351	3,276	7,627
2004 - 2005	3,692	1,751	5,443
Total	42,333	29,832	**72,165**

Source: Detail of Single Seat Pour Flush Water Seal Latrines Constructed in Goa, Sulabh International Social Service Organization, Goa Stare Branch

The existing sewerage systems in the municipalities of Panaji, Margao and Vasco are described in Table 32.3.

Table 32.3 Features of Existing Sewerage Systems in Goa

Item	Panaji	Vasco	Margao
Area covered (% of municipal area)	85	100	40
Number of connection	3,311	1,643	62
Number of households covered	11,000	4,090	484
Length of sewer network (km)	36	40	47
Capacity of STP (MLD)	$5.7^{*1} + 12.5^{*2} = 18.2$	14.0	7.5

Source: Sector Status Study, Water and Sanitation, Goa, August 2004
Note : *1; Capacity of Trickling Filter System
*2; Capacity of SBR System

Although Vasco is the out of study area, the outline of its facilities is also presented below as reference.

- The total length of sewer: 40 km
- Number of intermediate pumping stations: 7
- Number of treatment plant: 1

The Vasco sewage treatment plant as shown in Table 32.4 is located at the seaside in Baina and was constructed and partially commissioned in 1985, and fully commissioned in 1992.

Table 32.4 Summary of STP Facilities in Vasco Municipality

Item		Dimension
1	General Condition	
1.1	Location	Baina, Vasco da Gama
1.2	Capacity in MLD	14.0 MLD
1.3	Commissioning Year	1985 (partial), 1992 (fully)
2	Technical Details	
2.1	Intake Facility	
	Connection pipe diameter	700 mm CI pipe
	Inlet chamber well	2.3m×2.3m×0.91m
2.2	Screen & Grit Removal	
	Screen Type	Manual Bar Screen
	Grit Removal	23.31m
2.3	Aeration Tank	
	Treatment method	Extended aeration
	Size of Tank	36.0m×44.0m×4.5m, Surface aerators (12 units)
2.4	Clarifier	
	Size of Tank	25.0 m diameter×3.0m

Source: Sector Status Study, Water and Sanitation, Goa, Appendices, August 2004

3.2.2 Panaji Sewerage System

(1) Introduction

Panaji Municipality receives drinking water from the Opa water treatment plant, which is situated 35km away from the municipality. The whole population is supplied with this water and the present total supply is in the order of 12.0 MLD. The present population in Panaji is 59,066 (2001 census), besides sizable seasonal tourist and floating population.

The sewage network and treatment plant for Panaji was installed in the year 1965 – 67, this being the first sewerage project in the State of Goa. The old STP was designed to cater for a population of 30,000 with a capacity of 5.68 MLD. At present, the sewage flow is in the order of 11.52 (12.0 ×0.8×1.2) MLD, and thus the existing old STP was inadequate and has badly overloaded. The old STP was constructed about 40 years ago and its facility which was adopted the trickling filter treatment process is not operated now because of its deteriorated condition. As a result, the sewage treatment is not effective and part of sewage is not treated. This situation has created dangerous environmental effects, due to pollution hazards of partly treated/untreated sewage discharged into Mandovi estuary. Since the estuary waters are used for bathing, swimming and recreational purposes by local population, as well as by tourists, the pollution of the estuary is a grave health hazard.

With the above conditions, PWD started the sewerage expansion project to increase treatment capacity and to improve the water quality in December 2001.

(2) Sewer Network

The sewer network plan was formulated in 1960's originally, but original documents are not available during this study. Therefore, a report named "Project Report on Environmental Upgradation of Panaji City Phase I, December 2001" including summary of basic data on sewerage facility plan has been reviewed for this study. In addition, sewerage zone wise sewer network maps (12 maps, sewerage zone I to XII) are also available for the review and reference.

1) Sewerage Zone and Zone wise Wastewater Quantity

The sewerage service area of Panaji City is divided into 12 sewerage zones as shown in Figure 32.1 and given in Table 32.5. The sewerage zone areas have been measured on the sewerage zone maps because there is no data of the area in each sewerage zone. The total service area measured using the map is 434.9 ha versus the total area of 400 ha mentioned in the Report "Project Report on Environmental Upgradation of Panaji City Phase I".

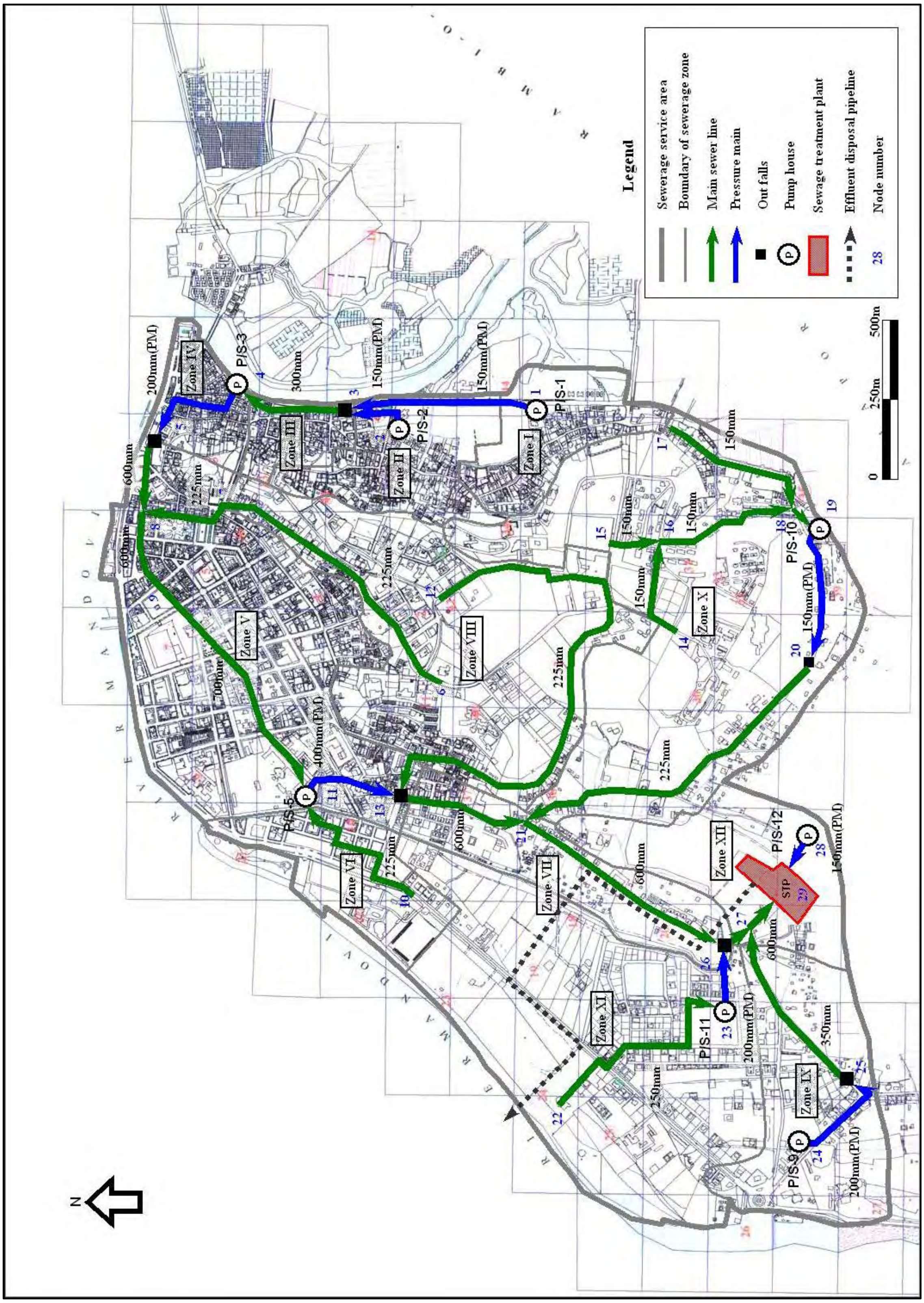

Figure 32.1 Existing Sewer Network, Panaji City

It is considered that this difference in the areas is due to ambiguities of the Municipality, sewerage service area and sewerage zone area boundary in the drawings.

Table 32.5 Sewerage Zone Description and Area of Sewerage Zone

Zone	Area covered	Area (ha)	Remarks
Zone I	From Portais church upto Fontainhas & Neuginagar	15.4	Installed in 1965-67
Zone II	Fontainhas, Mala to Peoples High School including Bhandare Hospital, PDA office	17.9	Ditto
Zone III	Merri Immaculate High School, Cortin Rua de Orem	6.7	Ditto
Zone IV	From Cortin upto Old Bus stand including Head Post Office, Vihar Hotel & surrounding area	9.1	Ditto
Zone V	From Secretariate upto St. Inez, old GMC, Market area upto Foot of Altinho hill, Mahalaxmi Temple	69.6	Ditto
Zone VI	From old GMC upto Football ground including Military Hospital. Campal area	16.9	Added in 1973
Zone VII	From St. Inez upto PWD Garage including Govt. Quarters & area either side of St. Inez, Tonca Road	21.1	Installed in 1965-67
Zone VIII	Altinho area including All India Radio, PWD office, Govt. Banglows, Military Camp	60.7	Added in 1976-77
Zone IX	Miramar Circle upto Adarsh Colony, part on Tonca	31.0	Added in 1980
Zone X	Bhatulem from Portais Church upto T.B. Hospital part of Tamadimati area, part of Altinho including Govt. Quarters	86.8	Added in 1984
Zone XI	La Campal. Lake view colony, Indoor game stadium	74.7	Added in 1984
Zone XII	Part of Tonka area from Hotel Goa international upto Municipal Quarter & Surrounding area & part of Tamadi Mati	25.0	Added in 1995
Total		**434.9**	

Source: Table II, Project Report on Environmental Upgradation of Panaji City Phase I
Note: Areas of each zone has been measured

Zone wise wastewater quantities are mentioned in Volume IV Appendix M35.2 Flow Calculation Sheet for Branch Sewers, Panaji City (Year 2001) of the Report, but sum of zonal wastewater quantity, 12.75 MLD in year 2001 as shown below does not coincide with estimated wastewater quantity (12.11 MLD) based on water demands shown in the Report "Project Report on Environmental Upgradation of Panaji City Phase I". The sum of zonal wastewater quantity of 12.75 MLD has been adopted as total wastewater quantity for study in this section, because sewerage zone wise wastewater quantity is necessary for the study although value of 12.11 MLD has been estimated as total wastewater generation in the sewered area.

In addition, there are no data of sewerage zone wise populations. Therefore, populations of each zone have been estimated based on zone wise wastewater quantity with the assumption that wastewater generation of hotels and non-domestic category is proportional to domestic wastewater quantity. The value of sewerage zone wise population, population density and wastewater quantity based on this assumption are shown in Table 32.6. From the estimated values, it is observed that the average population density of whole sewerage service area is 135 person/ha. Furthermore, it can be said that the most densely populated sewerage zone is Zone III with a population density of 1,045 person/ha in the year 2001.

Table 32.6 Sewerage Zone wise Population and Population Density

Zone	Area (ha)	Year 2001		
		Population	Population Density (Person/ha)	Wastewater Quantity (MLD)
Zone I	15.4	4,196	272	0.91
Zone II	17.9	4,196	234	0.91
Zone III	6.7	7,008	**1,045**	1.52
Zone IV	9.1	2,766	304	0.60
Zone V	69.6	16,782	241	3.64
Zone VI	16.9	1,383	82	0.30
Zone VII	21.1	4,242	201	0.92
Zone VIII	60.7	4,749	78	1.03
Zone IX	31.0	5,026	162	1.09
Zone X	86.8	2,812	32	0.61
Zone XI	74.7	4,242	57	0.92
Zone XII	25.0	1,383	55	0.30
Total	434.9	58,785	**135**	12.75

Source: Annexure J, Table II, Project Report on Environmental Upgradation of Panaji City Phase I (wastewater generation)

Note: Areas of each zone were measured

2) Main Sewer and Sub Main Sewers

Due to Altinho Hill, about 200 meters high at the center of the sewerage service area of Panaji City, a main sewer was installed as if it goes half around the hill. The main sewer starting from Zone I in the east side of the sewerage service area goes north, then turns west, and finally turns south to the sewage treatment plant in Zone XII located in the southwest side of the area. Main sewer receives wastewater from sub main sewers on the way to the sewage treatment plant as shown in Figure 32.1. Main sewer and sub main sewers were installed in the period between 1965 and 1967, about 40 years ago. There are two pumping stations along the main sewer in Zones IV and V. The lengths of main and sub mains have been measured on sewerage zone map. Summary of main and sub main sewers is shown in Table 32.7. The node numbers in Table 32.7 corresponds to node numbers shown in Figure 32.1. See flow calculation sheets in Volume IV Appendix M35.1 Flow Calculation Sheet for Main and Sub Main Sewers, Panaji City for detailed information of main sewer and sub main sewers. The total length of main sewer and sub main sewers are 4,110 m and 7,700 m with their diameter varying from 150 mm to 700 mm.

Table 32.7 General Description of Main and Sub Main Sewers

(A) Main Sewer

Node		Diameter (mm)	Length (m)	Type	Sub main connected to main
From	To				
1	3	150	580	Pressure main	
3	4	300	350	Gravity sewer	Sub main from Zone II
4	5	200	320	Pressure main	
5	8	600	270	Gravity sewer	
8	9	600	240	Gravity sewer	Sub main from Zone VIII
9	11	700	840	Gravity sewer	
11	13	400	310	Pressure main	Sub main from Zone VI
13	21	600	370	Gravity sewer	Sub main from Zone VIII
21	26	600	680	Gravity sewer	Sub main from Zone X
26	STP	600	150	Gravity sewer	Sub main from Zone IX and XI
Sub total			**4,110**		

(B) Sub Main Sewer

Node		Diameter (mm)	Length (m)	Type	Catchment
From	To				
2	3	150	210	Pressure main	Zone II
6	8	225	960	Gravity sewer	Zone VIII (north part)
10	11	225	550	Gravity sewer	Zone VI
12	13	225	1,740	Gravity sewer	Zone VIII (south part)
14	21	150-225	2,960	Gravity sewer Pressure main	Zone X
23	26	200	180	Pressure main	Zone XI
24	26	200-350	740	Gravity sewer Pressure main	Zone IX
27	STP	150	360	Pressure main	Zone XII
Sub total			**7,700**		
Total			**11,810**		(A) + (B)

Source: (1) Diameter: Sewerage zone map
(2) Length of sewer measured on sewerage zone map

3) Branch Sewers

Branch sewers in main part of Panaji City (Zone I, II, III, IV, V and VII) were installed in the period between 1965 and 1967, about 40 years ago. After that, branch sewers in Zones VI, VIII, IX, X, XI and XII were laid gradually. The lengths of branch sewers have also been measured on the sewerage zone map same as in case of main and sub main sewers. The minimum and maximum diameters of branch sewers are 150 mm (6") and 300 mm (12"), respectively.

Summary of branch sewers are shown in Table 32.8. See flow calculation sheets in Volume IV Appendix M35.2 Flow Calculation Sheets for Branch Sewers, Panaji City for detailed information of branch sewers. The node numbers in Volume IV Appendix M35.2 Flow Calculation Sheets for Branch Sewers, Panaji City corresponds to nodes shown in sewerage zone maps.

Summary of the existing sewer length in sewerage zone and diameter wise are attached in Volume IV Appendix M35.3 Sewerage Zone and Diameter wise Sewer Length, Panaji City .

Table 32.8 General Description of Branch Sewers

Zone	Area (ha)	Diameter (mm)	Length (m)	Sewer density (m/ha)
Zone I	15.4	150-225	1,680	147
Zone II	17.9		2,090	128
Zone III	6.7		1,390	251
Zone IV	9.1		1,900	251
Zone V	69.6		8,320	147
Zone VI	16.9		520	63
Zone VII	21.1		500	81
Zone VIII	60.7		2,560	82
Zone IX	31.0	150-300	2,150	93
Zone X	86.8	150	3,670	76
Zone XI	74.7	-	-	-
Zone XII	25.0	150	2,490	114
Total	434.9		27,270	108

Source: (1) Diameter: Sewerage zone map
(2) Length of sewer measured on sewerage zone map
Note (1) Sewer density of whole sewerage service area is calculated excepting Zone XI.
(2) Length includes pressure main

(3) Pumping Station

There are eight pumping stations in Panaji City. Submersible pumps are installed in only one pumping station (P/S-12), dry well pumps are installed for the other stations. There are no flow measuring instruments, thus, the sewerage flow cannot be measured accurately. The outline of the pumping station is shown in Table 32.9. The location of the facility is presented in Figure 32.1.

Table 32.9 Outline of Pumping Station in Panaji

NO.	Location	Collecting Area	Inflow (m3/sec)	Number of Pump
P/S – 1	Neuginagar	Zone-1	0.0237	3 units
P/S – 2	Bhandari Hospital, Mala	Zone-2	0.0237	2 units
P/S – 3	Hotel Avanti	Zone-1, 2, 3, 4	0.0870	3 units
P/S – 5	Don Bosco	Zone-1, 2, 3, 4, 5, 6, 8 (part)	0.2320	5 units
P/S – 9	Dempo Collage	Zone-9	0.0170	3 units
P/S – 10	Bhatulem	Zone-10	0.0111	2 units
P/S – 11	Miramar, Campal	Zone-11	0.0240	3 units
P/S – 12	Kamrabhat	Zone-12	0.0020	2 units

Note: Inflow data is taken from the "Project report on environmental upgradation of Panaji City, December 2001"

(4) Sewage Treatment Plant

As mentioned before, the existing old STP (trickling filter process) is not working since February 2005 because of its deteriorated condition. Its treatment capacity is only 5.68 MLD, it is about half of the current sewage flow of 11.5 MLD.

The water quality analysis result of the Panaji old STP is shown in Table 32.10. In that Table, there are some values which are exceeding the effluent quality standard. This situation is meaning that the old treatment facilities are not proper working.

With the above conditions, PWD started the sewerage expansion project named "Project on Environmental Upgrading of Panaji City, Phase-1" to increase treatment capacity and to improve the water quality in December 2001.

Table 32.10 Water Quality Examination Result of Panaji STP

	Characteristics	2002. 5.25 - 6.22				January 1999	July 1999	Jan. - Dec. 1998		Tolerance Limit
		Raw sewage	Primary effluent	Bio-filter effluent	Treated effluent	Raw sewage	Raw sewage	Raw sewage	Treated effluent	
1	pH	7.0	6.9	7.4	7.5	7.2	7.2	7.1	7.4	5.5 - 9.0
2	Temp. (℃)	29.0	29.0	29.0	29.0	28.0	27.0	29.0	28.9	-
3	Total solids (mg/l)	871	1,090	1,114	1,175	1,320	422	862	789	-
4	Total dissolved solid (mg/l)	750	973	1,013	1,127	1,146	342	731	642	-
5	Suspended solids (mg/l)	121	101	101	47.5	176	80	113	36	100
6	BOD (mg/l)	183	130	147	82.4	208	66	189	55	30
7	COD (mg/l)	-	-	-	-	379	171	277	106	250
8	Chloride as Cl (mg/l)	260	408	413	508	527	104	297	318	-
9	Chloride as Nacl (mg/l)	429	673	681	838	870	172	495	536	-

	Characteristics	1979. 10.3			1979. 10.8			1979. 11.9		
		Raw sewage	Primary effluent	Treated effluent	Raw sewage	Primary effluent	Treated effluent	Raw sewage	Primary effluent	Treated effluent
1	pH	7.1	7.15	-	7.1	7.2	7.2	7.2	7.2	7.4
3	Total solids (mg/l)	390	739	884	3399	2418	8939	9785	7965	6405
4	Total dissolved solid (mg/l)	316	720	867	3292	2376	8815	9624	7921	6382
5	Suspended solids (mg/l)	74	19	17	107	42	124	161	44	23
6	BOD (mg/l)	180	36	12	170	50	16	140	36	16

Source : GOVERNMENT OF GOA-INDIA, PROJECT REPORT ON ENVIRONMENTAL UPGRADATION OF PANAJI CITY PHASE I , DECEMBER 2001, Page 147