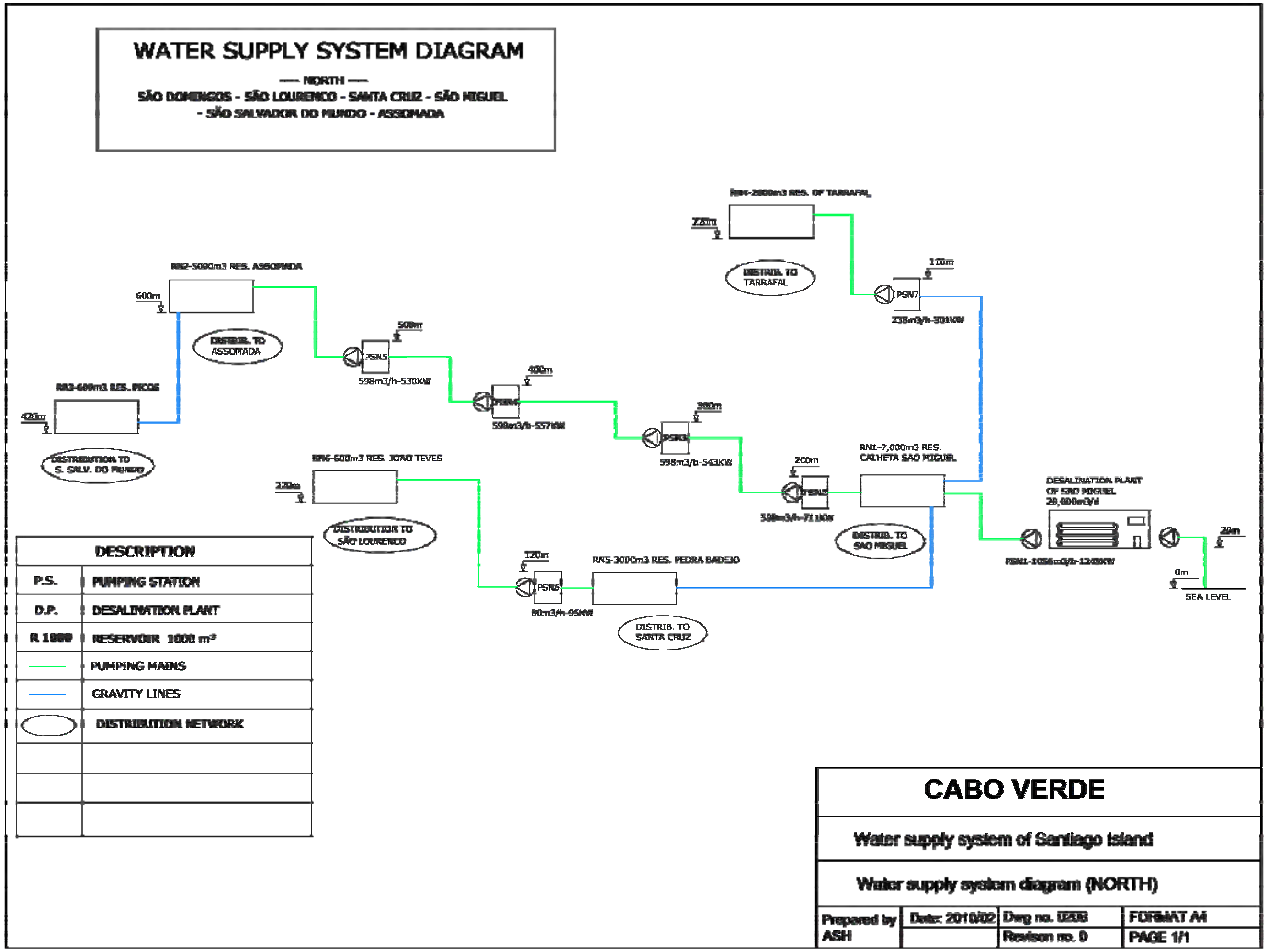


Source: Study team

Figure 4.1-4: Water supply system diagram (North)

4.1.3 Outline of Sea Water Desalination Facility

An outline of the sea water desalination facility based on 20,000 m^3/day of drinking water production is as follows:

The sea water desalination facility consists of the following subsystems.

- Sea water intake system
- Pre-treatment system
- RO system
- Post treatment system
- RO membrane cleaning system
- Chemical Injection system

(1) Sea water intake system

To produce 20,000 m^3/day drinking water, a total of 50,000 m^3/day sea water intake is required. A sea water intake system can be classified broadly into 3 categories, namely for the following in industry.

- Surface water intake type
- Underwater intake head type
- Intake well type

Each of the above systems has advantages and disadvantages in terms of capacity, durability, constructability and cost feasibility. Table 4.1-2 is a summary of the comparisons for sea water intake type.

Table 4.1-2: Comparison of Sea Water Intake Type

Type	Direct		Indirect
	Surface Water Intake	Underwater Intake Head	Intake Well
Example	- open surface	- Curtain Wall - Deep Sea Water intake	- Beach well - infiltration
General	- Easier and more common - Surface water quality, such as temperature and suspended solid, fluctuates	- Offshore bottom water - Depth can be selected - Water quality is stable	- Easier and more common - Water quality is stable
Intake Volume	For small amounts	For big amounts	For small amounts
Water Intake Depth	Up to 5 m from water surface	No limitation (depends on marine fleet)	30 – 100m from ground level
Wave Impact	Impact is unavoidable	Small impact	Only tidal movement
Suspended Solids in Sea Water	Larger impact	Less impact	Little impact
Durability	Easy maintenance	Easy maintenance	Risk of clogging of well
Constructability	Larger frontline is required for large amount of intake	Need attention for installation of underwater intake pipe	Easier than others
Cost Feasibility	Medium cost	Higher cost	Lower cost

Source: Study Team

In this case, considering the water intake volume, existing system and limited construction area, the intake well type can be adopted. The intake well type has the following advantages compared to the other methods.

- As the intake well serves as a natural filter, the pre-treatment system can be simplified. That is, pressurized dual media sand filters are installed for pre-treatment in the case of the intake well type. However, in the case of the surface water intake or underwater intake head type, clarifier or coagulated filtration would be required in addition to the pressurized dual media sand filter for pre-treatment.
- No marine environmental impact during construction work.
- Familiar to local construction contractors therefore avoiding construction contingencies.
- Recirculation of concentrated brine into water intake can be protected.

Features of the well would be as follows:

- 9 wells including 1 spare well would be planned in total to intake 50,000 m^3/day of sea water. The number of intake wells is derived from the number of intake wells for the existing desalination system in Palmarejo. The location of each well would be close to and along the shoreline.
- The diameter of each well might be φ350mm, the depth might be approximately 40m from the ground surface, and separation among each well might be 20m (with reference to the existing intake wells).
- 1 set of submerged intake pumps is installed in each well. Additionally, 1 set of pumps will be at a warehouse as a spare.

(2) Pre-treatment system

A pre-treatment system is provided to control biological, particulate and colloidal matter, which has a fouling potential for the RO membrane. The pre-treatment system mainly consists of hypochlorite injection, sand filter and filtered water pond.

Hypochlorite is injected at the inlet header of the sea water to sand filters to control biological matter.

A sand filter consists of 9 trains, including 1 spare, each of which has the filtering capacity of 270 m^3/h. A dual media, pressure type and horizontal filter will be provided. The filter will be constructed of carbon steel and will be rubber lined. Packed material will be anthracite and sand. Normally 8 filters will be in service and 1 filter will be on stand-by. Backwashing of each filter will be done once a day by water and air. When 1 filter enters into backwashing, the stand-by filter will be in service to maintain the required filtered water flow. Backwashing time per train will be around 30 minutes. For backwashing, a backwash pump and air wash blower are provided.

Filtered water will be stored in a filtered water pond which has a capacity of 520m^3, equivalent to around 15 minutes holding capacity.

(3) RO system

An RO system is provided to produce desalinated water from feed sea water which has approximately 37,800 mg/l in TDS. 2-stage RO systems will be provided to reduce the boron content to less than 0.5 mg/l, which is based on the WHO guidelines 3rd edition, 2008.

Filtered water will be supplied from the filtered water pond to a 1st stage RO module through a safety filter. Acid and sodium bisulphite (SBS) will be injected at the inlet of the safety filter. Hydrochloric acid is injected for $CaCO_3$ scaling prevention. Injection rate is to adjust the pH value to 7.3. Sodium bisulphite is injected to remove any traces of free chlorine content which would adversely affect the RO membrane.

Filtered sea water is further treated through a safety filter as polishing and emergency back up in case of sand filter failure. 5 safety filters including 1 stand-by train will be provided. The Silt Density Index (SDI) should be less than 3.5 as recommended by RO membrane manufacturers. The safety filter is a cartridge type and the nominal filtering range is 5 micron meters.

The polished water passing through the safety filter is further pressurized by a high-pressure, 1st-stage RO feed pump to approximately 70 kg/cm^2 G and fed to a 1st-stage RO unit.

1st-stage RO unit consists of 4 trains, each having a production capacity of 5,625 m^3/day. Each unit is composed of 504 pieces of 8” RO element. 7 elements are packed in series in one pressure vessel. Pressure vessels are arranged as multiple, parallel and identical. A total of 72 pressure vessels are arranged parallel in each unit. As a summary, the specifications of a 1st-stage RO unit are as follows:

- 5,625 m^3/day production x 4 trains
- 72 pressure vessels per train
- 7 RO elements in each pressure vessel
- Total 504 elements per train x 4 trains

Permeate from the 1st-stage RO unit is stored in an intermediate tank. Concentrated brine is utilized for energy recovery because of its high pressure and finally discharged into the sea. The recovery rate is controlled at 45%. Expected salt contents in the permeated and concentrated brine are 260 mg/l and 68,500 mg/l as TDS, respectively.

From the intermediate tank, 1st-stage permeate will be fed to the 2nd-stage RO unit for further removal of boron to satisfy drinking water quality. To reduce the boron content efficiently in the 2nd-stage RO, the pH value of the 1st-stage permeate will be raised to 9.0 by injecting caustic soda. The 2nd-stage RO unit is arranged as 2 banks in series. All 1st-stage RO permeate will be fed to a 1st-bank RO unit and brine from the 1st-bank RO unit will be fed to a 2nd-bank RO unit to increase the recovery ratio. For this arrangement, the total recovery ratio in the 2nd-stage RO unit will be 89%. The arrangements for the 2nd-stage RO unit are as follows:

- 5,000 m^3/day drinking water production x 4 trains
- 22 pressure vessels per train for 1st-bank RO, and 8 pressure vessels per train for 2nd-bank RO
- 7 RO elements in each pressure vessel
- Total 154 elements per train for 1st-bank RO, and 56 elements per train for 2nd-bank RO

Permeate from the 2nd-stage RO unit is stored in a product water tank. Brine from the 2nd-stage RO unit, the flow rate of which will be 2,500 m^3/day, will be discharged into the sea without energy recovery.

<u>Energy Recovery Device (ERD)</u>

As for an energy recovery device utilizing high pressure brine from an RO unit, the following 4 types are considered. These types will be evaluated from the viewpoint of investment cost, energy recovery efficiency, experience, operability and maintainability. An outline of the qualitative comparison of various types of energy recovery device is shown in Table 4.1-3.

Table 4.1-3: Outline of Qualitative Comparison of Energy Recovery Device

Type	Turbine-based Centrifugal Energy Recovery Device		Isobaric Energy Recover Device	
	Turbo Charger	Pelton Turbine	PX (*1)	DWEER (*2)
Energy Recovery	50-65%	40-60%	Approx. 95%	Approx. 95%
Application	For smaller plant	For larger plant	Applicable to larger plant by multi-train	Applicable to larger plant
Experience	Much	Much	Lately developed, increasing experience	Lately developed, increasing experience

(*1) PX: Pressure Exchange

(*2) DWEER: Dual Work Energy Exchanger

Source: Study team

Among these types, the Pelton turbine (Turbine-based centrifugal type ERD) and DWEER (isobaric-type ERD) were compared quantitatively as shown in Table 4.1-4.

Table 4.1-4: Outline of Quantitative Comparison of Energy Recovery Device

	Pelton Turbine	DWEER
Permeate flow from 1st-stage RO	22,500 m^3/day	22,500 m^3/day
High Pressure RO feed pump		
Number of sets	4	4
Capacity	521 m^3/hour	235 m^3/hour
Head	69 bar	69 bar
Booster pump	NA	
Number of sets		4
Capacity		286 m^3/hour
Head		1.8 bar
Energy Recovery Device (ERD)	Pelton turbine	DWEER
Number of sets	4	4
Power consumption		
For High Pressure RO feed pump (each)	1,361 kW	632 kW
For Booster pump (each)	NA	12 kW
Recovered power by ERD (each)	- 424 kW	Incorporated in above
Power consumption (each train)	937 kW	644 kW
Total power consumption	3,748 kW	2,576 kW
Electricity unit cost	US$0.265/kWh	US$0.265/kWh
Yearly power cost	US$8,700,607/year	US$5,979,926/year
Difference of power cost	Base	US$-2,720,681/year
Difference of initial cost	Base	US$+427, 000
Simple payout period	Base	0.16 year

Source: Study team

The above comparison is based on 22,500 m^3/d 1st RO permeate to produce 20,000 m^3/d drinking water. If unit power cost is assumed as US$0.265/kWh, the yearly power cost of the

DWEER base ERD plant is US$5,979,926/year and the Pelton turbine base ERD plant is US$8,700,607/year. The yearly power cost difference is US$2,720,681/year. On the other hand, the initial cost difference between both types of ERDs for the High Pressure RO feed pump, booster pump and ERD is US$427,000. That means the initial cost difference is simply paid in 0.16 year. Considering this comparison, an isobaric-type ERD should be selected for this project. As for reference, the power consumption of the whole desalination plant with 20,000 m^3/d drinking water production is 4.7 kWh/m^3 for the DWEER base ERD and 6.1 kWh/m^3 for the Pelton turbine base ERD.

(4) Post Treatment System

As 2nd-stage RO permeate contains very low TDS (12 mg/l) and almost nil hardness, it is highly corrosive and not suitable for drinking water. Therefore, remineralization is mandatory. Calcium chloride and sodium carbonate will be injected to adjust the Ca hardness to more than 15 mg/l as $CaCO_3$ and the Langelier Saturation Index from -0.5 to 0.0.

In addition, sodium hypochlorite will be injected to keep the residual chlorine of drinking water for disinfection.

The post-treated product is transferred to a reservoir from a product water tank by a product water pump.

(5) RO Membrane Cleaning System

A membrane cleaning system is provided to remove foulants on membrane surfaces by dissolving the fouling substances with chemical cleaning agents. The cleaning system is provided for 1st-stage and 2nd-stage RO units independently. Each system consists of a cleaning tank, cleaning pump and cleaning filter.

The frequency of chemical cleaning will depend on the quality of feed water to the RO unit and the performance of the facility. Cleaning will be required if the following is observed during operation. The expected frequency of the cleaning will be every three or four months.

- High differential pressure (Feed/Concentrate)
- Loss of product water
- Lower quality of product water (High conductivity)

The type of chemicals for cleaning will be selected according to the nature of foulants. Inorganic scale is typically cleaned by acidic cleaning solutions such as hydrochloric acid and citric acid, etc. Organic foulants are cleaned by solutions such as high pH dodecyl sodium sulfate (DSS) solution adjusted with sodium hydroxide, sodium tripolyphosphate or trisodium phosphate, etc.

(6) Chemical Injection System

The following chemical injection system is provided.

Table 4.1-5: Chemical injection system

Chemical	Purpose	Supply Condition
Sodium hypochlorite	For sterilization of feed sea water and product water	NaClO (10%) solution by drum
Hydrochloric acid	For pH adjustment of 1st-stage RO feed water	HCl (35%) solution by drum
Sodium bisulphite	For removal of residual chlorine	$NaHSO_3$ (100%) solid by bag
Caustic soda	For pH control of 2nd-RO feed water	NaOH (20%) solution by drum
Calcium chloride	For remineralization	$CaCl_2$ (100%) solid by bag
Sodium carbonate	For remineralization	Na_2CO_3 (100%) solid by bag

Source: Study team

Each injection system consists of a tank and injection pump. If dissolving is required in the case of solid chemicals, a dissolving tank and mixer will be provided. The provision for drum filling and dissolving shall be considered for the detailed design.

Cleaning chemicals are prepared in cleaning tanks.

(7) Effluent Discharge System

Effluent from the facility will be backwash waste water from the sand filter and concentrated brine from 1st-stage and 2nd-stage RO units. Backwash waste water from the sand filter is intermittently discharged. Flow rate and TDS of 1st-stage RO brine will be 27,500 m^3/day and 68,500 mg/l, respectively, which corresponds to almost 55 % and 1.8 times of the intake sea water. However, it might impact on the surrounding environment, especially marine life. Therefore, these effluents are collected in the waste water pit, then transferred and discharged into the sea by the method of natural mixing and dilution with the surrounding sea water.

(8) Power Consumption

Electrical power consumption per cubic meter of production water will be expected to be 4.7 kWh/m^3 at 20°C sea water temperature and 20,000 m^3/day production by adopting an isobaric energy recovery device.

Consumption might be further decreased through the detailed design and based on the allowable boron content in the drinking water

(9) Chemical Consumption

The expected chemical consumption for 20,000 m^3/day drinking water production will be as follows:

Table 4.1-6: Chemical consumption

Chemical		Injection rate (mg/l)	Consumption (kg/day)
Sodium Hypochlorite	NaClO (10%)	5 to intake water	250
Sodium Hypochlorite	NaClO (10%)	10 to product water	200
Hydrochloric Acid	HCl (35%)	13.8	690
Sodium Bisulfite	NaHSO3 (100%)	1.5	36
Caustic Soda	NaOH (20%)	33.0	740
Calcium Chloride	CaCl2 (100%)	17.0	333
Sodium Carbonate	Na2CO3 (100%)	16.0	318

(Note): Cleaning chemicals are excluded.

Source: Study team

(10) Other Consumables

The expected consumables for 20,000m^3/day drinking water production will be as follows:

Table 4.1-7: Consumption quantities of filters

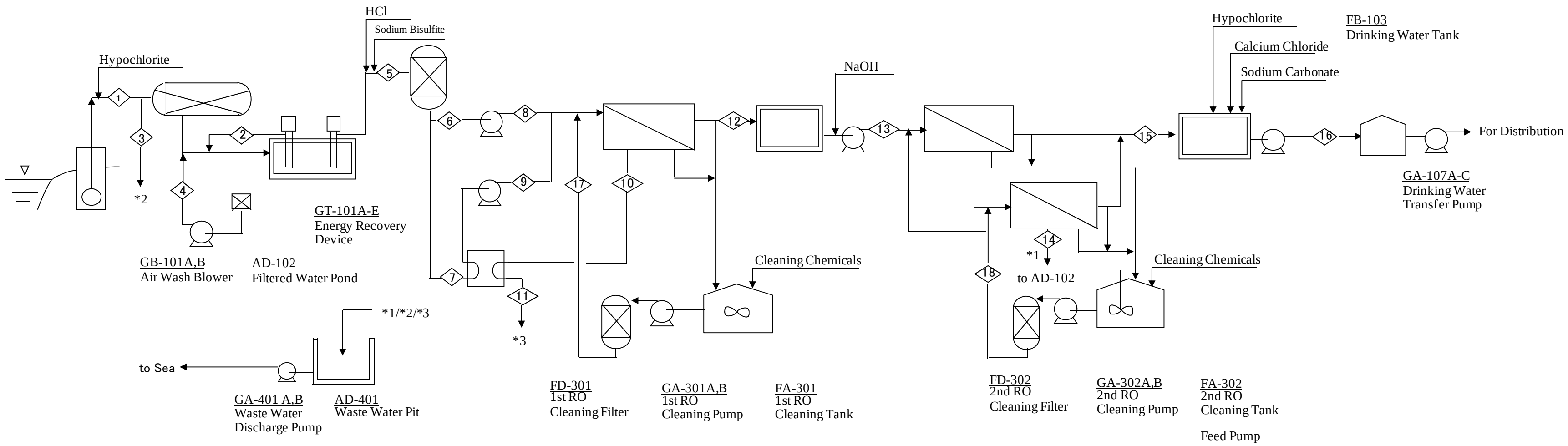
Service	Installed No. (elements)	Replacement ratio (%/year)	Consumption (elements/year)
Cartridge for safety filter	800	400	3,200
Cartridge for cleaning	204	400	816
1st-stage RO membrane	2,016	20	403
2nd -stage RO membrane	840	15	126

Source: Study team

The following are attached as below:

Figure 4.1-5: Sea Water Desalination Facility Flow Sheet at Palmarejo Plant
Figure 4.1-6: Sea Water Desalination Facility Flow Sheet at Calheta Plant
Figure 4.1-7: Sea Water Desalination Facility General Layout at Palmarejo
Figure 4.1-8: Sea Water Desalination Facility General Layout at Calheta
Figure 4.1-9: Sea Water Desalination Facility General Layout at Calheta (Alternative)
Figure 4.1-10: Sea Water Desalination Facility Plot Plan at Palmarejo (1/2)
Figure 4.1-11: Sea Water Desalination Facility Plot Plan at Palmarejo (2/2)
Figure 4.1-12: Sea Water Desalination Facility Plot Plan at Calheta
Figure 4.1-13: Sea Water Desalination Facility Single Line Diagram

Table 4.1-8: Sea Water Desalination Facility Equipment List at Palmarejo Plant
Table 4.1-9: Sea Water Desalination Facility Equipment List at Calheta Plant

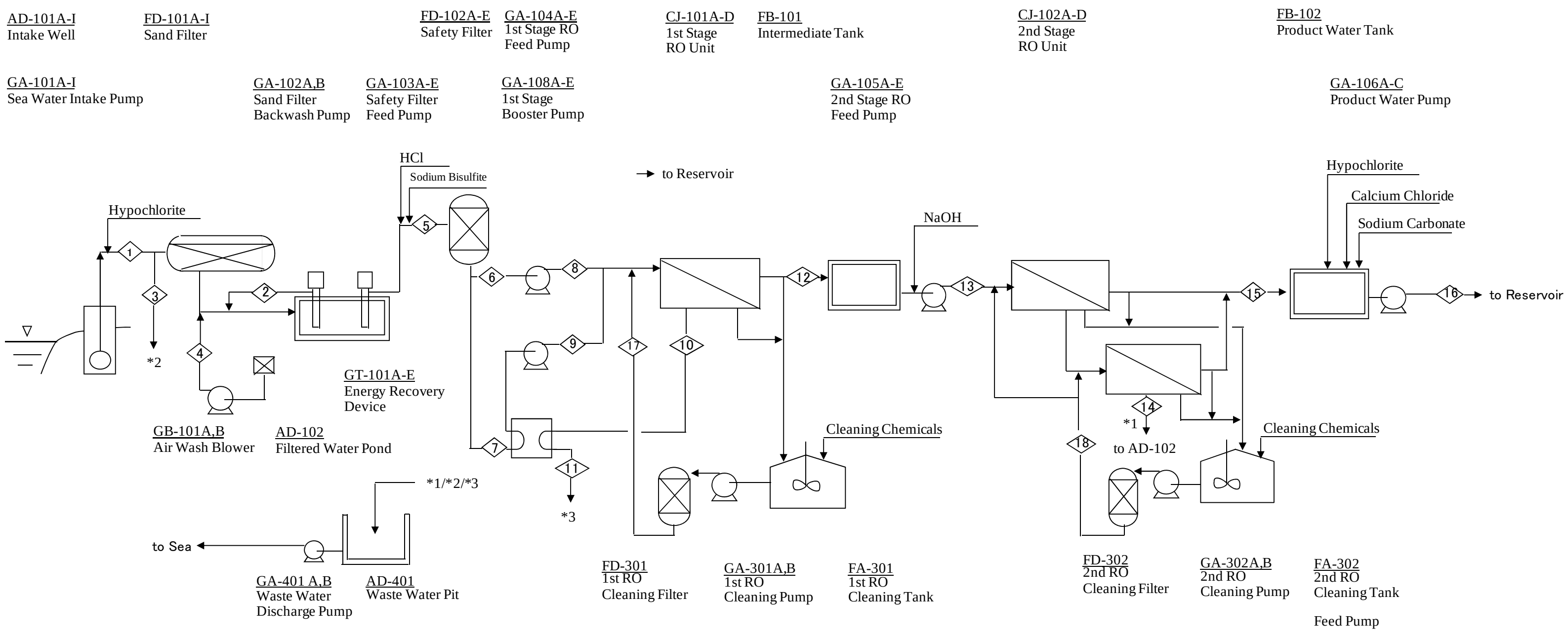


Stream No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Description	Feed Sea Water	Filter Backwash Water	Backwash Waste to Sea	Filter Backwash Air	Safety Filter Feed	HP Pump Feed	ERD Feed	1st RO HP Feed	1st RO HP Feed	1st RO HP Brine	1st RO HP Brine	1st RO Permeate	2nd RO Feed Water	2nd RO Brine to Sea	2nd RO Permeate	Product Water	1st RO Cleaning Water	2nd RO Cleaning Water
Flow m3/d	50,000	–	–	–	50,000	22,584	27,416	22,584	27,416	27,500	27,500	22,500	22,500	2,500	20,000	20,000	–	–
Flow m3/h	2,083	580	580	1,160	2,083	941	1,142	941	1,142	1,146	1,146	937	937	104	833	833	430	180
Operation time	24 h/d	10min x 8 times/d	10min x 8 times/d	3min x 8 times/d	24 h/d	24 h/d	24 h/d	24 h/d	24 h/d	24 h/d	24 h/d	24 h/d	24 h/d	24 h/d	24 h/d	24 h/d	–	–
Temp ℃	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Pressure kg/cm2G	3.0	2.0	1.0	0.5	2.0	1.8	1.8	61.4	61.4	60.8	0.3	1.0	11.0	1.0	1.0	5.0	5.5	5.5
TDS mg/l	37,800	37,800	37,800	–	37,800	37,800	37,800	37,800	38,550	69,260	68,500	260	260	2,360	12	12	12	12
Total Hardness mg/l as CaCO3	6,368	6,368	6,368	–	6,368	6,368	6,368	6,368	6,495	11,694	11,567	13	13	113	0	15	0	0
pH	7.8	7.8	7.8	–	7.3	7.3	7.3	7.3	7.3	7.5	7.5	5.4	8.7	8.9	7.7	7.7	–	–
Boron mg/l	5.0	5.0	5.0	–	5.0	5.0	5.0	5.0	5.1	8.5	8.5	0.9	0.9	4.0	0.5	0.5	–	–

PROCESS FLOW DIAGRAM 20,000m3day/day Desalination Facility in Palmarejo	
DWG.NO.	

Source: Study team

Figure 4.1-5: Sea Water Desalination Facility Flow Sheet at Palmarejo Plant (Production: 20,000m^3/d)



Stream No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Description	Feed Sea Water	Filter Backwash Water	Backwash Waste to Sea	Filter Backwash Air	Safety Filter Feed	HP Pump Feed	ERD Feed	1st RO HP Feed	1st RO HP Feed	1st RO HP Brine	1st RO HP Brine	1st RO Permeate	2nd RO Feed Water	2nd RO Brine to Sea	2nd RO Permeate	Product Water	1st RO Cleaning Water	2nd RO Cleaning Water
Flow m3/d	50,000	–	–	–	50,000	22,584	27,416	22,584	27,416	27,500	27,500	22,500	22,500	2,500	20,000	20,000	–	–
Flow m3/h	2,083	580	580	1,160	2,083	941	1,142	941	1,142	1,146	1,146	937	937	104	833	833	430	180
Operation time	24 h/d	10min x 8 times/d	10min x 8 times/d	3min x 8 times/d	24 h/d	24 h/d	24 h/d	24 h/d	24 h/d	24 h/d	24 h/d	24 h/d	24 h/d	24 h/d	24 h/d	24 h/d	–	–
Temp ℃	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Pressure kg/cm2G	3.0	2.0	1.0	0.5	2.0	1.8	1.8	61.4	61.4	60.8	0.3	1.0	11.0	1.0	1.0	5.0	5.5	5.5
TDS mg/l	37,800	37,800	37,800	–	37,800	37,800	37,800	37,800	38,550	69,260	68,500	260	260	2,360	12	12	12	12
Total Hardness mg/l as CaCO3	6,368	6,368	6,368	–	6,368	6,368	6,368	6,368	6,495	11,694	11,567	13	13	113	0	15	0	0
pH	7.8	7.8	7.8	–	7.3	7.3	7.3	7.3	7.3	7.5	7.5	5.4	8.7	8.9	7.7	7.7	–	–
Boron mg/l	5.0	5.0	5.0	–	5.0	5.0	5.0	5.0	5.1	8.5	8.5	0.9	0.9	4.0	0.5	0.5	–	–

PROCESS FLOW DIAGRAM 20,000m3day/day Desalination Facility in Calheta	
DWG.NO.	

Source: Study team

Figure 4.1-6: Sea Water Desalination Facility Flow Sheet at Calheta Plant (Production: 20,000m^3/d)

Source: Study team

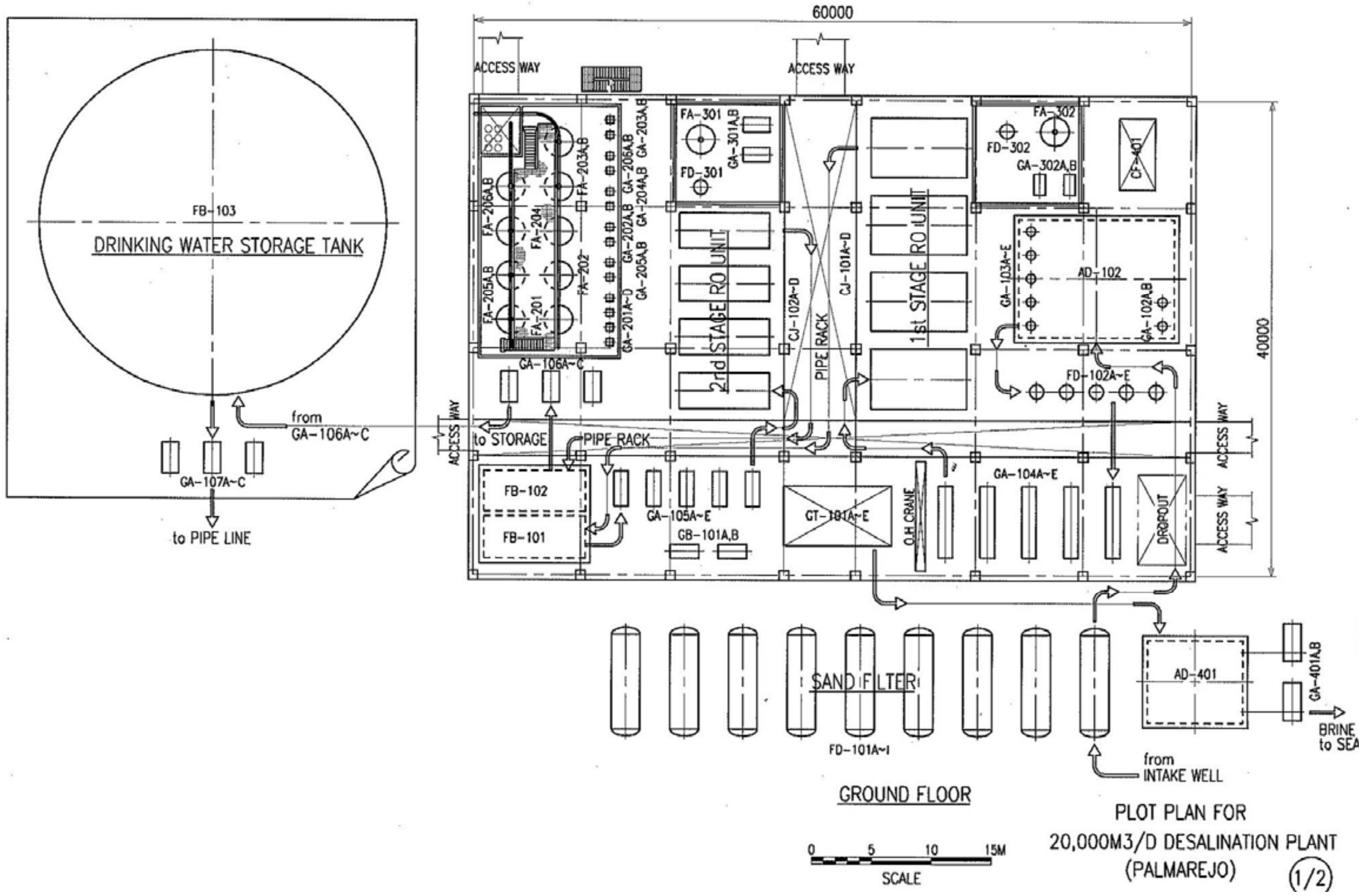
Figure 4.1-7: Sea Water Desalination Facility General Layout at Palmarejo

Source: Study team

Figure 4.1-8: Sea Water Desalination Facility General Layout at Calheta

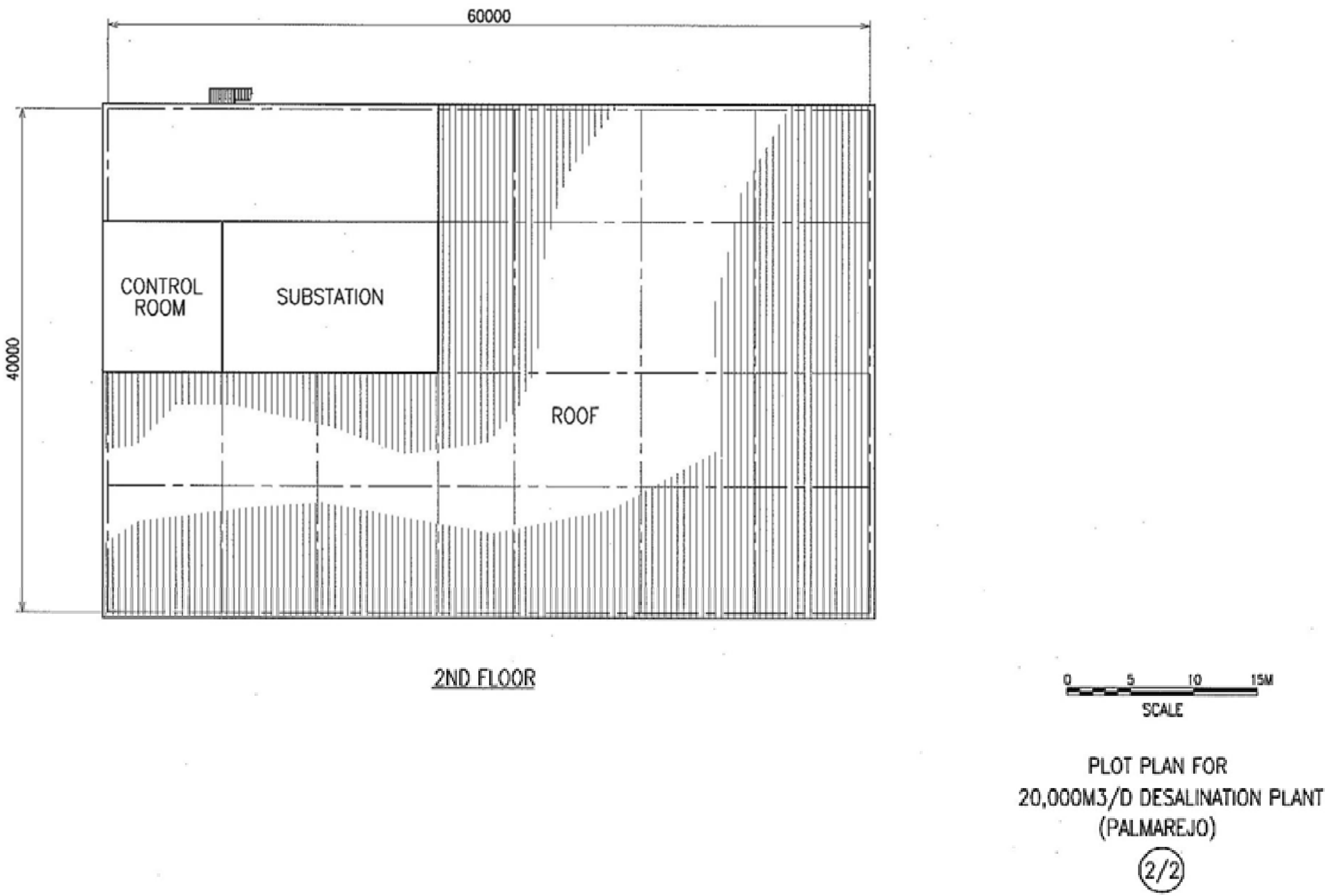
Source: Study team

Figure 4.1-9: Sea Water Desalination Facility General Layout at Calheta (Alternative)



Source: Study team

Figure 4.1-10: Sea Water Desalination Facility Plot Plan at Palmarejo (1/2)



Source: Study team

Figure 4.1-11: Sea Water Desalination Facility Plot Plan at Palmarejo (2/2)

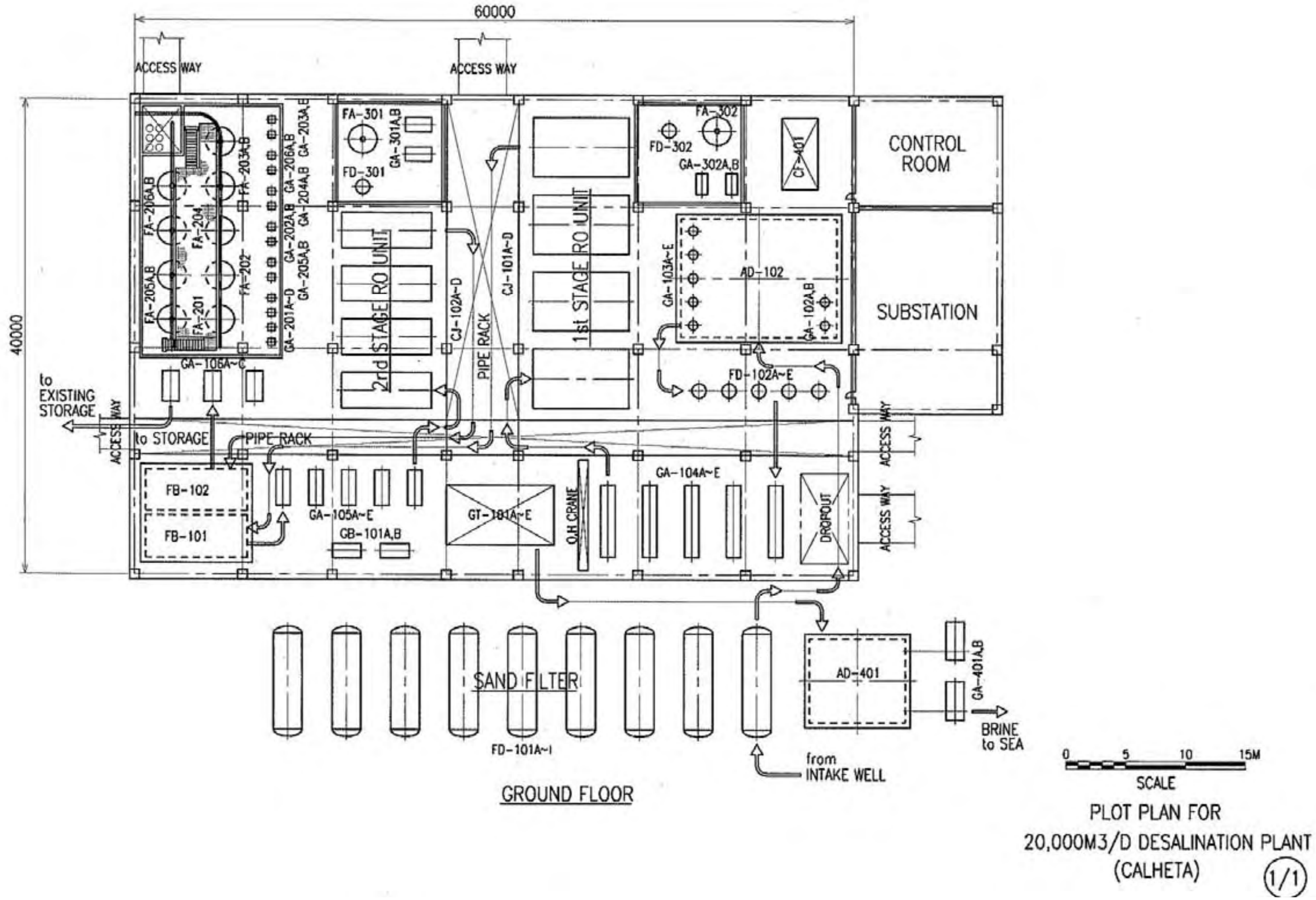
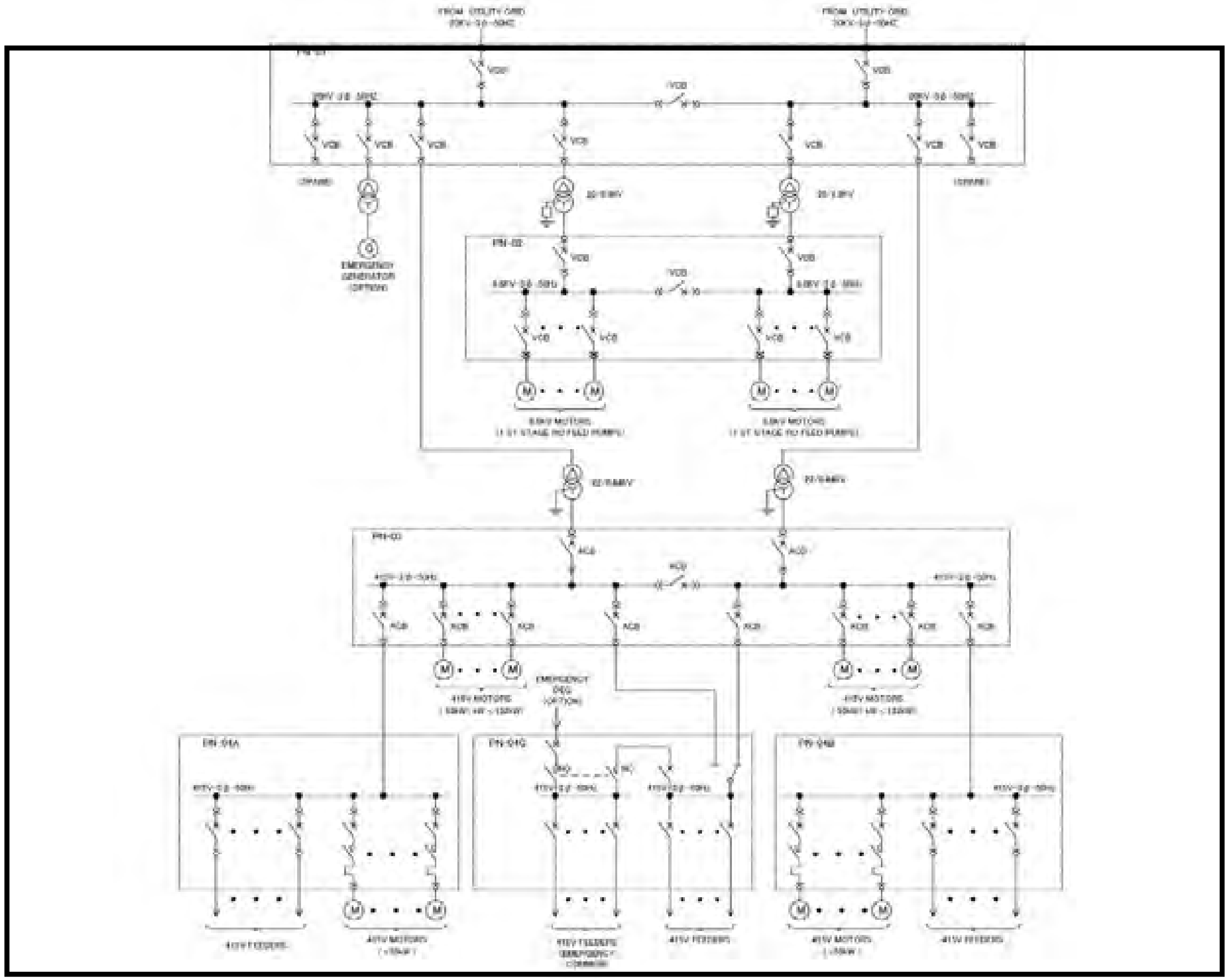


Figure 4.1-12: Sea Water Desalination Facility Plot Plan at Calheta



Source: Study team

Figure 4.1-13: Sea Water Desalination Facility Single Line Diagram

Table 4.1-8: Sea Water Desalination Facility Equipment List at Palmarejo Plant

Item No.	Service	No.	Type	Short Specification	Motor kW	Material
AD-101A-I	Intake Well	8+1		14" x 50000mmDepth		
AD-102	Filtered Water Pond	1	Semi-UG	520m3, 10000mmW x 13000mmL x 4500mmH		Concrete
AD-401	Waste Water Pit	1	AG	240m3, 8000mmW x 7500mmL x 4500mmH		Concrete
CJ-101A-D	1st Stage RO Unit	4 blocks		72 Pressure Vessels, 7 elements/PV, 8"element 5000mmW x 6000mmH x 8000mmL		
CJ-102A-D	2nd Stage RO Unit	4 blocks		30 Pressure Vessels, 7 elements/PV, 8"element 3000mmW x 6000mmH x 7500mmL		
FA-201	Hypochlorite Tank	1	Cone Roof	10m3, 2400mmID x 2600mmH, by Drum		FRP
FA-202	HCl Tank	1	Cone Roof	10m3, 2400mmID x 2600mmH, by Lorry		FRP
FA-203A,B	SBS Tank	2	Cone Roof	10m3, 2400mmID x 2600mmH, by Bag & Dissolving		FRP
FA-204	NaOH Tank	1	Cone Roof	10m3, 2400mmID x 2600mmH, by Lorry		FRP
FA-205A,B	Calcium Chloride Tank	2	Cone Roof	10m3, 2400mmID x 2600mmH, by Bag & Dissolving		FRP
FA-206A,B	Sodim Carbonate Tank	2	Cone Roof	10m3, 2400mmID x 2600mmH, by Bag & Dissolving		FRP
FA-301	1st RO Cleaning Tank	1	Cone Roof	20m3, 2400mmID x 6000mmH		FRP
FA-302	2nd RO Cleaning Tank	1	Cone Roof	10m3, 2000mmID x 4000mmH		FRP
FB-101	Intermediate Tank	1	Semi-UG	200m3, 4000mmW x 9000mmL x 6000mmH		Concrete
FB-102	Product Water Tank	1	Semi-UG	200m3, 4000mmW x 9000mmL x 6000mmH		Concrete
FB-103	Drinking Water Storage Tank	1	Cone Roof	7000m3 @Palmarejo, 29000mmID x 12000mmH		CS/Epoxy
FD-101A-H	Sand Filter	8+1	Horizontal	2400mmID x 8000mmL, Sand and Anthracite		CS/Rubber
FD-102A-E	Safety Filter	4+1	Vertical	1200mmID x 3000mmH, 5 micron Cartridge		CS/Rubber
FD-301	1st RO Cleaning Filter	1	Vertical	1200mmID x 3000mmH, Cartridge		CS/Rubber
FD-302	2nd RO Cleaning Filter	1	Vertical	800mmID x 3000mmH, Cartridge		CS/Rubber
GA-101A-I	Sea Water Intake Pump	8+1	Submerged	270m3/h x 50mH	55kW	Duplex SS or 316SS
GA-102A,B	Sand Filter Backwash Pump	1+1	Centrifugal	580m3/h x 20mH	55kW	Duplex SS or 316SS
GA-103A-E	Safety Filter Feed Pump	4+1	Centrifugal	530m3/h x 20mH	45kW	Duplex SS or 316SS
GA-104A-E	1st Stage RO Feed Pump	4+1	Centrifugal	530m3/h x 700mH	1400kW	Duplex SS or 316SS
GA-105A-E	2nd Stage RO Feed Pump	4+1	Centrifugal	240m3/h x 110mH	110kW	316SS
GA-106A-C	Product Water Pump	2+1	Centrifugal	420m3/h x 50mH	90kW	304SS
GA-107A-C	Drinking Water Transfer Pump	2+1	Centrifugal	420m3/h x 50mH @Parmarejo	90kW	304SS
GA-201A-D	Hypochlorite Injection Pump	2+2	Diaphragm	40L/h x 20mH	0.4 kW	SS/PTFE
GA-202A,B	HCl Injection Pump	1+1	Diaphragm	40L/h x 20mH	0.4 kW	SS/PTFE
GA-203A,B	SBS Injection Pump	1+1	Diaphragm	60L/h x 20mH	0.4 kW	SS/PTFE
GA-204A,B	NaOH Injection Pump	1+1	Diaphragm	60L/h x 20mH	0.4 kW	SS/PTFE
GA-205A,B	Calcium Chloride Injection Pump	1+1	Diaphragm	250L/h x 20mH	1.1 kW	SS/PTFE
GA-206A,B	Sodium Carbonate Injection Pump	1+1	Diaphragm	500L/h x 20mH	2.2 kW	SS/PTFE
GA-301A,B	1st RO Cleaning Pump	1+1	Centrifugal	430m3/h x 55mH	110kW	316SS
GA-302A,B	2nd RO Cleaning Pump	1+1	Centrifugal	180m3/h x 55mH	45kW	316SS
GA-401A,B	Waste Water Discharge Pump	1+1	Centrifugal	1400m3/h x 20mH	110kW	Duplex SS or 316SS
GB-101A,B	Air Wash Blower	1+1	Roots	1160m3/h x 4.5mH	30kW	CI
GD-203A,B	SBS Tank Mixer	2	Vertical		1.1 kW	CS/Rubber
GD-205A,B	Calcium Chloride Tank Mixer	2	Vertical		1.1 kW	CS/Rubber
GD-206A,B	Sodium Carbonate Tank Mixer	2	Vertical		1.1 kW	CS/Rubber
GD-301	1st RO Cleaning Tank Mixer	1	Vertical		1.1 kW	CS/Rubber
GD-302	2nd RO Cleaning Tank Mixer	1	Vertical		1.1 kW	CS/Rubber
GT-101A-E	Energy Recovery Device	4+1				
CF-401	Air Supply Package	1		300Nm3/h, with Air Compressor and Dryer	30kW	

Source: Study team

Table 4.1-9: Sea Water Desalination Facility Equipment List at Calheta Plant

Item No.	Service	No.	Type	Short Specification	Motor kW	Material
AD-101A-I	Intake Well	8+1		14" x 50000mmDepth		
AD-102	Filtered Water Pond	1	Semi-UG	520m3, 10000mmW x 13000mmL x 4500mmH		Concrete
AD-401	Waste Water Pit	1	AG	240m3, 8000mmW x 7500mmL x 4500mmH		Concrete
CJ-101A-D	1st Stage RO Unit	4 blocks		72 Pressure Vessels, 7 elements/PV, 8"element 5000mmW x 6000mmH x 8000mmL		
CJ-102A-D	2nd Stage RO Unit	4 blocks		30 Pressure Vessels, 7 elements/PV, 8"element 3000mmW x 6000mmH x 7500mmL		
FA-201	Hypochlorite Tank	1	Cone Roof	10m3, 2400mmID x 2600mmH, by Drum		FRP
FA-202	HCl Tank	1	Cone Roof	10m3, 2400mmID x 2600mmH, by Lorry		FRP
FA-203A,B	SBS Tank	2	Cone Roof	10m3, 2400mmID x 2600mmH, by Bag & Dissolving		FRP
FA-204	NaOH Tank	1	Cone Roof	10m3, 2400mmID x 2600mmH, by Lorry		FRP
FA-205A,B	Calcium Chloride Tank	2	Cone Roof	10m3, 2400mmID x 2600mmH, by Bag & Dissolving		FRP
FA-206A,B	Sodim Carbonate Tank	2	Cone Roof	10m3, 2400mmID x 2600mmH, by Bag & Dissolving		FRP
FA-301	1st RO Cleaning Tank	1	Cone Roof	20m3, 2400mmID x 6000mmH		FRP
FA-302	2nd RO Cleaning Tank	1	Cone Roof	10m3, 2000mmID x 4000mmH		FRP
FB-101	Intermediate Tank	1	Semi-UG	200m3, 4000mmW x 9000mmL x 6000mmH		Concrete
FB-102	Product Water Tank	1	Semi-UG	200m3, 4000mmW x 9000mmL x 6000mmH		Concrete
FD-101A-H	Sand Filter	8+1	Horizontal	2400mmID x 8000mmL, Sand and Anthracite		CS/Rubber
FD-102A-E	Safety Filter	4+1	Vertical	1200mmID x 3000mmH, 5 micron Cartridge		CS/Rubber
FD-301	1st RO Cleaning Filter	1	Vertical	1200mmID x 3000mmH, Cartridge		CS/Rubber
FD-302	2nd RO Cleaning Filter	1	Vertical	800mmID x 3000mmH, Cartridge		CS/Rubber
GA-101A-I	Sea Water Intake Pump	8+1	Submerged	270m3/h x 50mH	55kW	Duplex SS or 316SS
GA-102A,B	Sand Filter Backwash Pump	1+1	Centrifugal	580m3/h x 20mH	55kW	Duplex SS or 316SS
GA-103A-E	Safety Filter Feed Pump	4+1	Centrifugal	530m3/h x 20mH	45kW	Duplex SS or 316SS
GA-104A-E	1st Stage RO Feed Pump	4+1	Centrifugal	530m3/h x 700mH	1400kW	Duplex SS or 316SS
GA-105A-E	2nd Stage RO Feed Pump	4+1	Centrifugal	240m3/h x 110mH	110kW	316SS
GA-106A-C	Product Water Pump	2+1	Centrifugal	420m3/h x 50mH	90kW	304SS
GA-201A-D	Hypochlorite Injection Pump	2+2	Diaphragm	40L/h x 20mH	0.4 kW	SS/PTFE
GA-202A,B	HCl Injection Pump	1+1	Diaphragm	40L/h x 20mH	0.4 kW	SS/PTFE
GA-203A,B	SBS Injection Pump	1+1	Diaphragm	60L/h x 20mH	0.4 kW	SS/PTFE
GA-204A,B	NaOH Injection Pump	1+1	Diaphragm	60L/h x 20mH	0.4 kW	SS/PTFE
GA-205A,B	Calcium Chloride Injection Pump	1+1	Diaphragm	250L/h x 20mH	1.1 kW	SS/PTFE
GA-206A,B	Sodium Carbonate Injection Pump	1+1	Diaphragm	500L/h x 20mH	2.2 kW	SS/PTFE
GA-301A,B	1st RO Cleaning Pump	1+1	Centrifugal	430m3/h x 55mH	110kW	316SS
GA-302A,B	2nd RO Cleaning Pump	1+1	Centrifugal	180m3/h x 55mH	45kW	316SS
GA-401A,B	Waste Water Discharge Pump	1+1	Centrifugal	1400m3/h x 20mH	110kW	Duplex SS or 316SS
GB-101A,B	Air Wash Blower	1+1	Roots	1160m3/h x 4.5mH	30kW	CI
GD-203A,B	SBS Tank Mixer	2	Vertical		1.1 kW	CS/Rubber
GD-205A,B	Calcium Chloride Tank Mixer	2	Vertical		1.1 kW	CS/Rubber
GD-206A,B	Sodium Carbonate Tank Mixer	2	Vertical		1.1 kW	CS/Rubber
GD-301	1st RO Cleaning Tank Mixer	1	Vertical		1.1 kW	CS/Rubber
GD-302	2nd RO Cleaning Tank Mixer	1	Vertical		1.1 kW	CS/Rubber
GT-101A-E	Energy Recovery Device	4+1				
CF-401	Air Supply Package	1		300Nm3/h, with Air Compressor and Dryer	30kW	

Source: Study team

4.1.4 Water Supply Network System

(1) Design criteria and philosophy of system

The purpose of the transmission pipeline network is to transfer the produced desalinated water from 2 sea water desalination facilities to the main reservoirs located in high elevation sites in order to satisfy the consumption demand of the population by 2020 for each municipality. The main reservoirs will enable the feeding of the local existing and/or projected future distribution network and will have a storage capacity corresponding to approximately 12 hours of demand. The supply of electricity is assumed to be sufficient and stable for all pumping stations.

a. Potable water production capacity

The potable water production capacity from the project facilities is tentatively set to be 40,000 m^3/day to meet the water demand of 2020, while the daily maximum demand is estimated to be 56,229 m^3/day. The remaining demand will be supplied by the existing and planned desalination plants.

b. Potable water transmission network

The potable water transmission capacity is tentatively set to be 40,000 m^3/day to meet the water demand of 2020.

c. Annual operating days

The system is operated 365 days per year.

Corrective and preventive maintenance will be considered.

The pumping system is operated 20 hours per day in the desalination facility and 15 hours per day for all other pump stations.

d. System configuration

The system consists of

- A water transmission line
- pumping stations
- water reservoirs
- lighting, fence, building, gate
- Each pumping station shall receive information from downstream by an optical fiber connection in order to have a minimum automatism level for operation.

e. Water pump mechanism

All water pumps will be driven with electric motor drives.

f. Spare equipment

In order for the plant to be operated at full capacity, equipment that will require occasional maintenance will be used as spares.

Especially for pumps, one pump for each pumping station will be a spare.
There will be no spare chemical injection pump.

g. Storage capacity
Reservoirs: 12 hours of consumption demand

h. Soil conditions
Soil conditions and data are provided in the soil survey report.

i. Seismic conditions
The site is located in ZONE 1 (Z factor : 0.075), in accordance with the Uniform Building Code (UBC).

j. Potable water specifications
Potable water specifications will be applied according to Guidelines for WHO Drinking-water Quality, 3rd edition, 2008.
Due to long distance transmission pipelines and the consequent water transfer duration, the needed complementary on line injection equipment for chlorination shall be expected to meet WHO's minimum drinking water quality level. An officially designated externally approved laboratory shall continuously control the water quality but some simple portable water quality control equipment shall be considered in the current project cost estimation for simplified daily control.

k. Emergencies
In case of emergencies with consideration of potential natural disasters (e.g., earthquakes, floods, damage to electrical equipment by lightning strikes, landslides), accidents (e.g., spills in the watershed), damage to treatment plant and distribution system and human actions (e.g., strikes, sabotage), the following are recommended but not included in the current study:

- Increased monitoring systems
- Water trucks
- Communication protocols and strategies, including notification procedures (internal, regulatory body, media and public

(2) Units of measurement

The measuring units shall be based on the SI metric system. The following SI units and abbreviations shall be applied in general:

Application	Unit	Abbreviation
Length	meter or millimeter	m or mm
Area	square meter	m^2
Time	second, minute, hour, day	s, min, h, d
Volume	cubic meter	m^3
Weight (mass)	kilogram or metric ton	kg or ton
Flowing Quantities		
Mass	kilogram/hour	kg/h
	metric ton/day	t/d
Liquid	cubic meter/hour	m^3/h
	liter/hour	l/h
Density	kilogram/cubic meter	kg/m^3
Pressure		
Above Atmospheric	bar	bar (g) or bar (a)
Below Atmospheric	millimeter of mercury, Torr or bar	mmHg or Torr (at 0°C) or bar (a)
Temperature	degree Celsius	°C
Energy, Heat	joule, kilo-joule	J, kJ
Power	watt, kilowatt, megawatt	W, kW , MW
Revolution Speed	revolution per minute. or revolution per second	rpm, min^{-1} or s^{-1}
Current	ampere or kilo-ampere	A or kA
Voltage	volt or kilovolt	V or kV
Concentration		mol.%, vol.% or wt.% mol. ppm, vol. ppm, wt. ppm

(3) Codes and standards

ISO, EN, DIN, BS, JIS or any international standards are applicable. Ones can be selected, if they are equivalent or superior to ISO ones.

(4) General description of treated water transmission pipelines

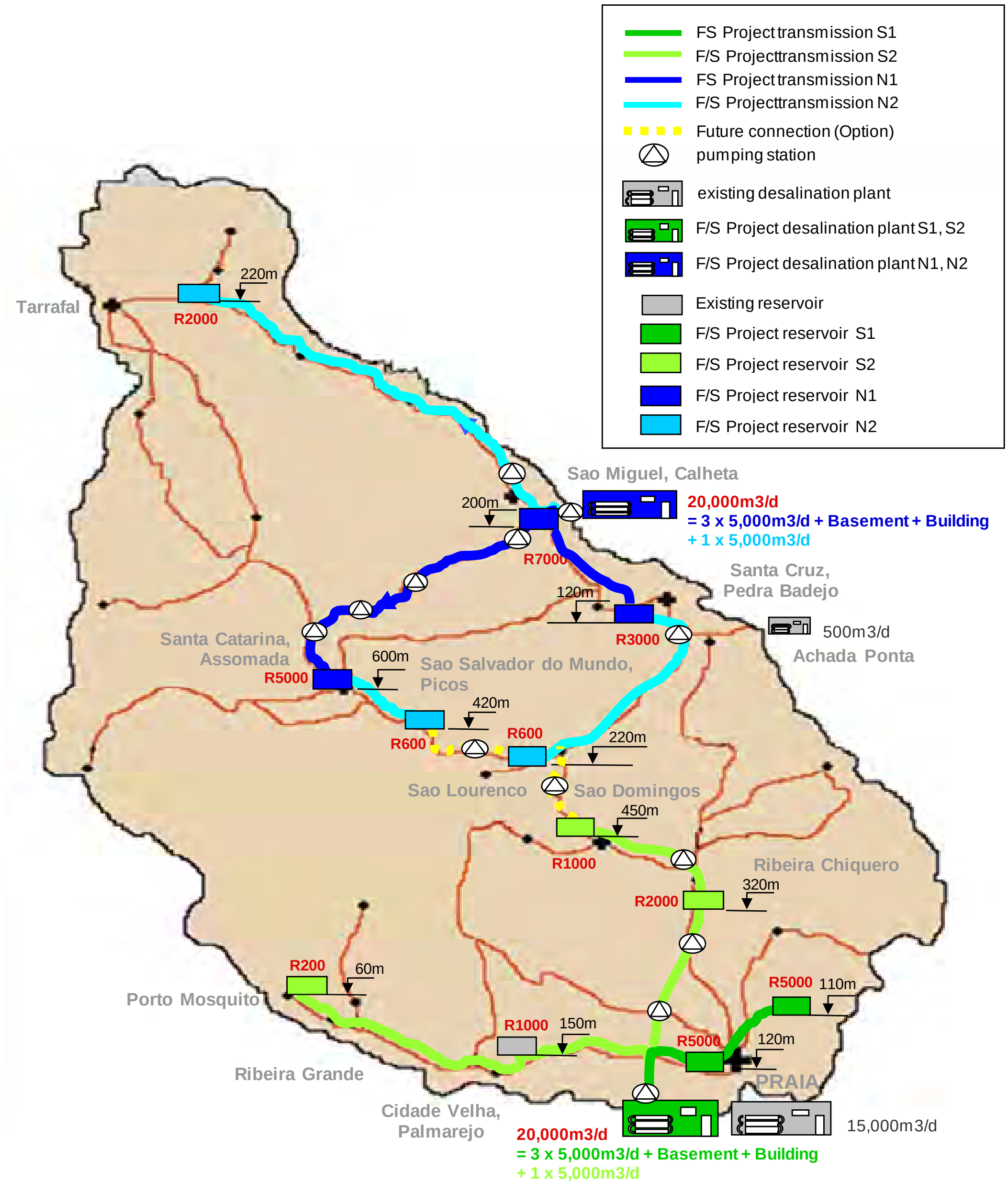
In order to ease the detailed description and analysis of the operation of the system, the whole network system is divided into 4 main sub-projects as follows:

Table 4.1-10: Project's subdivisions

Name	Description	Municipalities concerned
S1	Southern Area 1	Praia
S2	Southern Area 2	Ribeira Grande, Sao Domingos
N1	Northern Area 1	Sao Miguel, Santa Catarina, Santa Cruz
N2	Northern Area 2	Tarrafal, San Salvador Do Mundo, Sao Lorenco

Source : Study team

CABO VERDE - Water Supply System of Santiago Island



Altitude levels are indicative
Pumps location and reservoirs locations are indicative

Source : Study team

Figure 4.1-14: Treated water transportation pipeline route

Codification:

All the network components are named in the following manner:

TLNa: Transmission Line North N°a TLSb: Transmission Line South N°b

PSNc: Pumping Station North N°c PSSd: Pumping Station South N°d

RNa-x000: Reservoir North N°a - x000 m^3 RSb-y000: Reservoir South N°b – y000 m_3

A description of each section shall be carried according to the following table:

Table 4.1-11: List of pipe sections (South Area)

No.	Start	End	Type	Length (m)	Material
S1 : Network for Praia Center					
TLS1	PSS1 Praia WTP*	RS1-5000 / RS2-5000	Pumped	8,000	500 DICL
S2a : Network for Ribeira Grande					
TLS2	PSS2 Praia WTP*	Existing Cidade Verlha Tank	Pumped	8,000	250 HDPE PN 16
TLS3	Existing Cidade Verlha Tank	RS3-200	Gravity	13,200	160 HDPE PN16
S2b : Network for Sao Domingos					
TLS4	PSS3 Praia WTP*	PSS4	Pumped	5,000	225 HDPE PN 16
TLS5	PSS4	PSS5	Pumped	6,500	225 HDPE PN 16
TLS6	PSS5	RS4-2000	Pumped	4,700	225 HDPE PN 16
TLS7	PSS6	RS5-1000	Pumped	5,700	200 HDPE PN 16

*Praia WTP: Desalination Plant in Palmarejo

Source : Study team

TLS1: PSS1 to Praia City

Starting from the pumping station PSS1 in Palmarejo Desalination Facility (Praia WTP), the pipeline will follow the road going to Praia until reaching Monte Babosa reservoir (5,000 m^3) and then the Vila Nova reservoir (5,000 m^3) .

Pipe: diameter 500 mm, ductile iron; total length: 8,000 m.

TLS2 & TLS3: PSS2 to Ribeira Grande: Cidade Velha – Porto Mosquito

Starting from the pumping station PSS2 in Palmarejo Desalination Facility (Praia WTP), the pipeline TLS2 goes west along the road to Cidade Velha and reaches the existing 1000 m^3 reservoir.

Pipe: diameter 250mm, HDPE PN 16 length: 8,000 m.

Then the water can reach, by gravity, the reservoir of Porto Mosquito (RS3-200) through a HDPE 160 mm pipe TLS3 installed along the coastal area. Specific protection in the form of gabions shall be needed for river crossings.

Pipe: diameter 160 mm, HDPE PN 16 length: 13,200 m.

TLS4; TLS5; TLS6 & TLS7: PSS3 to Sao Domingos

Starting from the pumping station PSS3 also located in Palmarejo Desalination Facility (Praia WTP), the pipeline TLS4 follows the new road heading north for 5 km to reach the pumping station PSS4. It then follows another pumped section TLS5 till PSS5 to finally reach the reservoir of Ribeirao RS4-2000 through the TLS6.

The pipeline route and the RS4-2000 are also ideally located to enable a future branch connection to supply water along its route and to the next valleys.

The last pumped section TLS7 from PSS6 (beside the RS4-2000) is laid along the road to the reservoir RS5-1000 located at the north entrance of Sao Domingos City.

TLS4 Pipe: diameter 225 mm, HDPE PN 16 length: 5,000 m.

TLS5 Pipe: diameter 225 mm, HDPE PN 16 length: 6,500 m.

TLS6 Pipe: diameter 225 mm, HDPE PN 16 length: 4,700 m.

TLS7 Pipe: diameter 200 mm, HDPE PN 16 length: 5,700 m.

Table 4.1-12: List of pipe sections (North Area)

No.	Start	End	Type	Length (m)	Material
N0 : Network for all the North Area					
TLN1	PSN1 Calheta WTP	RN1-7000 Calheta tank	Pumped	1,300	500 DICL
N1a: Network for Santa Catarina – Assomada					
TLN2	PSN2	PSN3	Pumped	9,700	400 DICL
TLN3	PSN3	PSN4	Pumped	1,600	400 DICL
TLN4	PSN4	PSN5	Pumped	2,300	400 DICL
TLN5	PSN5	RN2-5000 Assomada	Pumped	1,000	400 DICL
N1b : Network for Santa Cruz					
TLN7	RN1-7000	RN5-3000 Pedra Badejo	Gravity	11,200	300 DICL
N2a: Network for Tarrafal					
TLN9	RN1-7000	PSN7	Gravity	20,000	400 DICL
TLN10	PSN7	RN4-2000 Tras Os Montes	Pumped	6,000	315 HDPE PN 16
N2b: Network for Sao Salvador Do Mundo					
TLN6	RN2-5000	RN3-600 Picos	Gravity	9,800	200 HDPE PN16
N2c:Network for Sao Lorenco					
TLN8	PSN6	RN3-600 Joao Teves	Pumped	16,400	250 HDPE PN16

**Calheta WTP: Desalination Plant in Sao Miguel
DICL: Ductile iron pipe
HDPE: Hugh Density Polyethylene
Source: Study team

TLN1: from PSN1 to RN1-7000

The reservoir capacity corresponding to 8 hours of production, initially designed inside the desalination plant boundaries, will be located at a higher altitude of approximately 200m in order to be able to distribute water by gravity to Sao Miguel City. This reservoir will also enable the sending of water, by gravity, towards Tarrafal in the north part of the island and towards Santa Cruz in the south of Sao Miguel.
TLN1 Pipe: diameter 500 mm, ductile iron; length: 1,300 m.

TLN2; TLN3; TLN4 & TLN5: from PSN2 to RN2-5000 Assomada

4 stages of pumping stations are necessary to reach the city of Assomada from the central tank RN1-7000. The pipeline route shall be inside the newly constructed asphalted road.
TLN2 Pipe: diameter 400 mm, ductile iron; length: 9,700 m.
TLN3 Pipe: diameter 400 mm, ductile iron; length: 1,600 m.
TLN4 Pipe: diameter 400 mm, ductile iron; length: 2,300 m.
TLN5 Pipe: diameter 400 mm, ductile iron; length: 1,000 m.

TLN7: from RN1-7000 to RN5-3000 - Santa Cruz

From the reservoir RN1-7000 the pipeline route goes (by gravity) down to the coastal area to RN5-3000. The route is along the coastal road heading towards Santa Cruz.
TLN7 Pipe: diameter 300 mm, ductile iron; length: 11,200 m.

TLN9 & TLN10: Pipelines for Tarrafal Area

From the reservoir RN1-7000, the water level is able to reach, by gravity, PSN7 located along the coast. Then a small pumping section is needed to reach the reservoir RN4-2000 on the plateau above the city of Tarrafal.
TLN9 Pipe: diameter 400 mm, ductile iron; length: 20,000 m.
TLN10 Pipe: diameter 315 mm, HDPE PN 16; length: 6,000 m.

TLN6: Pipeline for Sao Salvador Do Mundo

From the reservoir RN2-5000 located in Assomada, the pipeline route follows the existing gravity line towards the reservoir RN3-600 of Picos.
TLN6 Pipe: diameter 200 mm, HDPE PN 16; length: 9,800 m.

TLN8: Pipeline for Sao Lorenço

From PSN6 located beside the reservoir RN5-3000, the water is pumped to the reservoir RN6-600.
TLN8 Pipe: diameter 250 mm, HDPE PN 16; length: 16,400 m.

LOOP SECTIONS (optional sections)

To complete and to secure the networks, the CV side propose to build loops.
Those sections are considered to be optional and are not included in the current cost estimation. Nevertheless, in order to secure a water distribution system, it is highly recommended to consider the extension of the network to loop the whole system.

LOOP N°1

This loop connects the North Area network to the South Area network: From a connection on the TLN8, the pipeline DN 200 goes to the RS5-1000 in Sao Domingos. Some pumping stations must be installed on the route.
In this way (north to south) the water could flow easily to the city of Praia.
In the reverse flow, the part secured is only for Sao Salvador Do Mundo and Sao Lorenço.
LOOP N°1 Pipe: diameter 200 mm, HDPE PN 16; length: 5,800m.

LOOP N°2

This loop connects the RN3-600 Picos to the RN6-600 Joao Teves. Some pumping stations must be installed on the route.
This Transmission Line DN 200 secures the supply of Sao Salvador from the south and the supply of Sao Lorenço from the north.
In the future we could perfect the system and secure the water supply of Assomada from the south by building some pumping stations between Sao Salvador and Assomada.
LOOP N°2 Pipe: diameter 200 mm, HDPE PN 16; length: 6,300 m.

Pumping stations

Typically, the pumping stations will be built with a buffer tank with adapted volume and a room for the pumps and the electric devices. For certain ones, a reservoir could be the buffer tank.
The pumps will be non-submersible, horizontally installed and multi-cellular.
Every pumping station will have at least one pump ‘on duty’ (2 pumps for the big pumping stations) plus one on stand-by. Electrical energy will be the three-phase AC current.
Table 4.1-9 shows the installed power for the CAPEX calculations (number of pumps) which is different from the real power consumption which serves for the OPEX calculations.

Table 4.1-13: List of pumping stations

No.	Flow (m^3/h)	Pressure (barg.)	Total installed power (kW) for CAPEX	Power consumption (kW) for OPEX
PSS1	1,599	16.0	1,661	1,110
PSS2	98	15.7	134	70
PSS3	126	14.1	154	80
PSS4	126	17.6	193	100
PSS5	126	14.7	161	85
PSS6	42	14.0	51	30
PSN1	1,056	18.2	1,249	840
PSN2	598	13.3	711	350
PSN3	598	10.4	543	275
PSN4	598	10.6	557	280
PSN5	598	10.2	530	270
PSN6	80	13.7	95	50
PSN7	238	14.6	301	160

Source: Study team

Reservoirs

The reservoirs shall be square shaped with multiple cells in reinforced concrete with a top roof.

Size of 1 standard cell: 1,000 m^3

As a minimum for operation the following indicators shall be installed at different levels:

Level 1: overflow

Level 2: stop pumping

Level 3: start pumping

Level 4: minimum low level

Table 4.1-14: List of reservoirs

Name	Description	Capacity (m^3)	Elevation (m)
RS1-5000	Praia – Tira Chapeu	5 x 1000 = 5,000	120
RS2-5000	Praia- Vila Nova	5 x 1000 = 5,000	110
Existing	Existing reservoir Cidade Velha	1 x 1000 = 1,000	150
RS3-200	Porto Mosquito	1 x 200 = 200	60
RS4-2000	Ribeiro Chiquero	2 x 1000 = 2,000	320
RS5-1000	Sao Domingos	1 x 1000 = 1,000	450
RN6-600	Joao Teves	1 x 600 = 600	220
RN5-3000	Pedra Badejo	3 x 1000 = 3,000	120
RN3-600	Picos	1 x 600 = 600	420
RN1-7000	Calheta Sao Miguel	7 x 1000 = 7,000	200
RN2-5000	Assomada	5 x 1000 = 5,000	600
RN4-2000	Tras Os Montes	2 x 1000 = 2,000	220

Source: Study team

RS1-5000 Praia – Tira Chapeu / RS2-5000 Praia – Vila Nova

In order to increase the storage capacity for the growing city of Praia, those reservoirs are complementary to all other existing reservoirs around Praia. Both reservoirs are located in the western part of the city, currently nearly on the border but future expansion will continue and the reservoirs shall be ideally integrated in the city network.

Existing reservoir Cidade Velha

Completely buried underground the reservoir is located on an existing pipeline route that was previously feeding Praia from a water resource called "Aguas Verdes" in the northern part of the valley. The city is rapidly installing house connections and also developing a sewerage network and a treatment plant.

RS3-200 Porto Mosquito

The city is already equipped with a distribution system with water meters on each house connection and an existing small reservoir (50m^3) is feeding the local distribution system by gravity. But, the scarcity of supply by water tankers does not enable a continuous service. This new complementary reservoir will ideally carry out a continuous water distribution service for all connected users.

RS4-2000 Ribeira Chiquero

This reservoir is located in the north part of Praia, on the road to Sao Domingos. The choice of the location is due to the future development axes of the capital city that are expected to be mainly towards the north and east.

RS5-1000 Sao Domingos

The existing supply from wells was considered to be insufficient for the future planned development of the city. Even a desalination plant project in San Francisco was studied to try to solve the water deficit. The reservoir considered in the current project will take into account the existing facilities and will be in a position to be connected to the existing one as much as possible by gravity.

RN6-600 Joao Teves

Near Sao Lourenco, located at a junction between the north water supply system and the south water supply system, the reservoir RN6 is also the starting point for optional loop line no. 2 that links RN6 to RN3 Picos.

RN5-3000 Pedra Badejo

The eastern coastal area has a large population concentration around the city of Pedra Badejo. It was an obvious decision to locate a main reservoir with enough capacity around this location in order to support the growing area. RN5 will also be able to supply Santa Cruz.

RN3-600 Picos

With a dispersed population due to the mountainous relief the continuous distribution of drinking water is not easy to carry out at these altitudes. All the same, the installation of a reservoir fed by a desalination plant will certainly improve the comfort of supply and eliminate anxiety over the long-term about the availability of water resources.

RN1-7000 Calheta Sao Miguel

This reservoir is the starting point for 3 transmission lines: TLN2, TLN7, TLN9. A large and unique reservoir elevated at around 200 m is optimizing operations by concentrating the facilities. And the feeding energy of this reservoir from the desalination plant will also be minimal as there is only a short distance for pumping section to cover.

RN2-5000 Assomada

Located on one of the highest hills that surround Assomada, this reservoir will be strategic for the growth of this young city, which has many schools and universities. This reservoir will not only bring complementary storage capacity but also a regular supply of drinking water. Moreover, as the existing large capacity reservoirs are very old and leaking this project will also be a needed renewal.

RN4-2000 Tras Os Montes

This reservoir is located on the highest point in the northern part of the island. Its position will enable the distribution of water by gravity to both the eastern coast area and the western coast area with Tarrafal.

(5) Technical specifications and typical drawings

Pipes

Ductile Iron Cement Lining pipes (DICL) and High Density Polyethylene (HDPE) pipes are proposed to be laid.

These kinds of pipes are well known all around the world and in the Republic of Cape Verde.

They avoid the use of a cathodic protection, which is always an issue for the entity in charge to operate a water network, especially in these kinds of countries.

The succinct soil investigation carried out had pointed out some areas with potential soil bearing problems. Nevertheless, as the investigation point density is not enough to clearly identify and precisely quantify the conditions, all needed measures shall be studied during the detailed design phase with appropriate data and a complementary survey. All the same, the current feasibility study shall take into account some allowance for possible variations of pipe installation costs in particular sections.

Ductile iron pipes: They will be manufactured in compliance with the international standards ISO 2531, ISO 4179, ISO 8179 and EN 545.

They receive an external coating composed of at least of one layer of sprayed metallic zinc (130 g/m^2 at least) covered with bituminous paint (minimum thickness 100 microns) which is a pore-sealer.

For corrosive soil, reinforced protection could be applied on the pipe such as PE sleeves or PE bonded coating.

Internally, a cement mortar lining is applied by a centrifugal process so as to have a high mortar compaction and low roughness. Moreover, this lining provides good preservation of the carried water quality and effective protection of pipe walls against ‘aggressive’ water.

The connection between pipes is done by spigot-socket with an elastomeric gasket in EPDM.

To self-anchor the canalisation and avoid the thrust block construction, the manufacturers propose special joints.

HDPE pipes: They will be manufactured in compliance with all the international standards.

They will use the best quality virgin resin PE 100; the design pressure will be 16 bars in order to offer both high security against mechanical effects and reduce the number of pumping stations.

This pipe is welded (butt fusion) and so is a self-anchored pipeline.

The chemical and physical properties of this pipe give it the advantage of being able to be laid in very ‘aggressive’ soil without special requirements.

Drawings

The drawings are typical drawings and shall only be used as indicative drawings. They are representing the type of infrastructure on which the cost estimation is based.

- General route layout of pipelines and pumping stations
- Typical reservoir
- Typical pumping station

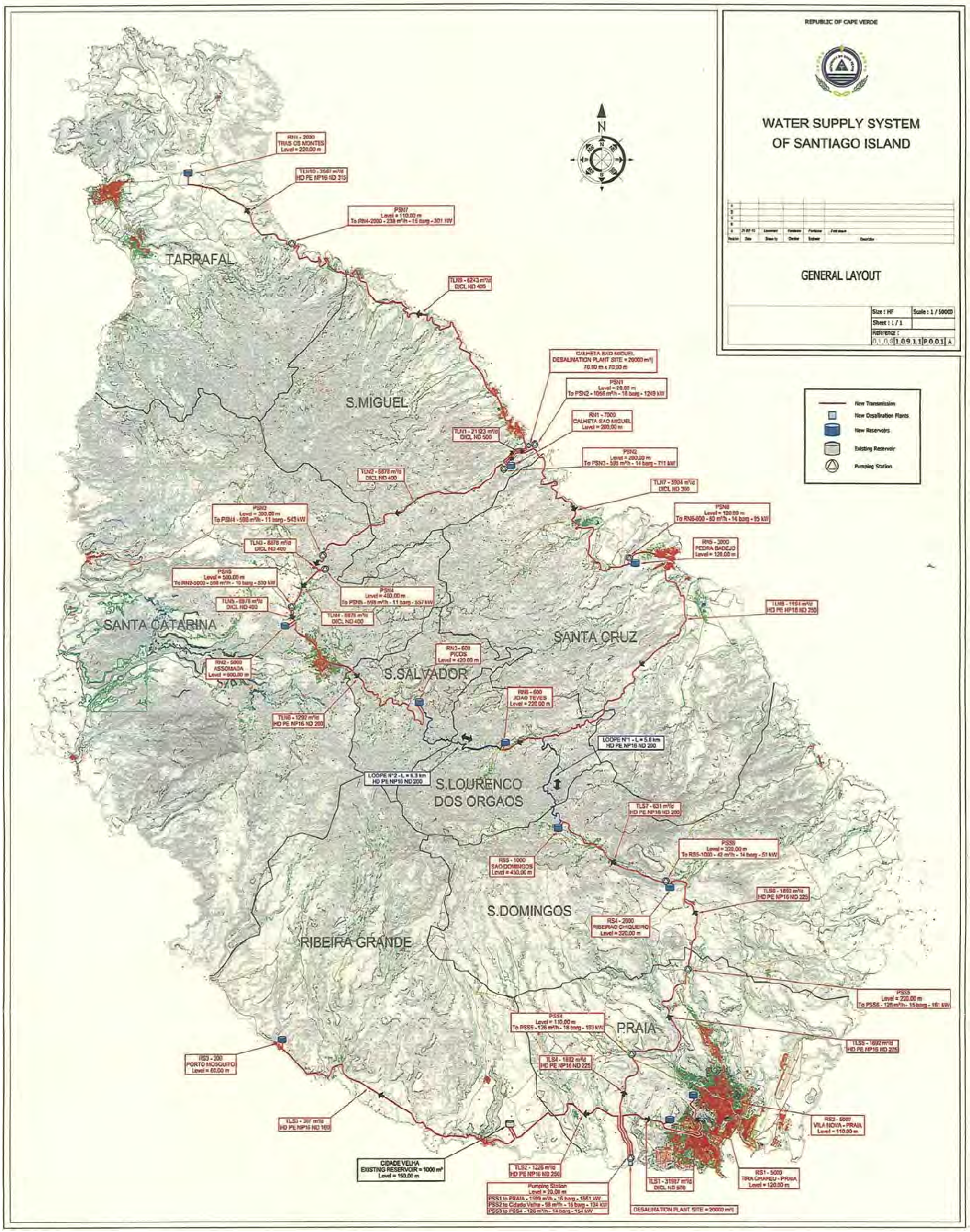
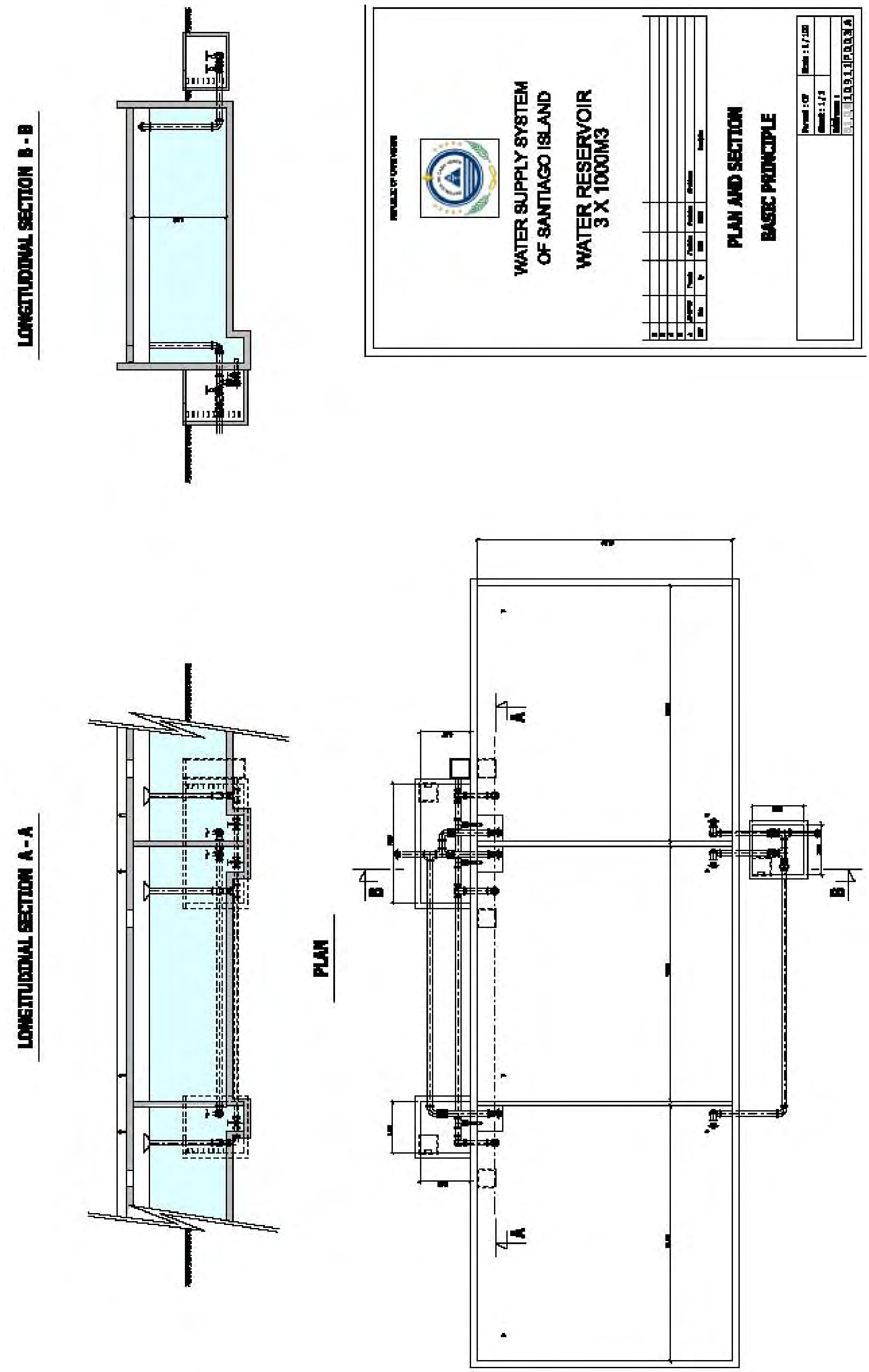
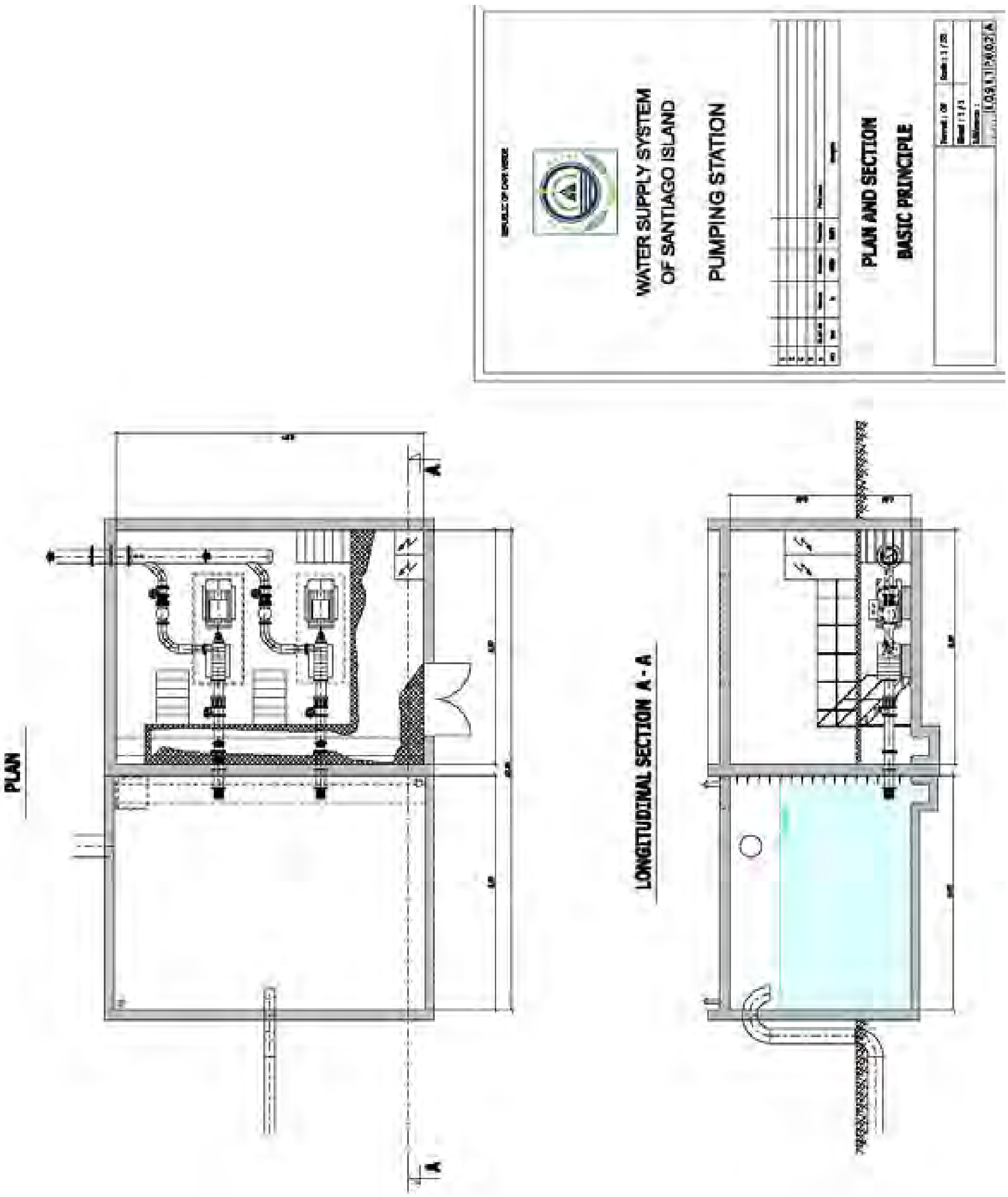


Figure 4.1-15: General route layout of pipelines and pumping stations



Source: Study team

Figure 4.1-16: Typical reservoir



Source: Study team

Figure 4.1-17: Typical pumping station

4.1.5 Costing

(1) Basis of Base Cost Estimation

Base cost is estimated on a Basic Design basis.

The cost estimation source comes from consultant in-house data and some vendor information.

The cost estimation time is August 2010

This water supply system consists of 2 Sea Water Desalination Facilities and a Water Transmission Facility, including water transmission lines, pumping stations and water reservoirs.

The water supply system is described in sections 4.1.1 and 4.1.3.

Each sea water desalination facility will have a potable water production capacity of 20,000 m^3/day; one will be constructed in Calheta Sao Miguel and the other in Palmarejo in the existing desalination facility operated by ELECTRA.

The water transmission facility is divided into 4 main sub-projects throughout Santiago Island as follows:

Name	Description	Municipalities concerned
S1	South Area Phase 1	Praia
S2	South Area Phase 2	Ribeira Grande, Sao Domingos
N1	North Area Phase 1	Sao Miguel, Santa Catarina, Santa Cruz
N2	North Area Phase 2	Tarrafal, San Salvador Do Mundo, Sao Lorenco

Source: Study team

The water supply system is described in sections 4.1.2 and 4.1.4.

(2) General Methodology of Cost Estimation

The methodology of cost estimation is generally applied in the Association for the Advancement of Cost Engineering International, AACE International, Recommended Practice No. 18R-97 in the February 2005 version.

The Recommended Practice is titled “Cost Estimate Classification System as Applied in Engineering, Procurement and Construction for the Process Industries.”

Considering the purpose of the cost estimation, the methodology is applied in Class 4 described in the above practice.

General Cost Estimate Classification Matrix for Process Industries is shown in Table 4.1-15.

Table 4.1-15: Cost Estimate Classification Matrix for Process Industries

ESTIMATE CLASS	***Primary Characteristic***	***Secondary Characteristic***			
	LEVEL OF PROJECT DEFINITION Expressed as % of complete definition	**END USAGE** Typical purpose of estimate	**METHODOLOGY** Typical estimating method	**EXPECTED ACCURACY RANGE** Typical variation in low and high ranges (a)	**PREPARATION EFFORT** Typical degree of effort relative to least cost index of 1(b]
Class 5	0% to 2%	Concept Screening	Capacity Factored, Parametric Models, Judgment, or Analogy	L: -20% to -50% H: +30% to +100%	1
Class 4	1 % to 15%	Study or Feasibility	Equipment Factored or Parametric Models	L: -15% to -30% H: +20% to +50%	2 to 4
Class 3	10% to 40%	Budget, Authorization, or Control	Semi-Detailed Unit Costs with Assembly Level Line Items	L: -10% to -20% H: +10% to +30%	3 to 10
Class 2	30% to 70%	Control or Bid/Tender	Detailed Unit Cost with Forced Detailed Take-Off	L: -5% to -15% H: +5% to +20%	4 to 20
Class 1	50% to 100%	Check Estimate or Bid/Tender	Detailed Unit Cost with Detailed Take-off	L: -3% to -10% H: +3% to +15%	5 to 100

Notes:

(a) The state of process technology and availability of applicable reference cost data affect the range markedly. The +/- value represents typical percentage variation of actual costs from the cost estimate after application of contingency (typically at a 50% level of confidence) for given scope.

(b) If the range index value of "1" represents 0.005% of project costs, then an index value of 100 represents 0.5%. Estimate preparation effort is highly dependent upon the size of the project and the quality of estimating data and tools.

Source: Study team

Class 4 estimates are generally prepared based on limited information and subsequently have fairly wide accuracy ranges. They are typically used for project screening, determination of feasibility, concept evaluation, and preliminary budget approval. Typically, engineering is from 1% to 15% complete, and would comprise at a minimum the following: plant capacity, block schematics, indicated layout, process flow diagrams for main process systems, and preliminary engineered process and utility equipment lists.

Class 4 estimates are prepared for a number of purposes, such as but not limited to detailed strategic planning, business development, project screening at more developed stages, alternative scheme analysis, confirmation of economic and/or technical feasibility, and preliminary budget approval or approval to proceed to the next stage.

The estimate of plant cost has been applied with the so-called “Stochastic Estimating

Method" such as Capacity Factored, Cost Factored, Quantity Ratio, Parametric Model and their combination.

The Capacity Factored estimate is one in which the cost of a new facility is derived from the cost of a similar facility of a known (but usually different) capacity.

The Cost Factored is the method to estimate the bulk materials, indirect cost of the plant using a certain range of cost ratio to equipment, etc.

The Quantity Ratio is the method to estimate the construction bill of quantity (BQ) such as tons of steel structure, m^3 of concrete, piping weld quantity, etc., using a certain quantity ratio to ton of equipment, etc.

The Parametric Model is the method to estimate equipment cost, etc., using the cost estimating formula taking the design pressure, flow rate, etc., as parameters.

(3) Methodology of cost estimation for this survey

For this study, the methodology is applied as follows:

The cost estimation of the Sea Water Desalination Facility is generally conducted using

1) Itemized equipment:	Short specification basis, except 1st-Stage Booster Pump and Energy Recovery Device
2) Bulk material:	Similar facility ratio basis with Flow Sheet and layout
3) Civil and erection:	Local vendor hearing similar facility basis with equipment list, Flow Sheet and layout
4) Instrumentation:	Similar facility ratio basis with I/O numbers
5) Electrical work:	Similar facility ratio basis with single line diagram, motor list and layout

The cost estimation of the Water Transmission Facility is generally conducted using

1) pipe sections:	Short specification basis of size, length and material
2) pumping stations:	Short specification basis of capacity and head
3) reservoirs:	Short specification basis of size and material

(4) Base cost included

The base cost includes design, procurement and construction of sea water desalination facilities and water transmission facility with initial loading adsorbents/chemicals and 2 years of spare parts.

1) Sea water desalination facility

The base cost covers the following:

- itemized equipment
- piping from sea water intake to potable water delivery, and brine water discharge
- instrument and control system
- electrical facility including main-sub station
- civil work and foundations
- steel structure
- building
- insulation and painting
- underground piping

2) Water transmission facility

The base cost covers the following:

- water transmission line
- pumping stations with one pump spare and optical fiber connection of level indicators
- water reservoirs
- lighting, fence, building, gate

3) Others:

The following is also included in the base cost:

- overhead lines from the existing or planned power grid
- access road from main route (only for desalination facility in Calheta)
- telecommunication lines with the existing or planned lines

(5) Base cost excluded

The following as owner's cost are not covered:

- construction site purchased or rental cost
- legal and regulatory cost
- environmental impact assessment cost
- habitat resettlement cost
- financing and bond charge as well as interest during construction period
- training cost
- local duty and tax
- owner's cost for project development
- detailed design cost

4.2 Fund Plan

This project feasibility study is supposed to make an application to Japan's official development assistance (ODA) financing facilities, which are to support economic and social development in Cape Verde in line with the Japanese government's medium- and long-term ODA policy. The descriptions about the loan process such as project cycle, identification and preparation of project, and appraisal of Japan's ODA Loan are explained hereunder in article 4.6 and provided by the Operational Guidance for the Preparation of the Projects Financed by Japan's ODA Loans ("the ODA Loan Operational Guidance") published by JICA, formerly "JBIC" in June 2004.

In the present report, the F/S Project costs are examined and estimated by the JICA consultant, which is one of the most important elements of project appraisal to confirm whether it is suitable for ODA loan financing. The F/S Project cost estimation provided by this report shall be a basis of the financing plan and for financial and economic evaluation of the project.

4.2.1 Composition of Project Cost

The total project cost, in general, consists of various items and contains local and foreign currency components. Local components represent the costs of local product and labor procurement costs of the below mentioned items, whereas foreign component represents imported elements necessary for the project.

The project cost is broken down into the following items:

(1) Goods and services comprising plant structure, equipment, construction materials, construction machinery, labor, fuel, transportation, etc., excluding consulting services.
(2) Consulting services being estimated based on the assignment schedule for experts. The cost is broken down into remunerations and direct costs (equipment, training, etc.).
(3) Land acquisition and compensation especially for involuntary resettlement, infrastructure at the relocation site and for other environmental measures if the EIA study requires them.
(4) Other costs such as taxes and duties, initial operation and maintenance costs after project completion, administration expenses of the Executing Agency and interest during construction.
(5) Contingencies consisting of two types of contingency fund:
   (a) Price contingency is a provision for an increase in prices, which is determined based on the trend of related price indices.
   (b) Physical contingency is a provision for increase in physical works due to unforeseen factors depending on the nature of the project.

4.2.2 Japan's ODA Loan

The present report describes the estimated F/S Project cost for investment and necessary financial analysis to realize the project. To achieve this goal, the Government of Japan has facilities for ODA loans for developing country governments. Since 1966, the Government of Japan has provided concessional loans for developing country governments and government agencies to support social and economic development. The Government of Japan has been supporting their self-help efforts in development in a wide range of sectors, including power, agriculture, transportation and education, by providing long-term, low-interest loans for development projects and plans that are difficult to obtain financing for in the private sector.

4.2.3 Type of Applicable Loan

The Project loan can be applied for, which provides funds for facilities, materials and equipment, civil works, consulting services for the projects.

4.2.4 Terms and Conditions of Loans

(1) Interest Rates and Repayment Periods

The interest rates and repayment periods of ODA loans are determined by the Government of Japan. The Government of Japan applies preferential terms to specially designated sectors, such as the environment and human resource development, and a specific portion of the loans, such as consulting services. Special Terms for Economic Partnership (STEP) is currently being introduced to raise the visibility of Japan's ODA to the citizens of the recipient countries and Japan through utilizing and transferring the excellent technologies and knowhow of Japanese firms.

(2) Procurement Conditions

The Government of Japan determines procurement conditions of ODA loans on a case-by-case basis.

Regarding Japan's ODA Loan applicable to Cape Verde, the standard terms including those of STEP mentioned above are shown in the following URL:
http://www.jica.go.jp/activities/schemes/finance_co/about/standard/index.html

It is recommended to use Japan's ODA loan to alleviate the burden of interest payment and period of repayment. The conditions of STEP are very much interesting compared to Standard Yen Loans, while the Government of Japan requires a Tied condition for procurement of goods and services. The Japanese manufacturers of RO membranes are very popular and competitive in the worldwide business market.

4.2.5 Examination of Financing Plan

The Government of Japan examines whether the financing plan for the F/S Project is adequate in light of the F/S Project cost and the implementation schedule. The following items shall be checked by the Government of Japan:

(1) Schedule for annual fund requirements

To review the annual fund requirement schedule, attention must be paid to whether it is in line with the F/S Project implementation schedule, whether foreign and local currency requirements are appropriately estimated and allocated for each year and whether adequate contingency funds are allocated for each year.

(2) Budgeting

The funding arrangements being planned must be checked so as to ensure that costs which will not be covered by the ODA loan will be adequately funded from other financing sources, such as the national or local budget, the Executing Agency's internal funds, borrowings from commercial financial sources, or loans or grants from the prospective co-financing institution(s). The financial soundness and financing procedures of such sources must be studied so as to ascertain whether the funds required will definitely be available for the F/S Project.

(3) Re-lending

The government policy and relending mechanism must be ascertained to ensure that the Cape Verde government has its own policy and mechanism for domestic lending by the central government to government agencies, financial institutions, and public corporations, as well as the possibility of the foreign exchange risk which shall be born by the entity and the proposed terms and conditions of sub-loans.

4.3 Economics Study

In this study, the existing facility and firmly planned projects (5,000 m^3/d + 2 x 5,000 m^3/d) are excluded because those projects may be evaluated in those projects.

4.3.1 Pre-requisition

(1) Operation Company

The Plant is assumed to be operated by one independent company that is jointly established by the local government and/or SAAS, etc.

(2) Project schedule

The project schedule is assumed to be as in the following Figure 4.3-1.

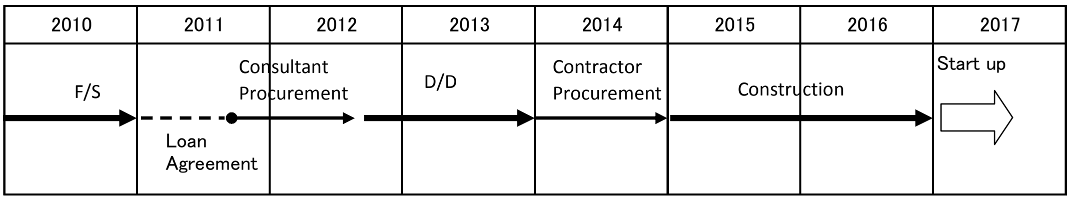


Figure 4.3-1: Project schedule

Source: Study team

(3) Project Life

20 years is set as project life

(4) Price inflation

The price and cost in August 2010 is applied in the calculation. Inflation in the future is considered for the FIRR calculation and in the total project cost.

(5) Currency

This study is calculated based on US dollars (US$).

The exchange rate between the Cape Verde Escudo (CVE) and US$ is set as follows:

US$ 1= CVE79.1 (based on exchange currency data in April 2010)

4.3.2 F/S Project cost

(1) F/S Project

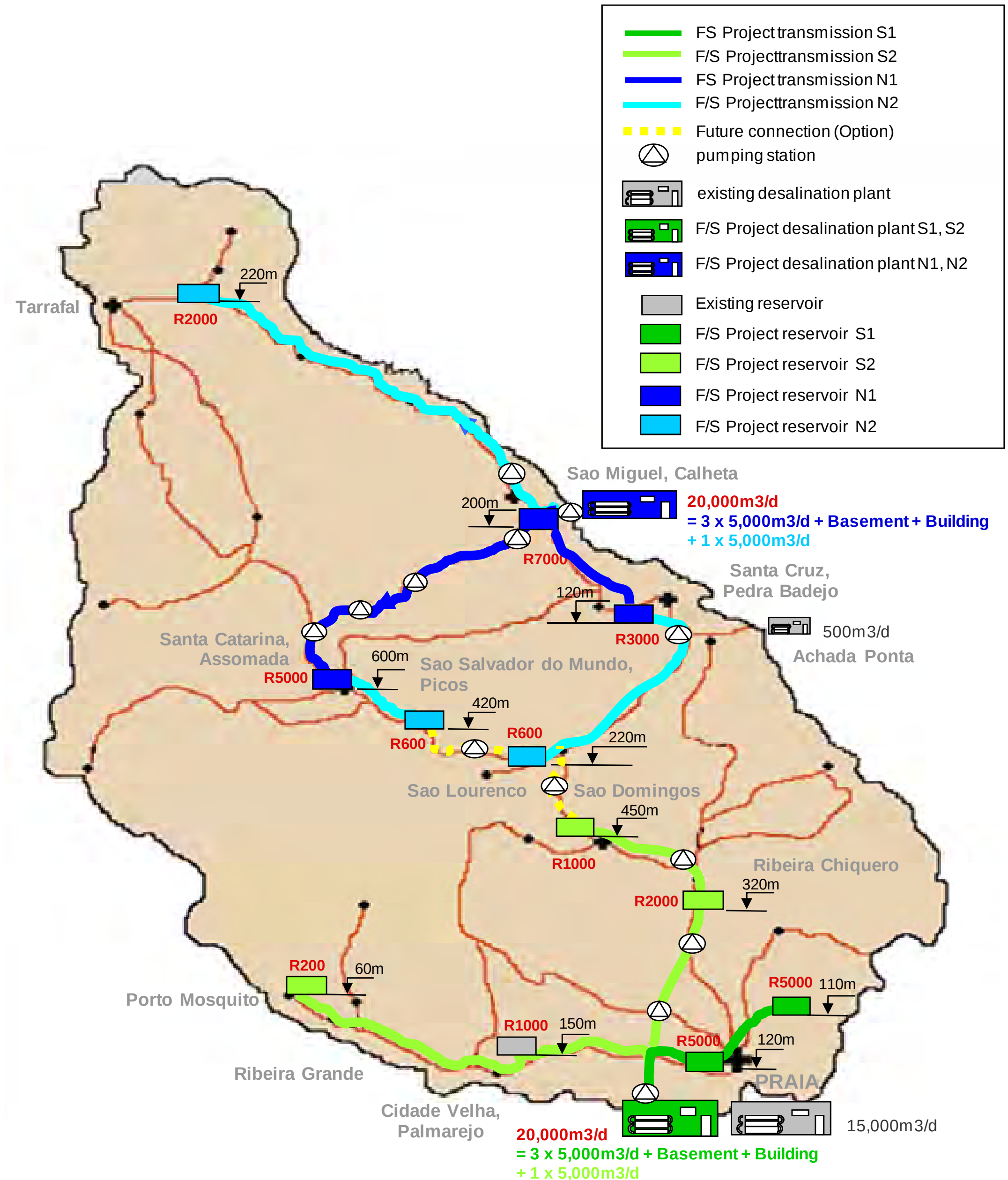
Projects are divided into the following 4 cases, which includes "S1", "S2", "N1" and "N2" cases. Each case includes the following plant and transmission pipeline and reservoirs. Refer to Table 4.3-1 and Figure 4.3-2.

Table 4.3-1: Project scope

Project Name	SWRO						Transmission and reservois	
	Location	Train capacity (m^3/d)	trains (unit)	Total quantity (m^3/d)	Civil work		Services Area	m^3/d
					Civil work, including equipment base	Building		
S1	Palmarejo	5,000	3	15,000	for all (4 trains)	for all (4 trains)	Praia	15,000
S2	Palmarejo	5,000	1	5,000	--	--	Ribeira Grande Sao Domingo	5,000
N1	Caliheta	5,000	3	15,000	for all (4 trains)	for all (4 trains)	Sao Miguel Santa Catarina Santa Cruz	15,000
N2	Caliheta	5,000	1	5,000	--	--	Tarrafal SS.Mundo Sao Laurence	5,000
Total				40,000				40,000

Source: Study team

CABO VERDE - Water Supply System of Santiago Island



Altitude levels are indicative
Pumps location and reservoirs locations are indicative

Figure 4.3-2: F/S Project location

Source: Study team

(2) Plant construction cost

Table 4.3-2 shows the SWRO (Sea water desalination RO) facility and transmission facility construction cost for each project. The total cost is US$134.5 million.

Table 4.3-2: Plant construction cost

Project Name	Service area	Project cost								
		Desalination				Transmission & Reservoir				(E) PC, Total
		Description	(E) PC			Description	(E) PC			
			million $	FC/LC ratio (%)			million $	FC/LC ratio (%)		
				FC	LC			FC	LC	
S1	Praia	itemized equipment	10.4	100	0	pipe section	2.7	70	30	
		bulk material	9.8	100	0	pump stations	1.7	60	40	
		civil and archtecture	5.3	30	70	reservoirs	2.5	60	40	
		erection	4.3	30	70	data transmission	0.3	100	0	
		others	4.8	70	30	others	0.4	70	30	
		contingency	1.7			contingency	0.9			
		Total	36.3			Total	8.5			44.8
S2	Ribeira Grande Sao Domingos	itemized equipment	2.2	100	0	pipe section	6.9	70	30	
		bulk material	1.4	100	0	pump stations	0.7	60	40	
		civil and archtecture	0.1	30	70	reservoirs	0.8	60	40	
		erection	0.6	0	70	data transmission	0.6	100	0	
		others	1.0	70	30	others	0.5	70	30	
		contingency	0.2			contingency	1.1			
		Total	5.5			Total	10.6			16.1
S1+S2			*41.8*				*19.1*			*60.9*
N1	Sao Miguel Santa Catarina Santa Cruz	itemized equipment	9.2	100	0	pipe section	7.9	70	30	
		bulk material	8.5	100	0	pump stations	5.2	60	40	
		civil and archtecture	4.8	30	70	reservoirs	3.8	60	40	
		erection	3.3	30	70	data transmission	0.8	100	0	
		others	4.0	70	30	others	1.0	70	30	
		contingency	1.5			contingency	2.1			
		Total	31.3			Total	20.8			52.1
N2	Tarrafal SS Mundo Sao Laurenco	itemized equipment	2.2	100	0	pipe section	11.8	70	30	
		bulk material	1.4	100	0	pump stations	0.5	60	40	
		civil and archtecture	0.1	30	70	reservoirs	0.8	60	40	
		erection	0.6	30	70	data transmission	0.6	100	0	
		others	1.0	70	30	others	0.7	70	30	
		contingency	0.2			contingency	1.6			
		Total	5.5			Total	16.0			21.5
N1+N2			*36.8*				*36.8*			*73.6*
Total			78.6				55.9			134.5

note: "(E)PC" stands for "(Engineering), Procurement, Construction"

FC: Foreign Currency (other than Cape Verde)
LC: Local Currency (Cape Verde currency)

Source: Study team

(3) F/S Project cost

The F/S Project cost is as per Table 4.3-3. Additional costs, such as the consultant fee, physical contingency, price escalation, etc., which are estimated to be 30% of the above plant construction cost (PC cost) in Table 4.3-2 are added to the F/S Project cost. Then the total F/S Project cost totals US$174.8 million. In Table 4.3-3, consultant fee for desalination facility is estimated by the experience of basic design in this F/S and similar project, with unit cost of 700 US$/man-day, which is referred to United Nations data etc.. Consultant fee for Transmission facility is 4% of construction cost.

Table 4.3-3: F/S Project Cost

Project Name	Service area	Project cost			Other Projkect cost : 30% of (E)PC cost								
		(E) PC, Desalination	(E) PC, Transmission & Reservoir	(E) PC, Total	Consultant fee, D/D, etc		Inflation, Contingency	Land	EIA	Training, etc	others	Total	Total Project Cost
		(mio $)	(mio $)	(mio $)	Desalination	Transmission & Reservoir	(mio $)	(mio $)	(mio $)	(mio $)	(mio $)	(mio $)	(mio $)
S1	Praia	36.3	8.5	44.8	3.5	0.3	6.7	1.0	0.1	0.3	1.5	13.4	58
S2	Ribeira Grande Sao Domingos	5.5	10.6	16.1	0.7	0.4	2.4	0.0	0.0	0.0	1.3	4.8	21
S1+S2		*41.8*	*19.1*	*60.9*	*4.2*	*0.7*	*9.1*	*1.0*	*0.1*	*0.3*	*2.8*	*18.2*	*79*
N1	Sao Miguel Santa Catarina Santa Cruz	31.3	20.8	52.1	2.8	0.8	7.8	1.0	0.1	0.3	2.8	15.6	68
N2	Tarrafal SS Mundo Sao Laurenco	5.5	16.0	21.5	0.7	0.7	3.2	0.0	0.0	0.0	1.9	6.5	28
N1+N2		*36.8*	*36.8*	*73.6*	*3.5*	*1.5*	*11.0*	*1.0*	*0.1*	*0.3*	*4.7*	*22.1*	*96*
Total		78.6	55.9	134.5	7.7	2.2	20.1	2.0	0.2	0.6	7.5	40.3	175

note: (E)PC : (Engineering), Procurement, Construction, D/D : Detail Design, EIA: Environment Impact Assesment

Note: Consultant fee (D/D) is estimated from the view point of one package project in all island, and tentatively divided it into each sub-project (S1,S2,N1,N2) accordingly. If each sub-project is implemented independently, these cost may increase

Source: Study team

(4) Total cost

Further to the above Table 4.3-3, additional costs which shall be borne by GoCV are estimated as per the following Table 4.3-4.

These costs consist of,

- Construction cost for existing desalination plant (5,000 m^3/day at Palmarejo)
- Construction cost for additional desalination plant #1 (5,000 m^3/day at Palmarejo, utilizing other funds)
- Construction cost for additional desalination plant #2 (5,000 m^3/day at Palmarejo, utilizing other funds)
- Additional distribution pipeline from reservoir to each house
- Others

Construction cost of exiting reservoirs and existing distribution pipeline are assumed to be already depreciated, therefore, these are not considered in this cost study. Additional construction costs for distribution pipelines in the future are estimated as per Table 4.3-4. A total of US$23 million is added. Then, “S1”, “S2”, “N1” and “N2” becomes US$68 million, US$25 million, US$74 million and US$31 million, respectively.

In this study, these costs are applied as total costs for delivery of potable water to each house or user point.

Table 4.3-4: Project cost including Cape Verde Government

Project name		Project Cost						Production capacity		
		F/S Project =SWRO+Trans mission+Other cost	by GoCV (Other than F/S project)				Total cost	F/S Project	by other fund (*note)	Total Production
			SWRO (*note)	Transmission pipe (in the past)	Distribution pipe (in future)	Sub Total				
Name	Service Area	million $	million $	million $	million $	million $	million $	m^3/d	m^3/d	m^3/d
by Others	*Praia*	-	*23*	*5*	-	*28*	*28*	-	*15,000*	*15,000*
S1	Praia	58	-	-	10	10	68	15,000	-	15,000
S2	Ribeira Grande Sao Domingo	21	-	-	4	4	25	5,000	-	5,000
N1	Sao Miguel Santa Catarina Santa Cruz	68	-	-	6	6	74	15,000	-	15,000
N2	Tarrafal SS.Mundo Sao Laurenco	28	-	-	3	3	31	5,000	-	5,000
F/S Projecct total		175	-	-	23	23	198	40,000	-	40,000
Total		175	23	5	23	51	226	40,000	*15,000*	55,000

(*note) The SWRO cost for others includes the existing 5,000 m^3/d, and additional new 2 units of 5,000 m^3/d SWRO.
Data base: Interview results from GoCV, etc.

Source: Study team

4.3.3 Financing required

(1) Total Capital Requirement

The total capital requirement shall be calculated by the following various costs shown in Table 4.3-5.

Table 4.3-5: Components of Total Capital Requirement

item	Reference
Project cost	Refer to 4.3.2
Pre-operational Expense	Refer to (2)
Interest during Construction (IDC)	Refer to (3)
Initial working capital	Refer to (6)

Source: Study team

(2) Pre-operational Expense (Owner's cost)

During the implementation phase of the project, the following expenditures are directly borne by the owners. They are recorded as deferred charges (assets) and will be depreciated according to their useful life, in this case, designated as 10 years.

1) New organization setting up costs (ex; registration fee, registration and license tax)

2) Financial costs (ex; stock or bond issue costs, discounts on bonds payable)

3) Start up costs:

a. New employee hiring and job training cost

b. Start up and commissioning cost

c. Chemical and electrical cost for trial plant operation

In this study, based on similar project data, around 1% of the construction cost is counted as pre-operational expense.

(3) Interest during construction (IDC)

The disbursement schedule is assumed as per Table 4.3-6 considered with the Project schedule shown in Figure 4.3-1.

Table 4.3-6: Disbursement schedule

Year	Year 1 (2015)	Year 2 (2016)
Investment ratio (%)	60%	40%

Source: Study team

IDC is calculated by the following formula:

$$IDC = (PC + IDC) \times L \times \{ d_1(1 + i)^{1.5} + d_2 (1 + i)^{0.5} - 1\}$$

PC: Plant construction cost

L: Loan ratio (85%)

i: Interest of long-term loan (1.4 %/year)

dn: Finance schedule of 85% loan (d1=60%, d2=40%)

(4) Physical contingencies expense

Contingencies for the plant construction cost are considered in the plant cost estimation.

(5) Import tax

Import material and/or equipment for this project are assumed to be exempt from import duties.

(6) Initial working capital

As for initial working capital, the following items in Table 4.3-7 are considered. Operating days per year are set to be 365 days (8,760 hours).

Table 4.3-7: Items for initial working capital calculation

(unit: million US$)

Item	S1	S2	N1	N2	reference
Product inventory	0.0	0.0	0.0	0.0	Product is continuously supplied to reservoir by pipeline.
Material inventory	0.0	0.0	0.0	0.0	Raw material (seawater from beach well) is continuously supplied to this facility by pipeline.
Accounts	4.1	0.9	3.9	1.5	60 days
Accounts	▲1.7	▲0.5	▲2.0	▲0.5	60 days
Total	2.4	0.4	1.9	1.0	

Source: Study team

4.3.4 Production and Sales plan

(1) Production and Sales plan

As per Chapter 3, the total required water capacity is 47,492 m^3/d (refer to item “C” in Table 3.1-10), and after considering 356 m^3/d (refer to item “j”) of seasonal additional demand, the necessary production capacity is calculated to be 47,848 m^3/d, the rounded figure is 48,000m^3/d.

Further, considering the leakage ratio in the distribution pipe network, etc., the necessary production capacity is 56,229 m^3/d (refer to item “E”). The existing and planned capacity is, in total, 15,000 m^3/d, then the necessary production quantity becomes 41,470 m^3/d. These figures are rounded as per Table 4.3-8 (item “D” in this Table). As a result, the necessary production capacity in this F/S Project is 40,000 m^3/d.

Table 4.3-8: Production and Sales Plan (unit: m^3/d)

Project name			F/S Project				by Other fund (rounded number)		
Name	Service Area	Population, in 2020 (persons)	Delivery (Sales) = Production - Leakage	Leakage = Production x 15%	Production: Delivery + Leakage	Production: Round figure	Delivery	Leakage = Production x 15%	Production
			A	B = C x 15%	C = A + B	D = rounded "C"	E	F	G
by other fund	Praia	157,978					*13,500*	*1,500*	*15,000*
S1			13,500	2,382	15,882	15,000	-	-	-
S2	Ribeira Grande Sao Domingo	28,893	3,000	529	3,529	5,000	-	-	-
N1	Sao Miguel Santa Catarina Santa Cruz	115,560	13,000	2,294	15,294	15,000	-	-	-
N2	Tarrafal SS.Mundo Sao Laurenco	52,888	5,000	882	5,882	5,000	-	-	-
Total (S1+S2 +N1+N2)		355,319	34,500	6,088	40,588	40,000	-	-	-

Source: Study team

(2) Sales price

Table 2.6-1 shows Electra's sales tariff which is equivalent to the tariff for Praia citizens in 2008, and Table 2.6-3 shows each SAAS' tariff. As reported in sect. 2.7.1 and sect. 2.7-2, the average consumption per month in each household is 6 m^3. The tariffs in this range in each area are listed up as per Table 4.3-9.

Table 4.3-9: Sales price

Area		South					North									
Project name		S1	S2			South total	N1				N2				North total	Total
Municipality		Praia	Ribeira Grande	Sao Domingos	Average		Sao Miguel	Santa Catarina	Santa Cruz	Average	Tarrafal	SS do Mundo	Sao Lourenco	Average		
Tariff in 2008, consumption range of 6m3/month	*CVE.m3*	***333***	*354*	*280*	***309***	*331*	*280*	*120*	*280*	***198***	*134*	*310*	*150*	***175***	*192*	***279***
	US$/m3	*4.2*	*4.5*	*3.5*	*3.9*	*4.2*	*3.5*	*1.5*	*3.5*	*2.5*	*1.7*	*3.9*	*1.9*	*2.2*	*2.4*	*3.5*
Sales quantity in 2020 (m3/d)	Normal	26,987	1,033	1,600		29,620	2,266	6,490	3,987		3,015	1,098	1,015		17,871	47,491
	Peak	237	10	10		257	10	49	20		20	0	0		99	356
	Total	27,224	1,043	1,610		29,877	2,276	6,539	4,007		3,035	1,098	1,015		17,970	47,847
			2,653				12,822				5,148					
	Round Figure	**13,500**	**3,000**			(30,000)	**13,000**				**5,000**				(18,000)	**34,500**
	by Others	13,500														

USD 1 =	79.1 CVE		
Praia area	333 CVE/m3=	4.2	USD/m3
Other Praia	207 CVE/m3=	2.6	USD/m3

Source: Study team

Also, according to a social survey (questionnaire), people are ready to accept a tariff increase if the tap water service is improved. The survey results are introduced in Section 2.7; people outside of Praia currently pay 207 CVE/m^3 but will accept 200-350 CVE/m^3, which is equivalent to 0.97-1.69 times of the tariff in 2008.

In this study, considering that the average tariff in the entire island was 279 CVE/m^3 (= US$3.5) in 2008, and an acceptable tariff increase is US$3.4-5.9/m^3 in the future, then US$5/m^3 is set as a base rate.

4.3.5 OPEX related

4.3.5.1 Variable cost

Major items related to variable costs are utility, membrane replacement and chemicals. Detailed consumption quantity/volume is mentioned in Section 4.1.

Unit cost is determined from in-house data.

(1) Utility (Electricity)

Due to the fact that plants adopt the membrane process, the major utility is electricity.

According to the Electra, the tariff of electricity for medium voltage in 2009 was announced as per Table 4.3-10. Based on this tariff table, the electricity cost per kWh in this scale of project is calculated to be around 21 CVE/kWh (=US$0.265/kWh).

Table 4.3-10: Tariff for medium voltage in 2009

Tariff	Fixed tariff (CVE/kW/month)	Proportional tariff (CVE/kWh)
	279.96	20.48

Source: Electra

Electricity consumption in this project is summarized in Table 4.3-11. Note that electricity for the distribution network from reservoirs to each house/use point is not considered because water is transported by gravity.

Table 4.3-11: Electricity cost

Project	Production quantity (m^3/day) (m^3/h)	Consumption (kWh/hr)		
		SWRO (4.7 kWh/m^3)	Transmission	Total
S1	15,000 (625)	3,104	1,110	4,214
S2	5,000 (208)	979	365	1,344
N1	15,000 (625)	2,938	2,015	4,953
N2	5,000 (208)	979	210	1,189
Total	40,000 (1,666)	8,000	3,700	11,700

Source: Study team

(2) Membrane

In this study, 20% of seawater RO membrane and 15% of brackish water RO membrane are assumed to be replaced every year, and the total cost is calculated as per Table 4.3-12.

Table 4.3-12: Membrane cost

Project	Trains	Annual Replacement (pcs)	US$/$m^3$ (note)
S1	3	303 (1st) + 96 (2nd)	0.058
S2	1	101 (1st) + 32 (2nd)	
N1	3	303 (1st) + 96 (2nd)	
N2	1	101 (1st) + 32 (2nd)	
Total	8	808 (1st) + 256 (2nd)	0.058

Source: Study team

For calculation purposes, the initial cost of the loaded membrane and refill for replacement cost during operation is counted as follows:

Initial cost: included in construction cost in Table 4.3-2

Refill cost: included in maintenance cost in Table 4.3-12

(3) Cartridge filter

In total, cartridge filter cost is estimated from market price data as US$0.011/$m^3$.

(4) Chemical

The type and consumption quantity of chemicals is mentioned in Section 4.1. The unit cost of each chemical is determined by market data and estimated in total to be US$0.027/$m^3$.

4.3.5.2 Fixed cost related

(1) Personnel cost

The unit cost of each category is determined by the information from GoCV and similar project data as per Table 4.3-13.

Table 4.3-13: Personnel cost

Project	Production quantity (m^3/d)	SWRO Plant	Transmission	Total	Average US$/person/year
S1	15,000	13	15	28	10,000
S2	5,000	0	2	2	
N1	15,000	11	15	26	
N2	5,000	0	2	2	
Total	40,000	24	34	58	10,000

Source: Study team

(2) Maintenance cost

The in-house data is employed for the maintenance costs.

0.5% of desalination facility construction cost and 3% for transmission facility cost are allocated as the costs for usual maintenance services.

Salary for maintenance staff is counted in the above personnel costs.

(3) Sales expense and general affairs cost

In this scenario, all of the product water shall be used by habitants, etc. Therefore, wide-scale sales work is not necessary for this special company, which means sales expenses are not large. From the similar project data, 2% of the sales amount, including other general affairs costs, is allocated to this study.

4.3.6 Taxation system

(1) Tax general

All taxes and duties, including, but not limited to, corporate income tax, business license tax and customs duties that might be added on to the EPC cost, are not considered in this study.

(2) Corporate income tax

In this study, the corporate income tax rate is set at 20%, and tax exemption is not applied.

(3) Depreciation allowance

The plant construction costs shall be depreciated in the following manner:

1) Manner of depreciation : Straight-line method
2) Salvage value : Zero
3) Service life : Process plant - 20 years
   Utility and ancillary facilities - 20 years

The construction costs incurred prior to the operation and interests during the construction shall be evenly depreciated over 20 years.

4.3.7 Operational fund

(1) Stock of the Product

The product (potable water) is planned to be continuously supplied to municipality reservoirs by pipeline. A product water tank will be prepared at the desalination plant site, but the idea of stock will not be adopted.

(2) Settlement of the account

Both settlement conditions for accounts payable and accounts receivable are set up in the same period of 60 days.

4.3.8 Fund arrangement

In this study, the following arrangement is assumed:

(1) Debt / Equity ratio

85% of required funds is prepared by a loan, and the remaining cost is covered by the project owner's private fund.

(2) Fund schedule

According to the construction schedule, 60% is paid in the 1st year and the remaining 40% is in the 2nd year. It is not considered that required payment is firstly from the owner's fund (equity), and secondly from a loan because of low interest rates.

(3) Long-term loan conditions

a) interest : 1.4% (Japanese yen loan)

b) repayment : 25 years (initial 7 years exempt)

4.3.9 Analysis of Economics of the Project

4.3.9.1 Analysis method

Based on the above prerequisites, the economics of the project using the DCF (Discount Cash Flow) method-based Financial Internal Rate of Return (FIRR) have been analyzed.

4.3.9.2 Results of study

(1) FIRR at Base case

FIRR is as per Table 4.3-14.

This figure is based on the sales price of the product water at US$5.0/$m^3$, but in future, if this price is discussed among related bodies and a different price is decided upon, this FIRR may be changed accordingly.

Tariff sensitivity is shown in paragraph (3).

Table 4.3-14: IRR at Base Case (FIRR)

Project		S1	S2	N1	N2
Production Capacity (m^3/day)		15,000	5,000	15,000	5,000
Sales Capacity (m^3/day)		13,500	3,000	13,000	5,000
Total Capital Requirement	(million US$)	72.0	26.0	77.6	32.7
Plant construction cost	(million US$)	68.0	25.0	74.0	31.0
Others	(million US$)	4.0	1.4	2.6	2.1
Sales	(million US$/year)	24.6	5.5	23.7	9.1
Direct cost (note)	(million US$/year)	11.5	3.7	13.6	3.6
Gross profit	(million US$/year)	13.1	1.8	10.1	5.5
FIRR, before tax	(%)	16.2	2.8	10.9	14.7
FIRR, after tax	(%)	13.6	2.5	9.2	12.4
Benefit population	(thousand person)	67	29	116	53

Note: Total benefit population: 265,000 person

Source: Study team

(2) Cash flow analysis at base case

DSCR (Debt Service Coverage Ratio), calculated from the following formula, is used as an index for judging the long-term debt-paying ability

$$\text{DSCR}=\frac{\text{Profit after tax + Depreciation \& Amortization + Interest on long-term loan}}{\text{Repayment on long-term loan + Interest on long-term loan}}$$

When the ratio of debt is 85%, with a sales price at US$5/$m^3$, DSCR is calculated as per Table 4.3-15.

From the table, these finance schemes, except project “S2”, are concluded to be healthy, because DSCR is always over one (1).

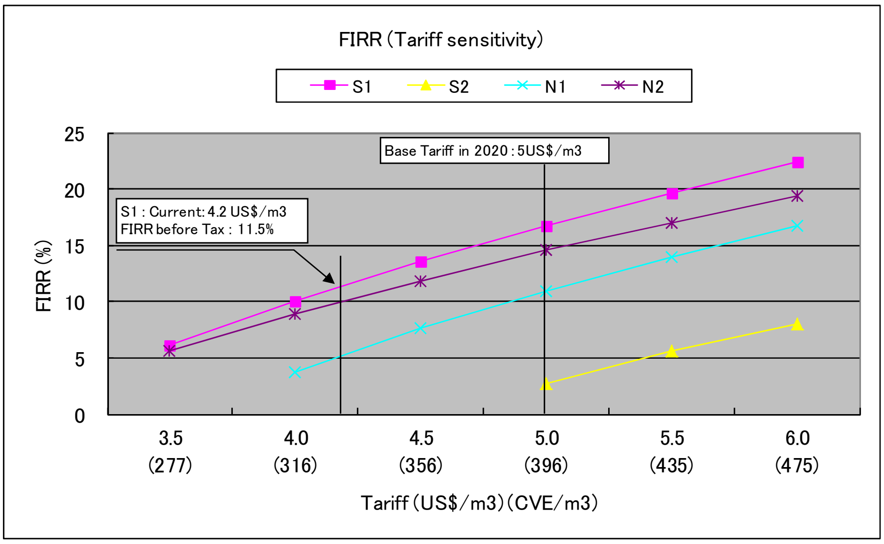
Table 4.3-15: DSCR (Unit: times)

year	S1	S2	N1	N2
1st year (2017) -- 7th year (2023)	-	-	-	-
8th year (2018)	2.68	1.11	2.25	2.48

Source: Study team

(3) Sensitivity Analysis

The variation effect of F-IRR before tax on the water tariff is shown in Figure 4.3-3. The current tariff is shown in Table 4.3-9.



Source: Study team

Figure 4.3-3: Tariff sensitivity

(4) OPEX-oriented costs

Table 4.3-16 shows the estimated cost for operation of the desalination facility and transmission pipeline, which does not include depreciation, interest for loan, and suitable profit, etc. In the case where the construction cost is subsidised by GoCV, this operation cost, as shown in Table 4.3-16, plus suitable profit, shall be used for the study on a potable water tariff.

Table 4.3-16: Rounded Operation Cost

Project Name	Production capacity	Average Tariff, in 2008	Electricity	RO membrane	Cartridge filter	Chemical	Manpower	Maintenannce material etc	Total	
	m^3/day	CVE/m^3 (US$/$m^3$)	US$/year	US$/year	US$/year	US$/year	US$/year	US$/year	US$/year	USD/m^3
S1	15,000	**333 (4.2)**	9,400,000	320,000	60,000	150,000	280,000	400,000	10,610,000	**1.9**
S2	5,000	**309 (3.9)**	3,100,000	110,000	20,000	50,000	20,000	350,000	3,650,000	**2.0**
S1+S2	*20,000*	*331 (4.2)*	*12,500,000*	*430,000*	*80,000*	*200,000*	*300,000*	*750,000*	*14,260,000*	***2.0***
N1	15,000	**198 (2.5)**	11,500,000	320,000	60,000	150,000	260,000	800,000	13,090,000	**2.4**
N2	5,000	**175 (2.2)**	2,800,000	110,000	20,000	50,000	20,000	500,000	3,500,000	**1.9**
N1+N2	*20,000*	*192 (2.4)*	*14,300,000*	*430,000*	*80,000*	*200,000*	*280,000*	*1,300,000*	*16,590,000*	***2.3***
Total	40,000	279 (3.5)	26,800,000	860,000	160,000	400,000	580,000	2,050,000	30,850,000	**2.1**

Note: This table does not include construction cost of seawater desalination plant, transmission pipeline, and suitable profit for the operation company.

Source: Study team

4.3.10 Economic analysis

In this section, from view points of social development and infrastructure improvement, economic by this F/S Project to the Republic of Cape Verde is reviewed and studied. Following items are assumed to be benefit and expenditure in this study.

Expenditure:

- Total investment cost (refer to sect.4.3.2)
- Operation and Maintenance cost for the facility

Benefit:

- Release from working time for water collection from reservoir to their houses
- Activation of agriculture industries by increase use of underground water
- Decrease of medical expenditure by improving sanitary conditions

(1) Release from water collection work, and increase the opportunity to join the other social job

Currently, water collection from nearest water reservoir to their home is mainly done by women and children. After completion of distribution pipeline network to each household, especially womem will be released from these water collection work. The benefit is assumed and calculated as follows.

Average working time

Average consumption per person per day : 20-30 litter/day/person

Average consumption per family per day : 100-150 litter/day/family (person per family : 5)

Average working time : 2-3 hrs/day (= 20 litter/time) x (5 – 8) times x 20 minutes/time)

Working cost

ILO report that average income or salary per women (age: 15-64 year-old) is 90,450 CVE/year/person.

Population of women in 15-64 year-old : 158,000 person (ILO data)

Working women : 57% of same age (ILO data)

If these women change to other general job from water collection work, total benefit is estimated as follows.

158,000 x 57% x 90,451 CVE x (2hrs/8hrs) = 2 million CVE/year (= 0.025 million US$/year)

(2) Use of underground water to agriculture

The Cape Verde has enough agricultural land (8,600 ha), but due to shortage of water, only 1/3 (3,000ha) is used for this purpose, and as the result, around 9% of GDP (144 million $ (= 1,600 million $ x 9%)) is used for importing food from other countries.

Data base: www.nationsencycopedia.com/economies/Africa/Cape-Verde-Agriculture)
http://en.wikipedia.org/wiki/Economy_of_Cape_Verde,

From above figure, 72 million $ is calculated for the Sanchago island where 50 % of population live. Also table 2.5-1 shows usage of water resopurces in Cape Verde in year 2007, then samtiago island is estimated as follows.

For household	: 11,300,000 m^3/year (Santiago islant: 5,700,000 m^3 /year)
For tourism	: 300,000 m^3/year
For industries	: 2,900,000 m^3/year
Sub total	*: 14,500,000 m^3/year(Santiago islan: 7,300,000 m^3 /year)*
Desalinated water	: 2,900,000 m^3/year
	(=5,000+2x1,200+500 = 7,900 m^3/day x 365 days/year)

Underground water for drinking water use: 4,400,000 m^3/year (= 7,300,000 - 2,900,000)

Also table 2.5-a shows 32,700,000 m^3/year (Snatiago island is estimated to be 16,400,000 m^3/year) underground water is used for agriculture.

Therefore, after completion of this F/S project, increase of agriculture production, around 25% (=4,400,000÷16,400,000), is expected.

This is equivalent to around 18 million $ /year (1,400 million CVE/year) (= 72million $ x 25%)

(3) Decrease of medical expendeiture by improving sanitary conditions

By connection with tapwater pipeline and start to supply better quality and enough quantity of water, people can enjoy well sanitated life, then it is expected that desease which caused by water contamination, etc., will be decreased. As the result medical expenditure is expected to be decreased.

According to the annula report in year 2008 by Ministry of Health, 15,863 personss were hospitalized for treatment, and 11,954 persons (75% of total) were caused by water quality.

Further WHO reports that 5.6% of GDP was medical expenditure in Caape Verde in year 2006. Then, if this trend continued up to year 2008, around 90 million $ (=GDP 1,600 millon $ x 5.6%) is estimated, and one half of which was in Santiago island. i.e 45 million $ is in

Santiago island

If ratio of hospital related expenditure to total medical expenditure is estimated to be 50%, around 17million $ (= 45million $ x 50% x 75%) is obtained.

As per above (2), total water for household (5,700,000 m^3/year) is from desalinated water (2,900,000 m^3/year) and underground water (2,800,000 m^3/year). Ration is alomost 50%/50%.

Then expected decrease of medical expenditure is calculated to be around 8 million $/year (=17million$ x 50%) (= 600million CVE/year).

(4) Total increase of economic income by this F/S project

In case of "Base case", total 63 million $/year (5,000 million CVE/year) of income is expected.

(5) Other related benefit

If seawater desalination plant is constructed at Palmarejo, Sao Miguel, working opportunity in Northern area may increase. Further for keeping spare parts for the plant, infrastructure for material storage/delivery etc, may be improved. If people become familiar with RO membrane desalination technology, people may study to use small type of desalination equipment for various usage, such as special agriculture purpose like Canary island in Spain (refer to section 2.9) which may creates new type of agriculture.

With regards to tourism industry, improvement of water quality and capacity is helpful for the development of hotel industries. And decreasing of women's water collection time makes women increase leisure time and/or education time which may develop these industries.

But in this study, these indirect benefit are not considered.

(6) EIRR

From above estimations, total economic impact is calculated to be around 89 million $ /year (7,000 million CVE/year), where total expenditure (except tax) is assumed to be the project cost of F/S and agricultural production cost. EIRR, with 20 years project life, is calculated to be 19.2%.

4.3.11 Project index

(1) Quantitative impact

Quantitative impact by this F/S project is as per table 4.3-17.

Table 4.3-17: Quantitative impact

item	When F/S started（2007~2010）	When completionof F/S project (2020 expected)
Total population	295 thousand person (2010 estimated)	355 thousand person
Total benefit population by this F/S project	0	265 thousand person
Water supply capacity	31,000 m^3/day (included seawater desalinated water: 5,000 m^3/day)	55,000 m^3/day (All are seawater desalinated water. 15,000 m^3/day are already existed and will be constructed by other fund)
Non Revenue Water ratio	24% (in 2007)	15%
Tapwater pipe connection ratio	48% (in 2007)	95%
Supply water(l/day/person)	Urban with pipe connection: 100 Urban with pipe non-connection: 25 Rural with pipe connection: 50 Rural with pipe non-connection:25	Urban with pipe connection: 150 Urban with pipe non-connection: 50 Rural with pipe connection: 80 Rural with pipe non-connection: 50

(2) Project benefit

As per 4.3.10, following benefit are expected by this F/S project.

1) Increase of social productionopprtunity by releasing women fromwater collection work (For EIRR calcculation, 2 million CVE of benefit is estimated)

2) Increase of agriculture production by increasing usage of underground water (For EIRR calcculation, 1,400 million CVE of benefit is estimated)

3) Decrease of medical expenditure by improving water quality (For EIRR calcculation, 600 million CVE of benefit is estimated)

4.3.12 Summary of Project Economics

From the above study, the following conclusion was reached.

(1) Summary of profitability study

Based on the above study, S1 shows the highest financial result, with a total capital requirement of US$72.0 million, and achieves an FIRR of 16.7% at a base tariff of US$5/$m^3$;

even with a current tariff of US$4.2/m^3, an FIRR of 11.5% is achievable. Further DSCR (Debt Service Coverage Ratio) for the 1st year of repayments and years afterward also show more than one (1), which means healthy cash flow. Other projects also show profitable FIRR and healthy cash flow (DSCR) at the base case.

(2) Tariff of potable water

The sales price is set up only based on the current tariff of potable water. In this study, all cases show healthy financial economics when the base case is applied, but if people cannot accept this base case tariff, the idea of a subsidy is recommended to be applied by the GoCV.

Table 4.3-16 is prepared for such discussion.

(3) Economic impact

EIRR of this F/S project is estimated 19.2%, which is also feasible for the Republic of Cape Verde

4.4 Implementation Planning

4.4.1 Purchase & Construction Planning

(1) Construction Location & Present Condition of Site

As per the description of Section 4.1.2, two (2) water desalination facilities will be constructed at Palmarejo in the south and at Calheta in the north, and water transmission facility will be constructed across Santiago Island. The construction location and its present condition are described.

1) Palmarejo

The new desalinization facility is proposed to be to the north-east of the existing desalination plant in the area of ELECTRA power and water works as shown in Figure 4.4-1.

Source: Study team

Figure 4.4-1: Proposed Location of new desalination facility at Palmarejo

Site condition:

The required building area is around 60m x 40m, on a stable layer of igneous rocks, partially with basalt. The area will be required to be graded by heavy construction equipment as half of the area is covered with igneous rock slopes.

Proposed layout;

a. The intake pipe header will run to the north-east of the proposed plant area; there will be 9 wells at 20m intervals.

b. The discharge pipe for brine will also run to the north-east of the proposed plant area. As the pipe will run beyond the intake pipe, the discharge outlet will be installed on the opposite side across the ledge.

2) Calheta

The new desalinization plant is proposed to be to the south of downtown Calheta de São Miguel, approximately 1.0km along the road, near the junction with the Assomada bypass as shown in Figure 4.4-2.

Source: Study team

Figure 4.4-2: Proposed Location of New Desalination Facility at Calheta

Site condition;

The proposed area is a barren field with sporadic bushes and no artificial structures. It seems the area is also stable due to igneous rocks, slightly covered with loose soil. The area might be required for grading for site preparation.

Proposed layout;

a. The intake pipe header will run to the south-east of the proposed plant area along the coast; there will be 9 wells at 20m intervals.

b. The discharge pipe for brine will run to the north-west of the proposed plant area along the coast; the discharge outlet will be installed in the water.

(2) Transportation of Equipment and Materials

The site in both Palmarejo and Calheta has relatively good road access. Equipment for the F/S Project will be off-loaded at Praia port then delivered to each proposed site.

Figure 4.4-3: Birds-eye view of Praia Port

Praia port is the only commercial port in Santiago Island equipped with a warehouse/cold warehouse/cargo area and other ancillary facilities. A mobile crawler crane (apparently 150t class) and forklifts are available for cargo handling but currently no overhead gantry crane is available at the port.

The distance along the most accessible road from Praia port to Palmarejo and Calheta is approximately 10km and 45km, respectively. The road conditions to Palmarejo are fair; however, the same road to Calheta is just acceptable with some stone pavements. During the survey no heavy traffic/blockage was confirmed along the road.

(3) General Construction Planning

1) Site Preparation

a) Palmarejo

Site grading is required. Some part may require blasting due to hard igneous or basalt rocks. No piling work will be required as the area is covered with rocky ground.

b) Calheta de São Miguel

Minor grading of the site will be required. No piling work will be required as the area is covered with rocky ground.

2) Boring of well

The boring of a well can be performed only by a specialized drilling contractor. It has been confirmed that there is one local contractor in Cape Verde who is famous among local general contractors.

3) Water transmission line installation

All transmission lines will be installed along with the existing road of either stone pavement or asphalt pavement. There will be no technical difficulty for line installation but traffic restrictions and material under the road may hinder the smooth progress of installation work, which may need to be checked in detail at the detailed design stage.

4) Reservoir construction

The areas for all reservoirs are near the existing road. Dedicated access may need to be established, then site cleaning may be required to start construction work.

5) Building construction

There will be no technical difficulties for building construction for the desalination facility. The delivery period of desalination equipment should be monitored to meet the construction schedule.

6) Water tank construction

A steel structural water tank for product water may be recommended for constructability and operability. A concrete tank is also acceptable due to the limited site area. There will be no technical difficulties.

7) Intake pipe header / Discharge pipe installation

a) Palmarejo

The intake pipe head will run across the heights in a suspended condition. The route must be closely checked and selected to be the most economical.

b) Calheta de São Miguel

The intake pipe head and discharge pipe will run along the ground. The route must be closely surveyed in the future phase.

(4) Local Contractor

Seven local contractors in Santiago Island were interviewed for their capability and ability regarding the proposed F/S Project. It can be concluded that the F/S Project scope need not to be sublet to a foreign contractor in terms of technical matters. Schedule, quality and safety issues should be controlled or monitored by the foreign prime contractor.

The local contractor information is summarized in Table 4.4-1.

Table 4.4-1: Local Contractor Information

ID	Name	Address	Tel	Fax	Foundation	Paid up capital (€)	Net Sales (€)	Permanent Staff	Split of scope
1	**SGL**	Rua Cidade Funchal, n°. 16 R/C-1° andar Achada de Sto Antonio C.P. n°452/C - Praia City, Republic of Cape Verde	+238-262 6383	+238-262 4828	Janurary 2002	9,069,008	13.150M(2009) 17.438M(2008) 19.951M(2007)	N/A	To be split with others
2	**Sogei**	Caixa Postal 426/A, Edificio Aguia, R/C Cha de Areia, Praia, Cape Verde	+238-260 2200	+238-262 7490	May 2007	907,000	6.230M(2009) 0.480M(2008) 0.172M(2007)	29	To be split with others
3	**CVC**	Achada Grande, Apartado 242 Praia República de Cabo Verde	+238-263 3879	+238-263 3221	July 1990	2,633,655	21.033M(2009) 23.893M(2008) 21.084M(2007)	110	not necessary to split
4	**MonteAdriano**	Rua Ilha de Maio, 1-2°Esq. C.P.859 Palmarejo, Cidade da praia - Cabo Verde	+238261 1173	+238261 1122	November 2003 1940(Pt HQ)	453,453	19.419M(2009) 14.882M(2008) 9.896M(2007) (CV only)	293 (incl. 25 Portuguese)	not necessary to split
5	**Engeobra**	Zona Industrical Tira-Chapéu -C.P.N° 902 Praia, Cabo Verde	+238-262 6030	+238-262 3775	June 1993	453,453	4.453M(2009) 8.298M(2008) 7.708M(2007)	N/A	not necessary to split
6	**Empreitel Figueiredo**	Achada Grande, C.P.70, Praia	+238-263 3954	+238-263 3660	November 1983	453,453	4.818M(2008) 3.904M(2007) 3.796M(2006) 2.712M(2005)	76	To be split with others
7	**MSF**	Rua Frederico George N° 37 Alto da Faia 1600-468 Lisboa Portugal	+351-217 213 500	+351-217 213 599	N/A	N/A	N/A	N/A	To be split with others

Source: Study team

(5) Construction Material

Most of the construction raw material is imported from foreign countries. Therefore, it may be recommended that the supply of material supply will be in local contractors' scope.

1) Sand / aggregate / rock

There is only one quarry in Santiago Island, located in the Santa Cruz region, which is under operation by Monte Adriano, the private local infrastructure contractors. Therefore, raw material and concrete products are available within Santiago Island itself.

2) Cement

It was confirmed that the cement raw material will be imported from foreign countries, then bagged in Santiago Island.

3) Structural steel

It was confirmed that the structural steel will be imported from foreign countries, then distributed within Santiago Island.

4) Water Transition pipe

It was confirmed that the material for the water transition pipe, ductile and HDPE will be imported from foreign countries, mainly from Europe.

(6) Construction Labor

During the meeting with local contractors, it was confirmed that labor in Cape Verde is normally available from domestic resources. In case some shortage of manpower arises, additional labor can be sourced from Senegal. Therefore, labor for construction should be no problem.

(7) Construction Equipment

It became clear through the number of interviews with local contractors that no construction equipment needs to be brought into Cape Verde from abroad. The arrangements for this equipment shall be put into the scope of work for local construction contractors..

4.4.2 Implementation Schedule

(1) Construction Schedule

First, the construction works bill of quantity (BoQ) summary for this F/S Project is estimated as the following Table 4.4-2.

Table 4.4-2: Bill of Quantity Summary

No.	Description	North (Calheta)	South (Palmarejo)	Total
1	Transition lines linear Inch-Kilometer	1,215	498	1,713
2	Number of sea water intake wells	9	9	18
3	Number of brine discharge lines	1	1	2
4	Site Preparation volume (m^3)	1,200	6,000	7,200
5	Pumping Stations (points)	7	6	13
6	Reservoirs (number/volume)	6/18,200	5/13,200	11
7	Building (m^2)	2,712	2,400	5,112

Source: Study team

The critical point during the construction will be for the transmission line installation works, as this work involves coordination with public traffic, a moving construction site and precise logistics. Several installation teams will need to work simultaneously at different points to facilitate the progress of installation work.

Considering the overall time schedule and work volume, the construction team for the water transmission facility will be assumed to be multiple teams as listed in Table 4.4-3.

Table 4.4-3: Construction Team for Water Transmission Facility

Work	Area	Municipalities concerned	Number of Teams	Construction Period (Months)
N1	Northern Area 1	Sao Miguel, Santa Catarina, Santa Cruz	2	9
N2	Northern Area 2	Tarrafal, San Salvador Do Mundo, Sao Lorenco	3	9
S1	Southern Area 1	Praia	1	6
S2	Southern Area 2	Sao Domingo, Ribeira Grande, Port Mosquito	1	12

Source: Study team

The construction schedule is tentatively developed as Table 4.4-4.

Table 4.4-4: Expected Construction Schedule

DESCRIPTION		YEAR	Year 1												Year 2												Year 3											
		Calendar Mth	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
		Project Mth	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
GENERAL SCHEDULE		Construction Team No.	Contractor Procurement												Construction																							
North Area																																						
N1	Desalination Facility Construction and Installation																																					
N1	Water Transition Facility Construction	2 teams																																				
N2	Desalination Facility Installation																																					
N2	Water Transition Facility Construction	3 teams																																				
	Commissioning																									N1◆												N2◆
South Area																																						
S1	Desalination Facility Construction and Installation																																					
S1	Water Transition Facility Construction	1 team																																				
S2	Desalination Facility Installation																																					
S2	Water Transition Facility Construction	1 team																																				
	Commissioning																									S1◆												S2◆

Source: Study team

4.4.3 Project Risk

Project risk and its countermeasure for the Project are summarized in Table 4.4-5.

Table 4.4-5: Risk Evaluation Summary

		Risk Occurrence Possibility			Risk Description	Countermeasure
		low	medium	high		
Technical						
	Capacity	✓				
	Sea Water Specification	✓				
	Potable Water Specification	✓				
	Water Transmission		✓		unforseen obstacle or soil condition	route change will be discussed
	Power Supply		✓		emergency failure	emergency generator will be installed
	Beach Well Water		✓		water volume decreasing	another well will be newly digged
	Regulation	✓				
Commercial						
	Funding	✓				
	Yen Loan	✓				
	Market	✓				
	Inflation	✓				
	Concession	✓				
Environment						
	Regulation	✓				
	Permission	✓				
	Natural Conditions	✓				
	Social Consideration	✓				
others						
	Policy	✓				
	Human Resources	✓				
	Construction Site	✓				
	Operation		✓		operation material shortage	material will be purchased
	Maintenance		✓		maintenance material shortage	material will be purchased
	other projects impact	✓				

Source: Study team

Operation and maintenance issues including human resource availability, working capital, water tariff fluctuation, and/or water tariff collection might be risks after the water supply system put in service, however those risks could be reduced or avoided by the proper counter measures.

4.5 Necessary F/S Project Implementation Procedure

The Necessary Procedure for Implementation of the F/S Project is described in this article according to Japan's ODA loan project cycle. The project cycle is similar to other donors with some exceptions. When the Cape Verde Government applies for a Japanese ODA loan for the project, it shall follow a sequence of standard procedures as follows 1) Project Identification, 2) Preparation, 3) Appraisal and Ex-ante Evaluation, 4) Prior Notification and Exchange of Notes, Loan Agreement, 5) Project Implementation and Supervision, 6) Ex-post Evaluation and Monitoring after Project Completion. Each step of the project cycle is summarized below and more detailed information can be acquired through "The Operational Guidance for the

Preparation of the Projects Financed by Japan's ODA Loans"[1] issued by JICA, which contains a flow chart to allow the Borrower to more easily understand the necessary sequential steps.

(1) Project Identification

The F/S Project will be identified by the current JICA Survey with a recommendation for the project and its scope by the final report of the feasibility study. The F/S Project shall be identified in line with the development goals, strategies and national and local needs. The result of the Survey consists of several potential elements of the project. The Cape Verde Government shall officially make a decision by procedures in line with government laws and regulations whether an identified project should proceed to the stage of project formation. If necessary, JICA will send a fact-finding (F/F) mission to conduct an initial analysis and study on the identified project in preparation for possible future financing.

(2) Preparation

In the preparation stage, usually pre-investment studies such as feasibility studies (F/S) are conducted for the project selected in the identification stage in order to bring the project to the level of maturity amenable to appraisal by JICA. However, the present JICA Survey report is a form of feasibility study carried out by a technical assistance (donation basis) of JICA. After the feasibility study has been approved by the Cape Verde Government, the request will be issued for an application for a Japanese ODA loan, accompanied by the project outline, and be submitted through the Japanese Embassy in Senegal to the Japanese Government. The project outline shall contain the following information:

1) Priority and necessity of the project
2) Investment and financing plans
3) Items and components of the project to be applied for Japan's ODA loan
4) Clear statement of the intention of the Cape Verde Government to undertake the project
5) Steps and procedures necessary to undertake the project in line with Cape Verde Government regulations (if any)

The project outline shall state precisely and adequately the government's intentions, including the modifications made in the project plan, in case the project plan differs from the F/S report of JICA Survey.

[1] http://www.jica.go.jp/english/operations/schemes/oda_loans/oda_op_info/guidance/index.html

In parallel, the result of the Environmental Impact Assessment (EIA) for the F/S Project should be submitted to JICA prior to appraisal by JICA. *(Refer to JICA Guidelines for Confirmation of Environmental and Social Considerations (the Environmental Guidelines)*[2]*).* EIA is a procedure where an F/S Project proponent assesses the environmental impact of the proposed project and considers mitigation measures in the project preparation stage.

(3) Appraisal and Ex-ante Evaluation

JICA will conduct an appraisal for the well-prepared project for which a request for an ODA loan has been made. The appraisal will proceed along the following steps:

1) JICA will review the F/S of the project and the relevant information obtained through sector studies and fact-finding missions.
2) JICA will recommend the project suitable for appraisal to the Government of Japan, specifically the Ministry of Foreign Affairs, the Ministry of Finance and the Ministry of Economy, Trade and Industry.
3) The Government of Japan will formally approve that appraisal be conducted for the proposed project and JICA will inform the Government of Cape Verde of the dispatch of an appraisal mission.
4) JICA will disclose the environmental category classification of the project on its website in accordance with *The Environmental Guidelines*.
5) JICA will send an appraisal mission to confirm the viability of the project by examining the economic, social, financial, technical and environmental aspects of the proposed project, as well as the operation, maintenance and monitoring systems of the Executing Agency. The appraisal mission will engage in detailed discussions with the Cape Verde Government while conducting a field survey of the project site.
6) Based on the results of the appraisal by JICA, the Government of Japan will make a decision as to whether the project is suitable for ODA loan financing, and will determine the loan amount and terms.

(4) Prior Notification, Exchange of Notes and Loan Agreement

Prior notification will be made by the Government of Japan to the Cape Verde Government regarding the decision to extend Japan's ODA loan. Afterwards, the two governments will enter into negotiations to proceed with a formal agreement. When an agreement is reached,

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[2] http://www.jica.go.jp/english/operations/social_environmental/guideline/index.html

the two governments will exchange notes confirming the matters agreed upon such as the amount and terms of the loan and other bilateral issues such as tax treatment or marine insurance.

Then two governments will start negotiations for a loan agreement (L/A) with the official representing agency designated as the Borrower. The L/A, by which JICA makes its financing commitment, set forth legal rights and obligations pertaining to the loan, laying out the details of the loan amount, terms and conditions, the purpose, scope and content of the project, the Executing Agency, procurement conditions, disbursement procedures and General Terms and Conditions for ODA Loans (GTC). After signing the L/A, JICA will swiftly disclose the results of its environmental review (undertaken in accordance with the Environmental Guidelines) as well as the ex-ante evaluation report of the project on its website.

(5) Project Implementation and Supervision

After the L/A is signed, the project enters the implementation stage, starting firstly with the hiring of consultants for engineering design, supervision as well as capacity building of the concerned agencies and other entities involved in the project. Consultants are to be selected and employed based on the international practice of the "short list method" in accordance with JICA's *Guidelines for the Employment of Consultants under JICA ODA Loans*. Then employed consultants will undertake assigned consulting services. Under certain circumstances such as a STEP loan, detailed design (D/D) may be done with a JICA's technical assistance (donation basis).

Procurement of goods and services for project implementation should follow either international competitive bidding (ICB) in line with the JICA's *Guidelines for Procurement under JICA ODA Loans,* or limited competitive bidding with the condition of Japan-tied.

JICA will review procurement procedures based on provisions in the L/A in order to ensure that the project will be implemented by a well-qualified and competent contractor. JICA recommends using JICA Guidelines in relation to the procedures for prequalification and bidding.

The progress of implementation shall be monitored and reviewed with a view to ensuring smoothness and efficiency by JICA's supervision missions who will discuss with the Executing Agency and the relevant authorities to solve, if necessary, any problems that emerge or to take necessary measures in a timely and effective manner. The supervision shall cover both the implementation of the project and the overall loan process.

The periodic progress report by the Executing Agency on implementation is required under the conditions of L/A in order to identify, at an early stage, any problems that may arise in the course of project implementation.

(6) Ex-Post Evaluation and Monitoring after Project Completion

Upon completion of the project, the ex-post evaluation will follow and shall be done by JICA reviewing the entire process of appraisal, implementation, and operation and maintenance, based on the project completion report (PCR) to be submitted by the Cape Verde Government as required by the L/A. JICA will monitor the operation and maintenance of the project for a certain period in order to ensure effective operation and maintenance and to sustain project benefits over the medium and long term.