MINISTRY OF AGRICULTURE, WATER RESOURCES AND FISHERIES

SOCIETE NATIONALE D'EXPLOITATION ET DE DISTRIBUTION DES EAUX （SONEDE）

THE PREPARATORY SURVEY
ON
SFAX SEA WATER DESALINATION PLANT CONSTRUCTION PROJECT
IN
THE REPUBLIC OF TUNISIA

FINAL REPORT

VOL. 1 : MAIN

AUGUST 2015

JAPAN INTERNATIONAL COOPERATION AGENCY

NJS CONSULTANTS CO., LTD.
INGEROSEC CORPORATION
JAPAN TECHNO CO., LTD.

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Exchange Rates: TND 1.000 ＝ JPY 61.02
USD 1.00 = JPY 119.6
TND: Tunisian Dinar
JPY: Japanese Yen
USD: United States Dollars

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ABBREVIATIONS AND ACRONYMS

AFD	France Development Agency (Agence Française de Developpement)
AfDB	African Development Bank
ANPE	National Agency for Environmental Protection (Agence Nationale de Protection de l'Environnement)
APAL	Coastline Protection and Planning Agency (Agence de Protection et d'Aménagement du Littoral)
C/P	Counter Part
COD	Chemical Oxygen Demand
CPI	Consumer Price Index
CRDA	Agricultural Development Regional Commission (Commisariats Régionaux du Développement Agricole)
DCIP	Ductile Cast Iron Pipe
DGBGTH	General Directorate of Dams and Large Hydraulic Works (Direction Générale du Génie Rurale et de l'Exploitation des Eaux)
DGGREE	General Directorate of Rural Engineering and Water Exploitation (Direction Générale du Génie Rurale et de l'Exploitation des Eaux)
DGRE	General Directorate of Water Resources (Direction Générale de Ressources en Eau)
EC	European Commission
EIA	Environmental Impact Assessment
EIB	European Investment Bank
F/S	Feasibility Study
FADES	Arabic Fund for Social Economic Development (Le Fonds arabe de développement économique et social)
GDA	Agricultural Development Groups (Groupments de Développement Agricole)
GDP	Gross National Products
GNI	Gross National Income
HDPE	High Density Polyethylene
ICT	Information and Communication Technology
IME	Mechanical and Electrical Industry
IT/R	Interim Report
ITH	Garments and Apparel Industry
JICA	Japan International Cooperation Agency
lpcd	Litres per Capita per Day
KfW	German Reconstruction Loan Banking Group (Kreditanstalt für Wiederaufbau)
MDICI	Ministry of Development, Investment and International Cooperation (Ministère du Développement, de l'Investissement et de la Coopération Internationale)

MOA	Ministry of Agriculture, Water Resources and Fisheries (Ministère de l'Agriculture, des Ressources Hydrauliques et de la Pêche)
ND	not detected
NT09.14	Tunisian Drinking Water Quality Standard (NT09.14:1983 or 2013)
NTU	Unit of Turbidity (Nephelometric Turbidity Unit)
ONAS	National Office of Sanitation (Office National de l'Assainissement)
PC	Cluster (Pôle de Compétitivité)
RO	Reverse Osmosis
SEDCI	State Secretary of Development and International Cooperation, Ministry of Economy and Finance (Secrétaire d'Etat au Développement et à la Coopération internationale, former Ministry of Development and International Cooperation (MDCI))
SECADENORD	National Corporation for Development of North Canal and Conveyors (Société d’exploitation du canal et des adductions des eaux du nord)
SONEDE	National Water Distribution Utility (Société Nationale d'Exploitation et de Distribution des Eaux）
STEG	Tunisian Company of Electricity and Gas (Société Tunisienne de l'Electricité et du Gaz)
TDS	Total Dissolved Solid
TOR	Term of Reference
TND	Tunisian Dinar (Tunisian currency unit)
WHO	World Health Organization

SUMMARY

CHAPTER 1 PURPOSE AND CONTENTS OF THE SURVEY

1.1 Purpose of the Survey

This survey is conducted for the formation of the project suitable for the Japanese ODA loan to the Tunisian government, with the Ministry of Foreign Affairs, the Ministry of Development, Investment and International Cooperation, and the Ministry of Finance as borrower, and the National Water Distribution Utility (French: Société Nationale d'Exploitation et de Distribution des Eaux, hereinafter referred to as "SONEDE") as the executing agency. The purpose of the survey is to contribute to the implementation of the Project as the Japanese ODA loan project by conducting feasibility study for Sfax Seawater Desalination Plant.

Accordingly, the accomplishment of the survey will be the reference for loan assessment by JICA and the scope of work planned in the survey will be the basis for the Project under the yen loan.

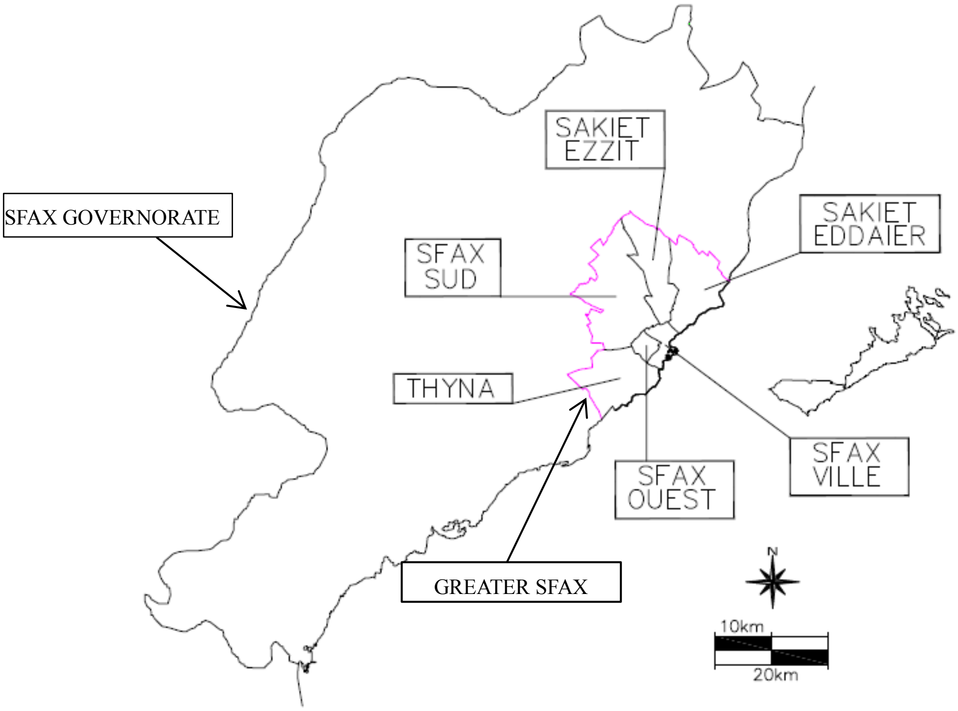
1.2 Scope of the Project

Scope of the Project is for a seawater desalination plant with a production capacity of 200,000 m^3/day. However, 100,000 m^3/day is the subject capacity for the Japanese ODA loan including intake and discharge facilities, transmission pipeline, distribution reservoir, and related pumping facilities.

1.3 Survey Area

The area of the survey is the Greater Sfax and its surrounding area. Sfax is a city, located 270 km southeast of Tunis, and is the capital of the Sfax Governorate. The city expansion is explained with the development as a harbour city, and of the road system to inland in multi-direction from the port. Recently, a circular road was developed and urbanization extends along the road.

The Greater Sfax consists of Sfax Ville and five (5) delegations i.e. Sfax Ouest (West), Sfax Sud (South), Thyna, Sakiet Ezzit and Sakiet Eddaier. Each delegation consists of several sectors. There are 43 sectors in total in the Greater Sfax.



Source: JICA Survey Team

Figure 1-1 Administrative Map of the Greater Sfax

1.4 Relevant Authorities

Authorities relevant to the survey are as follows:

- Counterpart: National Water Distribution Utility (SONEDE)
- Related Authorities :
  1) Ministry of Development, Investment and International Cooperation (MDICI, Window for the Japanese ODA loan)
  2) Ministry of Finance (Borrowing and repayment of the Japanese ODA loan)
  3) Ministry of Agriculture, Water Resources and Fisheries (Regulatory authority of SONEDE)
  4) Ministry of Foreign Affairs (International relation, Agreement with Foreign Countries)
  5) Ministry of Environment and Sustainable Development
     Environmental Protection Agency (ANPE, Appraisal of Environmental Impact Assessment)
     Coastal Protection and Development Agency (APAL, Approval of Development in Coast)

1.5 Schedule of the Survey

The survey was conducted in two phases as follows:

(1) Phase 1 (September to December 2013): Confirmation of Necessity and Viability of Seawater Desalination Plant

The Phase 1 survey was started from 13 September 2013, and the Field Work was conducted from 28

September to 23 November, 2013 after the preparatory work. After the fieldwork, the work was conducted in Japan up to the beginning of January 2014.

(2) Phase 2 (January 2014 to August 2015): Feasibility Study

The feasibility study was conducted from January 2014 to August 2015.

The second fieldwork was conducted from the middle of January to the beginning of March 2014. After the succeeding work in Japan, the accomplishments were compiled as the Interim Report 2.

The third fieldwork was started from the middle of April 2014 and was conducted up to the middle of June, after which the Draft Preparatory Survey Report was made in Japan from June to September 2014.

Explanation and discussion on the draft report were carried out on 29 September 2014. The Final Report, which included the revisions on the draft report reflects comments from Tunisian side, and was prepared and submitted in August 2015[1].

This report was prepared based on the information obtained up to June 2015.

CHAPTER 2 REVIEW OF EXISTING INFORMATION AND EXPLORATION

2.1 Natural Condition

The Greater Sfax is located in the middle area of semi-arid climate of the Republic of Tunisia. It has an area of 163,610 km^2, but is characterised by mild climate with relatively high humidity because it face the Mediterranean Sea.

2.1.1 Meteorological Information

(1) Temperature

The average annual temperature in the past 21 years (1992-2012) is 18 ^{o}C. The climate is divided into cold season from December to February and hot summer season from July to September. The climates in spring and autumn are pleasant.

(2) Humidity

Due to the influence of the Mediterranean Sea, the humidity is around 50% to 70% through the year. Figure 2.1-2 shows the humidity ranges during 2010-2013.

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[1] After explanation of the draft report, revision of water balance between demand and supply, water source allocation plan were conducted to reflect SONEDE's comments, and revision of facility development plan was conducted to cope with the change of distribution flow as well. Further, review of the project cost, and financial and economic analysis were also conducted.

(3) Wind

Wind blows 300 days in a year with varying directions by season. In winter, the land breeze blows from the direction ranging between North and Southwest. In summer, the sea breeze blows from the direction ranging between east and southeast. Figure 2.1-3 shows changes in wind blow directions from 2010 to 2013.

(4) Precipitation

Annual average precipitation in Greater Sfax in past 20years (1991-2010) is 228.5mm (464.5mm in Tunis). Rainfall averages about 25mm per month during the period of September to April, and then decreases from the beginning of May. There is scarce precipitation in the period from June to August.

2.1.2 Topography and Geography

Greater Sfax area is the urban area spreading like a fan from the harbour. It has a little monotonous undulating terrain, gently sloping towards the sea.

2.1.3 Marine Context

(1) Tidal data

The tidal data at Sfax Port is as shown in the table below.

Table 2-1 Tidal Data

	Average tidal	Maximum tidal	Minimum tidal
Above sea level (m)	+1.16	+2.15	+0.00

Source：RAPPORT DU CENTRE HYDROGRAPHIQUE ET OCEANOGRAPHIQUE DE LA MARINE NATIONALE DE LA TUNISIE

(2) Sea Current

The sea current in the Mediterranean is generally very weak, flowing towards the east Mediterranean from the west Mediterranean. It is characterized as an arid region of high temperature and high amount of evaporation region. Offshore of Sfax sees the current flow moving slowly along the coast from Sousse to Gabes. The cyclic tidal current flows along the coast of the Greater Sfax corresponding to the rise and fall of the tide.

(3) Bathymetric Survey

The coast of the Greater Sfax slopes gently away from the water’s edge. The offshore seabed from La Cheba to Sfax through Kerkennah continues with less than 5 m in depth. The seabed with less than 10m depth spreads to 5km offshore along Gabes Bay, south of Sfax. A 60 m wide channel to the Sfax seaport has been dredged to 11m depth to offshore of about 4.5 km.

2.2 Social and Economic Situation

Tunisia is positioned as a more developed country using the income classification by the World Bank. In

2013, Tunisian GDP was US$46.99 Billion and GDP growth rate was 2.5%. GNP per capita was US$4,317 although growth has slowed down. Overall unemployment rate for the second quarter of 2013 was 13.3% and the unemployment rate of young people was particularly high and has remained at high levels over a long period.

2.3 Population

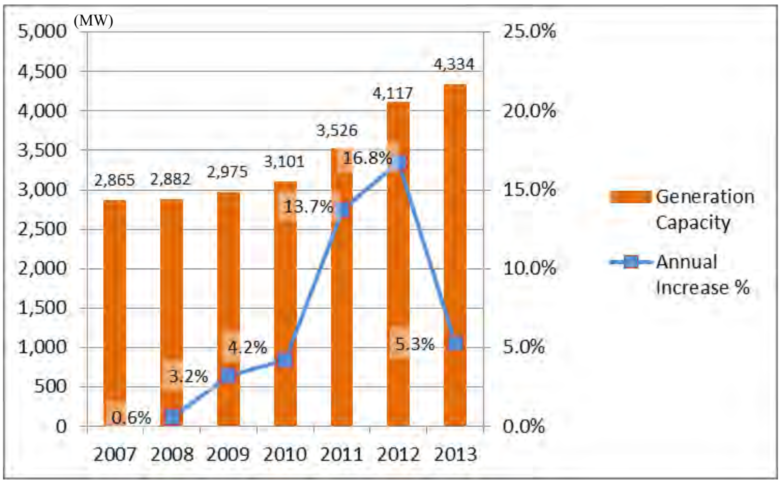
The population of Tunisia was 10.89 million in 2013. Urban population stood at 66%, and 34% of the population live in rural area. Working-age population was 43% and young working-age population was high at 33%.

The Greater Sfax, whose main area is inside the Route 11 bypass, is the second biggest city in Tunisia. It is a commercial hub where 620 thousand people out of 970 thousand of the entire Sfax region live as of July 2013. Many students, reaching almost 50,000, live in this area, but they come from other regions. During the summer holidays, the student population decreases. Many tourists stay in Tunisia during the summer holiday season, but most of them go to the resort areas such as Djerba and Sousse. Tourists do not generally stay in Sfax.

For the period between 2003 and 2013, the average population increase rate of Tunisia was 1.02%/year. For the Tunis Governorate, it was 0.21 %/year, while it ws 1.37%/year for the Sfax Governorate exceeding that of Tunis.

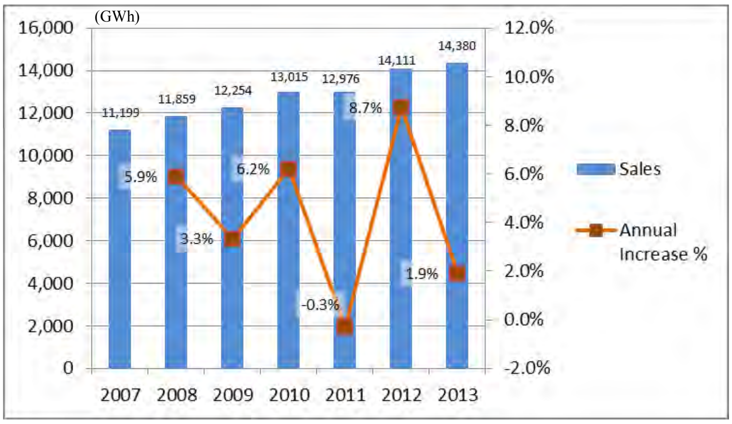
2.4 Situation of Power Supply

STEG is a main power supplier in Tunisia. The status of its power generation and power sales are as shown in Figures 2-1 and 2-2.



Source: Annuaire Statistique de la Tunisie 2007-11, https://www.steg.com.tn/en/institutionnel/produire.html (2012-13)

Figure 2-1 STEG Power Generation Capacity



Source: Annuaire Statistique de la Tunisie 2007-11, https://www.steg.com.tn/en/institutionnel/produire.html (2012-13)

Figure 2-2 STEG Power Sales

The power generation of STEG has been continuously increasing since 2008 at a relatively high rate. It was 3,526 MW in 2011 with an annual increase rate of 13.7%, 4,117MW with 16.8% increase in 2012, and 4,334 MW with 5.3% increase in 2013. Total power sales has also generally shown increasing tendency. It in 2011, however, showed slight decrease of 0.3% over the previous year at 12,976 GWh. It could be caused by the stagnation of industrial activities due to the Jasmine Revolution. However, it increased to 14,111 GWh in 2012 and 14,380 GWh in 2013.

Power Sales in 2007 was 44.6% (= (11,199 x 10^9) / (2,865 x 10^6 x 24 x 365)) of Generation Capacity. It was decreased to 37.9% (= (14,380 x 10^9) / 4,334 x 10^6 x 24 x 365)). This fact shows the improvement of balance between power supply and demand. STEG has been exerting effort to improve the situation.

CHAPTER 3 PRESENT STATUS OF WATER SUPPLY SERVICE IN TUNISIA

3.1 Relevant Organization and Legal Framework of Water Sector

3.1.1 Outline of Relevant Organization

The Ministry of Agriculture, Water Resources and Fisheries (hereinafter referred to as “MOA”) develops the policy framework of the water sector in Tunisia, based on the Water Act of 1975. The MOA, the governing authority of SONEDE develops policy and plans for the water sector as well as constructs, operates and maintains large scale hydraulic structures. SONEDE, on the other hand, supplies drinking and industrial water to urban and large-scale rural communities aligned with the policy and developed plan using the hydraulic structures managed by the MOA.

3.1.2 National Water Distribution Utility (SONEDE)

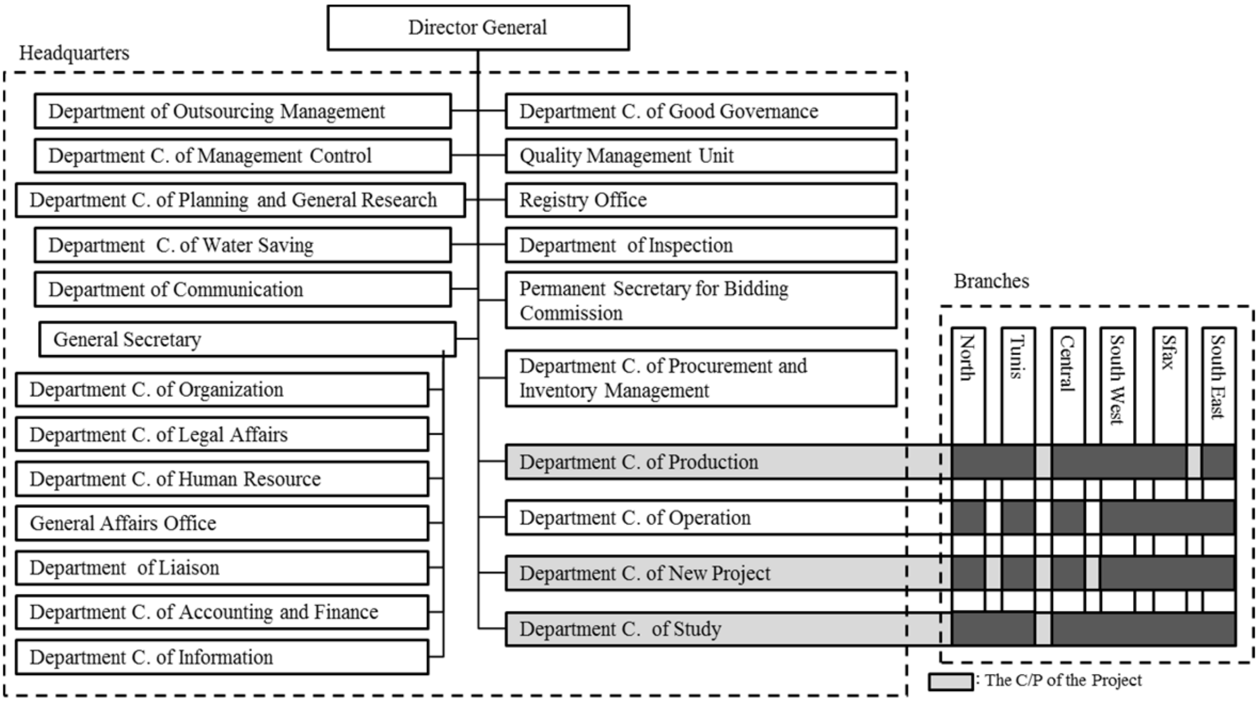
SONEDE was established in 1968 as a financially autonomous public company under the control of the MOA. It is in charge of supplying drinking water nationwide, and conducts research and planning on the intake, transfer, treatment, transmission and distribution of water, as well as uses, renews, operates and maintains constructed hydraulic works. The outline of organization and its activities as of 2013 are shown in Table 3-1.

Table 3-1 Outline of Organization and Activities of SONEDE (2013)

Item	Description	Remarks
Number connections	2,550,318 connections	Number of employees per 1,000 connections: 6,818 employees /2,550,318 connections /1000 =2.67
Served Population	9.11 million	
Annual Volume of Production	609.4 million m^3	Details of production: - Surface water: 347.2 million m^3 - Groundwater: 234.4 million m^3 - Desalinated water: 19.7 million m^3 - Deferrizated water: 6.2 million m^3
Annual Volume of Distribution	555.5 million m^3	
Annual Volume of Revenue Water	449.9 million m^3	
Length of Pipelines	49,500 km	Details: - Intake and Conveyance: 9,400 km - Transmission and Distribution:40,100 km
Personnel	Total 6,818 Permanent Employee 6,039 Temporary Employee 779	Breakdown of Permanent Employee - Technical: 4,505 - Administrative: 1,534

Source: SONEDE and JICA Survey Team

The organogram of SONEDE is shown in Figure 3-1.



Source: SONEDE and JICA Survey Team

Figure 3-1 Organogram of SONEDE (as of October 2014)

3.2 Water Balance in Tunisia

As shown in Table 3-2 and Table 3-4, among the available water resources of below 3000mg/L TDS, 100% of the surface water and almost the entire groundwater have been utilized, and only water sources of more than 3000mg/L are available. The utilization of the remaining water is limited due to salinity. For example, in accordance with the water norm for agricultural use, TDS is permissible up to 2000mg/L, but actually, the remaining water meet in this criterion is very limited. For olive cultivation the permissible TDS is about 3000mg/L; however, in the long run, the salinity accumulates in the ground and exceeds the permissible value.

Table 3-2 Water Resources and Water Availability for Use in Tunisia (2013)

unit: Million m^3/year

	Water Resources	Water Availability for Use*			
		TDS <1500mg/L	1500<TDS <3000mg/L	3000mg/L <TDS	Total
Surface Water	2,700	1,200	400	100	1,700
Groundwater	2,100	300	800	500	1,600
Total	4,800	1,500	1,200	600	3,300

Remarks*：MOA plans to take measures to increase the water availability for use.
Source: MOA Documents

Table 3-3 Water Demand and Resources in Tunisia (2013)

unit: million m^3/year

Usage	Demand	Surface Water			Groundwater		
		TDS <1500mg/L	1500<TDS <3000mg/L	3000mg/L <TDS	TDS <1500mg/L	1500<TDS <3000mg/L	3000mg/L <TDS
Irrigation	2,160	970	370	0	250	570	0
Drinking	380	160	0	0	40	110	70
Industries	130	60	20	0	10	40	0
Tourism	30	10	10	0	0	10	0
Total	2,700	1,200	400	0	300	730	70
Utilized rate		100%	100%	0%	100%	91%	14%

Source: MOA Documents, SONEDE Documents

Table 3-4 Water Balance between Demand and Resources in Tunisia (2013)

unit: million m^3/year

	Demand			Water Available to Use			Utilized rate		
Usage	Surface Water	Ground water	Total	Surface Water	Ground water	Total	Surface Water	Ground water	Total
Irrigation	1,340	820	2,160						
Drinking	160	220	380						
Industries	80	50	130						
Tourism	20	10	30						
Total	1,600	1,100	2,700	1,700	1,600	3,300	94%	69%	82%

Source: MOA Documents, SONEDE Documents

3.3 Future Plan of Water Sector

The Tunisian Government released the 12th Five Year Plan (2010 – 2014), before the revolution in 2011. This national plan, which includes water service rate of 100% in urban area and an installation of seawater desalination plants for the drinking water quality improvement, was cancelled because of the revolution. SONEDE, however, works based on the national plan.

This Project is to construct a seawater desalination plant contributing the improvement of drinking water quality while sustaining 100 % service rate in the urban area. Therefore, this Project meets the policy of the water sector in Tunisia. Presently, the Tunisian Government is preparing to implement its new social economic development plan from 2016 to 2020, which aims 7% annual increase of GDP.

CHAPTER 4 WATER SUPPLY PLAN FOR GREATER SFAX

4.1 Current Status and Future Plan of Water Sector

4.1.1 Current Status of Water Sector

SONEDE is in charge of water supply in urban areas and large rural centres in the Sfax Governorate, while the General Directorate of Rural Engineering and Water Exploitation (DGGREE, French; La Direction Générale du Génie Rural et de l'Exploitation des Eaux) is in charge of medium and small water supply systems. The population and the population served data in the Sfax Governorate from 2006 to 2012 are shown in Table 4-1.

Table 4-1 Administrative and Served Populations in Sfax Governorate

unit: 1,000m^3/year

Item Year		2006	2007	2008	2009	2010	2011	2012
Total Population		887.9	900.0	911.3	923.8	936.7	938.7	963.1
Urban	Population	570.0	578.9	586.5	595.6	605.0	613.8	624.2
	SONEDE Covered Pop.	570.0	578.9	586.5	595.6	605.0	613.8	624.2
	Covered Rate	100%	100%	100%	100%	100%	100%	100%
Rural	Population	317.9	321.1	324.8	328.2	331.7	334.9	338.9
	SONEDE Covered Pop.	179.2	183.8	188.6	192.3	194.4	197.6	199.9
	DGGR Covered Pop.	131.6	134.4	134.6	118.0	119.4	119.1	120.6
	Covered Rate	97.8%	99.1%	99.5%	94.5%	94.6%	94.6%	94.6%
Covered Rate in Sfax Governorate		99.2%	99.7%	99.8%	98.1%	98.1%	98.1%	98.1%

Source: SONEDE Annual Report

The annual water supplies (consumption) in the Sfax Governorate from SONEDE are shown in Table 4-2.

Table 4-2 Annual Water Supply in Sfax Governorate (Consumption)

unit: 1,000m^3/year

Item Year		2006	2007	2008	2009	2010	2011	2012
House Hold Water	Connection Supply	23,037	24,064	26,164	26,388	28,093	29,138	31,440
	Communal Tap	1,364	1,560	2,116	1,965	3,072	2.396	2,862
	Total	24,401	25,624	28,280	28,353	31,165	31,534	34,302
Public Office & Commercial		3,186	3,278	3,257	3,307	3,428	3.464	3,648
Industrial		2,784	2,817	2,921	2,786	2,963	2,826	3,441
Tourism		191	199	209	205	189	173	182
Others		229	246	188	136	138	177	97
Total		30,791	32,164	34,855	34,787	37,883	38,174	41,670

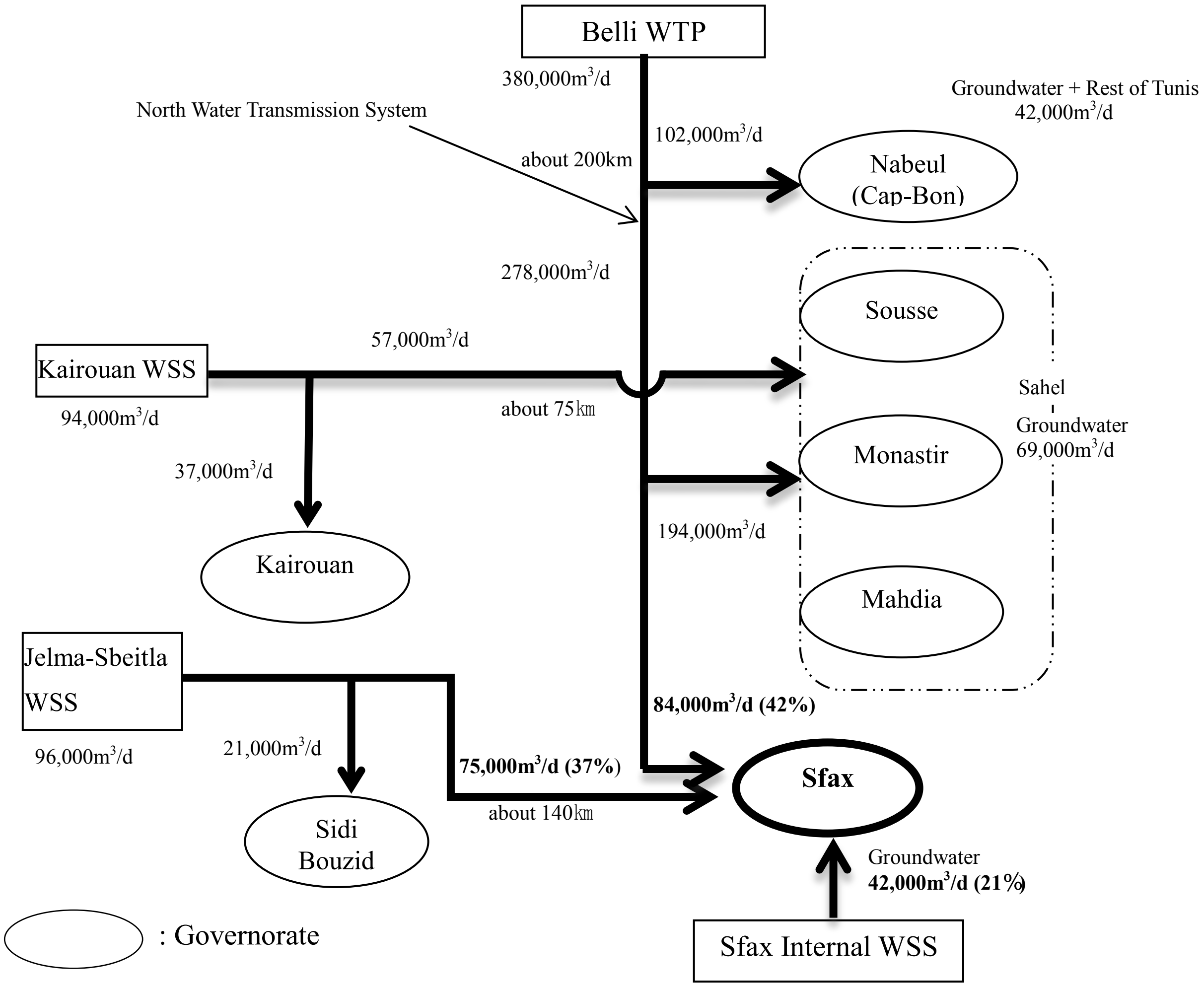
Source: SONEDE Annual Report

The usage-wise rates of SONEDE water supply in 2012 are as follows; Household; 82.3%, Administration and Commercial; 8.8%, Industrial; 8.3%, Tourism; 0.4%, Others; 0.2%. Regarding the water supply for industries, the figures are only from SONEDE's subscribers and relatively large-scale consumers such as factories which have their own private wells and to obtain required water supply. With the growth of population and industrial expansion, the water demand is also increasing. SONEDE's responsibility is to ensure continuous water supply services to their growing customer bases.

4.1.2 Water Resources for Water Supply in Sfax

(1) Outline of Water Resources

Water resources for the water supply in the Sfax Governorate are from the North Water Transmission System, the Jelma-Sbeitla Groundwater Transmission System from Sidi Bouzid Governorate and Sfax's own groundwater supply. Figure 4.1-2 shows a schematic diagram of the water resources for the water supply in the Sfax Governorate. Total available water supply volume at peak period in 2013 was 201,000 m^3/day and ratios by each water source are 42%, 37%, and 21% respectively.



Source: JICA Survey Team
Note: Water flow rate is estimated at the peak in 2013.

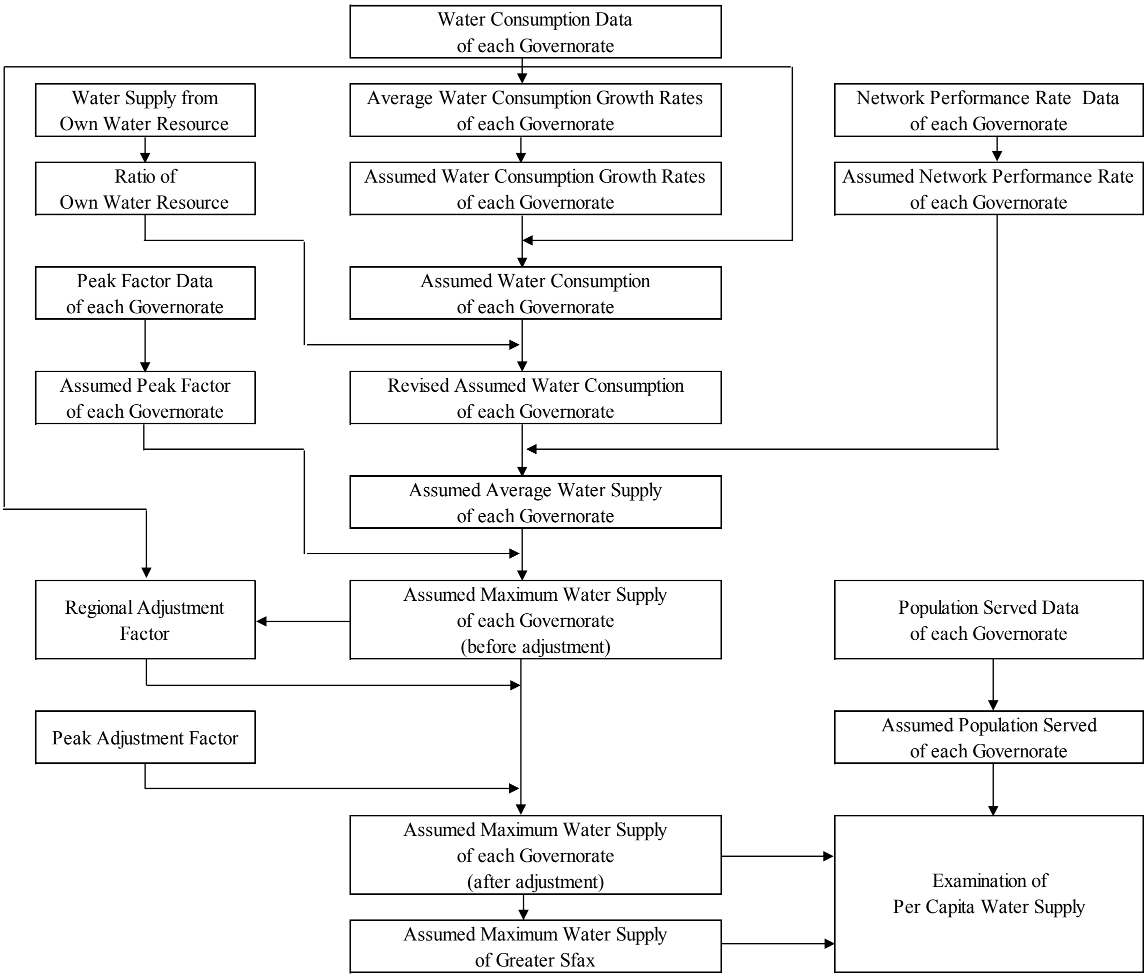
Figure 4-1 Schematic Diagram of the Water Resources for Sfax Governorate

4.2 Water Demand and Supply in North Water Transmission System

4.2.1 Water Demand in North Water Transmission System

SONEDE formulated the "Feasibility Study on the Mid-South Area Water Supply Scheme" in 2005, target year being on 2030. As the countermeasure against severe water shortage which occurred in 2012, the "Strategic Study" was formulated in 2013. The Strategic Study, however, was prepared within spending several months only because the Feasibility Study had been already formulated, and the formulated plan was requested to be implemented urgently. The future water demand was estimated by a statistical analysis on the past water supply data in seven Governorates such as Cap-Bon (Nabeul Governorate), Sahel (Sousse, Monastir and Mahdia), Kairouan, Sfax, and Sidi Bouzid, based on the following detailed assumptions:

In this survey, water demand was reviewed based on the method applied in the Strategic Study with revision by following adjustment parameters. Then, appropriateness of results was examined by considering the calculated per capita consumption. The flow diagram of projection of the survey stated above is as shown in Figure 4-2.



Source：JICA Survey Team

Figure 4-2 Flow Diagram of Water Demand Projection of the Survey

The maximum water demand by governorate is shown in Table 4-3.

Table 4-3 Maximum Water Demand by Governorate

Unit: m^3/day

Year	Nabeul	Sousse	Monastir	Mahdia	Sfax	Kairouan	Sidi Bouzid	Total
2011	134,247	124,110	102,740	71,233	173,425	35,068	19,452	660,274
2012	138,904	127,945	106,027	74,795	179,178	35,616	20,000	682,466
2013	144,384	131,507	109,863	78,630	185,479	36,986	21,096	707,945
2014	149,589	135,616	113,151	82,466	191,507	38,082	21,644	732,055
2015	154,795	139,726	116,438	86,575	198,356	39,178	22,740	757,808
2016	160,274	144,110	120,274	90,685	205,479	39,726	23,562	784,110
2017	166,301	148,493	123,562	95,342	211,781	40,548	24,658	810,685
2018	171,781	153,151	127,397	100,000	219,452	41,370	25,479	838,630
2019	178,082	156,986	131,233	104,932	226,575	41,918	26,301	866,027
2020	184,384	161,918	135,616	110,137	234,521	42,740	27,397	896,712
2021	190,959	166,849	140,000	115,616	242,466	44,110	27,945	927,945
2022	197,808	172,055	144,384	121,644	251,233	45,205	29,589	961,918
2023	205,205	177,260	148,767	127,397	259,452	46,301	30,137	994,521
2024	212,603	182,740	153,425	134,247	268,219	47,945	31,781	1,030,959
2025	219,726	187,945	158,082	141,096	277,260	48,767	32,877	1,065,753
2026	227,671	193,425	163,562	147,671	287,123	49,863	33,425	1,102,740
2027	236,164	199,452	167,945	155,068	296,986	50,959	35,342	1,141,918
2028	244,658	205,753	173,699	163,288	307,123	52,055	36,986	1,183,562
2029	253,425	211,507	179,178	171,507	317,808	53,151	38,082	1,224,658
2030	262,740	217,808	184,658	180,274	328,493	54,247	39,178	1,267,397
2031	272,329	224,384	190,137	189,315	340,822	56,438	41,370	1,314,795
2032	281,918	231,233	196,164	198,904	353,699	57,534	42,466	1,361,918
2033	292,603	238,082	201,918	209,315	366,301	59,726	44,658	1,412,603
2034	303,014	244,932	208,493	219,726	379,726	60,822	46,301	1,463,014
2035	313,699	252,055	214,521	230,685	393,425	63,014	48,219	1,515,616

4.2.2 Water Supply Plan in North Water Transmission System

In the Strategic Study, the scenario for the water supply to meet the demand until 2030 was studied. In the Survey, the JICA Survey Team confirmed from SONEDE about the implementation of the treatment plants planned in the Strategic Study. As a result of discussion, SONEDE indicated the one-year delayed schedule of the project for Saida reservoir and Kalaa Kebira reservoir and the water treatment plant as shown in Table 4-4. SONEDE also intends to expedite the project for Sfax Seawater Desalination Plant as soon as possible.

Table 4-4 Water Treatment Plant and Seawater Treatment Plant formulated in the Strategic Study

Name	Year	Production capacity	Supply to Greater Sfax
Saida reservoir & Kalaa Kebira reservoir / water treatment plant	2020	1,500 L/s (129,600 m^3/d)	-*
	2024	3,000 L/s (259,200 m^3/d)	-*
	2029	4,000 L/s (345,600 m^3/d)	-*
Sfax sea water desalination plant	2020	1,157 L/s (100,000 m^3/d)	1,157 L/s (100,000 m^3/d)
	2026	2,325 L/s (200,000 m^3/d)	2,325 L/s (200,000 m^3/d)

*: As a part of the North Water Transmission System, supplied water is mixed with the water supplied by existing water sources.

Source: SONEDE, 2014

In this survey, the schedule presented by SONEDE is applied for the project for Saida reservoir and Kalaa Kebira reservoir and the water treatment plant. The Sfax Seawater Desalination Plant, however, is scheduled taking into consideration the required period and procedures for the Japanese ODA loan for the Project. After examining the schedule, (which is discussed in detail in Chapter 10), the commissioning of the plant is expected by 2022. The period for the Phase 1 is therefore considered as the period when the capacity of the Phase 1 facilities, 100,000 m^3/day, which is a half of final capacity, can meet the demand. After that, the Phase 2 period will be started.

Even though new water resources stated above are developed, the upstream areas of the North water transmission system will experience water shortage by 2021 caused by increased water demand. Because of this reason, an additional water source with a capacity of 250,000 m^3/day will have to be developed at the place close to large water demand areas like Souse Governorate to avoid transmission of big volume of water.

4.2.3 Review on Demand and Supply Plan in the Strategic Study

Water demand and supply were reviewed under the conditions stipulated in Sections 4.2.1 and 4.2.2. The results are presented in Tables 4-5 to 4-7, and Figures 4-3. In addition, calculation table showing demand and supply analysis in seven governorates is presented in Table 4-8.

Table 4-5 Water Demand in Seven Governorates in North Water Transmission System

	2015	2020	2025	2030	2035
Population	4,469,600	4,731,500	4,993,700	5,255,700	5,517,800
Population Served	3,732,100	4,014,100	4,296,200	4,578,100	4,860,200
Per Capita Consumption (L/person/day)	103	114	127	143	161
Non Domestic Rate (%)	22	22	22	22	22
Average Non-Revenue Water (%)	23.7	23.0	22.4	21.8	22.0
Daily Average Demand (m^3/day)	581,400	687,700	816,700	971,000	1,161,100
Peak Factor (Daily Max/Daily Average)	1.303	1.291	1.305	1.305	1.305
Daily Maximum Demand (m^3/day)	757,800	887,500	1,065,700	1,267,400	1,515,600

*: Daily Max/Daily Average of seven governorates x adjusting coefficient (0.944)
Source: JICA Survey Team

Table 4-6 Water Balance in Seven Governorates in North Water Transmission System (existing facilities only)

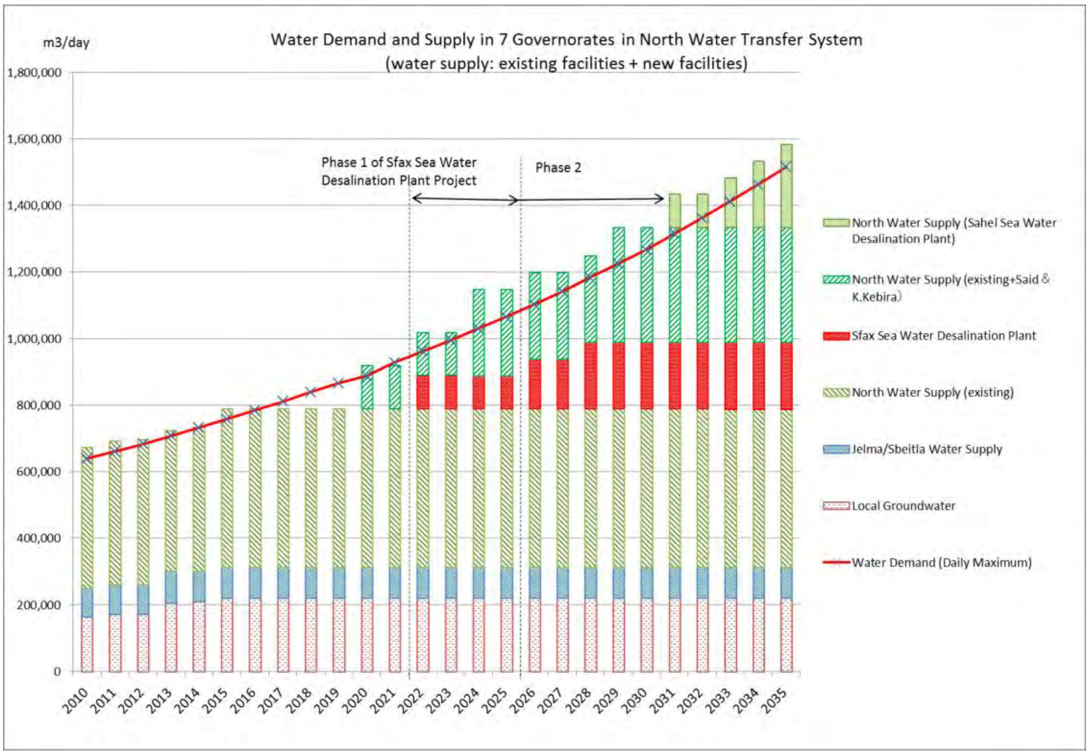
(m^3/day)		2015	2020	2022	2025	2030	2035
Available Water	North Water Transmission	476,800	477,600	477,500	477,200	476,800	476,300
	Jelma-Sbeitla GW Transmission	91,600	91,600	91,600	91,600	91,600	91,600
	Local Groundwater	221,400	221,400	221,400	221,400	221,400	221,400
	Total	789,800	790,600	790,400	790,100	789,700	789,300
Daily Maximum Water Demand		757,800	887,500	961,800	1,065,700	1,267,400	1,515,600
Balance		31,900	▲97,000	▲171,400	▲275,600	▲477,700	▲726,400

Source: JICA Survey Team (Note: Due to rounding, (available volume-demand) is not equal to Balance.)

Table 4-7 Water Balance in Seven Governorates in North Water Transmission System (existing facilities + new facilities)

(m^3/day)		2015	2020	2022	2025	2030	2035
Available Water	Sahel Desalination Plant	0	0	0	0	0	250,000
	Saida/Kalaa Kebira WTP	0	129,600	129,600	259,200	345,600	345,600
	Sfax Desalination Plant	0	0	100,000	100,000	200,000	200,000
	North Water Transmission	476,800	477,600	477,500	477,200	476,800	476,300
	Jelma-Sbeitla Groundwater Transmission	91,600	91,600	91,600	91,600	91,600	91,600
	Local Groundwater	221,400	221,400	221,400	221,400	221,400	221,400
	Total	789,700	920,200	1,020,000	1,149,300	1,335,300	1,584,900
Daily Maximum Water Demand		757,800	887,500	961,800	1,065,700	1,267,400	1,515,600
Balance		31,900	32,600	58,200	83,600	67,900	69,200

Source: JICA Survey Team



Source: JICA Survey Team

Figure 4-3 Water Demand and Supply in Seven Governorates in North Water Transmission System (water supply: exiting facilities + new facilities)

Table 4-8 Water Demand and Supply in Seven Governorates in North Water Transmission System

(unit: L/sec.)

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Nabeul																										
Belli Treatment Plant	4,268	4,398	4,398	4,398	4,398	4,798	4,798	4,798	4,798	4,798	4,798	4,798	4,798	4,798	4,798	4,798	4,798	4,798	4,798	4,798	4,798	4,798	4,798	4,798	4,798	4,798
Local Resources +Tunis Unit	634	611	646	489	596	720	737	735	733	731	730	729	728	727	726	725	724	723	722	721	720	719	718	717	716	715
Total resources in Nabeul	4,902	5,009	5,044	4,887	4,994	5,518	5,535	5,533	5,531	5,529	5,528	5,527	5,526	5,525	5,524	5,523	5,522	5,521	5,520	5,519	5,518	5,517	5,516	5,515	5,514	5,513
Qpj	1,503	1,554	1,608	1,671	1,731	1,792	1,855	1,925	1,988	2,061	2,027	2,210	2,289	2,375	2,461	2,543	2,635	2,733	2,832	2,933	3,041	3,152	3,263	3,387	3,507	3,631
Balance of Nabeul	3,399	3,455	3,436	3,216	3,263	3,726	3,680	3,608	3,543	3,468	3,501	3,317	3,237	3,150	3,063	2,980	2,887	2,788	2,688	2,586	2,477	2,365	2,253	2,128	2,007	1,882
Kairouan																										
Local resources in Kairouan	1,085	1,085	1,085	1,091	1,091	1,119	1,119	1,119	1,119	1,119	1,119	1,119	1,119	1,119	1,119	1,119	1,119	1,119	1,119	1,119	1,119	1,119	1,119	1,119	1,119	1,119
Qpj	396	406	412	428	441	453	460	469	479	485	495	511	523	536	555	564	577	590	602	615	628	653	666	691	704	729
Balance of Kairouan	689	679	673	663	650	666	659	650	640	634	624	608	596	583	564	555	542	529	517	504	491	466	453	428	415	390
Sahel (Sousse+Monastir+Mahdia)																										
Local Resources of Sahel	528	614	614	794	866	952	952	952	952	952	952	952	952	952	952	952	952	952	952	952	952	952	952	952	952	952
Saida/K.Kebira Reservoirs+WTP （1500L/s + 1500L/s + 1000L/s）											1,500	1,500	1,500	1,500	3,000	3,000	3,000	3,000	3,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
Sahel Desalination Plant （100,000 m3/d+50,000m3/d+50,000m3/d+50,000m3/d）																						1,157	1,157	1,736	2,315	2,894
Arrival from Kairouan	689	679	673	663	650	666	659	650	640	634	624	608	596	583	564	555	542	529	517	504	491	466	453	428	415	390
Arrival from Northern Water	3,399	3,455	3,436	3,216	3,263	3,726	3,680	3,608	3,543	3,468	3,501	3,317	3,237	3,150	3,063	2,980	2,887	2,788	2,688	2,586	2,477	2,365	2,253	2,128	2,007	1,882
Total resources	4,616	4,748	4,723	4,673	4,779	5,344	5,291	5,210	5,135	5,054	6,577	6,377	6,285	6,185	7,579	7,487	7,381	7,269	7,157	8,042	7,920	8,940	8,815	9,244	9,689	10,118
Qpj in Sousse	1,398	1,436	1,481	1,522	1,570	1,617	1,668	1,719	1,773	1,817	1,874	1,931	1,991	2,052	2,115	2,175	2,239	2,308	2,381	2,448	2,521	2,597	2,676	2,756	2,835	2,917
Qpj in Monastir	1,161	1,189	1,227	1,272	1,310	1,348	1,392	1,430	1,475	1,519	1,570	1,620	1,671	1,722	1,776	1,830	1,893	1,944	2,010	2,074	2,137	2,201	2,270	2,337	2,413	2,483
Qpj in Mahdia	786	824	866	910	954	1,002	1,050	1,104	1,157	1,214	1,275	1,338	1,408	1,475	1,554	1,633	1,709	1,795	1,890	1,985	2,087	2,191	2,302	2,423	2,543	2,670
Total Qpj in Sahel	3,345	3,449	3,574	3,704	3,834	3,967	4,110	4,253	4,405	4,550	4,719	4,889	5,070	5,249	5,445	5,638	5,841	6,047	6,281	6,507	6,745	6,989	7,248	7,516	7,791	8,070
Balance of Sahel	1,271	1,299	1,149	969	945	1,377	1,181	957	730	504	1,858	1,488	1,215	936	2,134	1,849	1,540	1,222	876	1,535	1,175	1,951	1,567	1,728	1,898	2,048
Sidi Bouzid																										
Local resources in Sidi Bouzid	977	1,019	1,019	1,115	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060
Qpj	219	225	231	244	251	263	273	285	295	304	317	323	342	349	368	381	387	409	428	441	453	479	492	517	536	558
Balance of Sidi Bouzid	758	794	788	871	809	797	787	775	765	756	743	737	718	711	692	679	673	651	632	619	607	581	568	543	524	502
Sfax																										
Local Resources of Sfax	301	301	301	491	491	491	491	491	491	491	491	491	491	491	491	491	491	491	491	491	491	491	491	491	491	491
Sfax Desalination Plant Ph1/2 (100,000+100,000 m3/d)													1,157	1,157	1,157	1,157	1,736	1,736	2,315	2,315	2,315	2,315	2,315	2,315	2,315	2,315
Arrival from Northern Water	1,271	1,299	1,149	969	945	1,377	1,181	957	730	504	1,858	1,488	1,215	936	2,134	1,849	1,540	1,222	876	1,535	1,175	1,951	1,567	1,728	1,898	2,048
Arrival from Sbeitla-Jelma	758	794	788	871	809	797	787	775	765	756	743	737	718	711	692	679	673	651	632	619	607	581	568	543	524	502
Total resources in Sfax	2,330	2,394	2,238	2,331	2,245	2,665	2,459	2,223	1,986	1,751	3,092	2,716	3,581	3,295	4,474	4,176	4,440	4,100	4,314	4,960	4,588	5,338	4,941	5,077	5,228	5,355
Qpj	1,937	2,007	2,074	2,147	2,217	2,296	2,378	2,451	2,540	2,622	2,714	2,806	2,908	3,003	3,104	3,209	3,323	3,437	3,555	3,678	3,802	3,945	4,094	4,240	4,395	4,554
Balance of Sfax	393	387	164	184	28	369	81	−228	−554	−871	378	−90	673	292	1,370	967	1,117	663	759	1,282	786	1,393	847	837	833	801
Total																										
Existing Resources	7,793	8,028	8,063	8,378	8,502	9,140	9,157	9,155	9,153	9,151	9,150	9,149	9,148	9,147	9,146	9,145	9,144	9,143	9,142	9,141	9,140	9,139	9,138	9,137	9,136	9,135
Saida/K.Kebira Reservoirs+WTP	0	0	0	0	0	0	0	0	0	0	1,500	1,500	1,500	1,500	3,000	3,000	3,000	3,000	3,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
Desalination (Sfax+Sahel)	0	0	0	0	0	0	0	0	0	0	0	0	1,157	1,157	1,157	1,157	1,736	1,736	2,315	2,315	2,315	3,472	3,472	4,051	4,630	5,208
Total Resources	7,793	8,028	8,063	8,378	8,502	9,140	9,157	9,155	9,153	9,151	10,650	10,649	11,805	11,804	13,303	13,302	13,880	13,879	14,457	15,456	15,455	16,611	16,610	17,188	17,766	18,343
Total Qpj	7,400	7,641	7,899	8,194	8,474	8,771	9,076	9,383	9,707	10,022	10,272	10,739	11,132	11,512	11,933	12,335	12,763	13,216	13,698	14,174	14,669	15,218	15,763	16,351	16,933	17,542
Global Balance	393	387	164	184	28	369	81	−228	−554	−871	378	−90	673	292	1,370	967	1,117	663	759	1,282	786	1,393	847	837	833	801

Qpj: Daily Maximum Water Demand

Source: JICA Survey Team

4.3 Water Demand and Supply in Sfax Governorate

A large amount of water is conveyed to the Sfax Governorate by the North Water Transmission System and the Jelma-Sbeitla Groundwater Transmission System. However, it is projected that there will be increased consumption in the regions upstream of the Sfax Governorate. As a result, the amount of water supplied to the Sfax Governorate is projected to decrease furthermore. It is also expected that no water, presently being conveyed by the North Water Transmission System, may reach the Sfax Governorate during summer, the peak consumption period due to increased water demand in the upstream areas.

Water demand and supply were reviewed under the conditions stipulated. In this calculation, the peak adjustment factor which was applied for water demand projection for whole seven governorates is not applied to the Sfax Governorate. The results are presented in Tables 4-9 to 4-11, and Figure 4-4.

Table 4-9 Water Demand in Sfax Governorate

	2015	2020	2025	2030	2035
Population	999,500	1,062,000	1,124,600	1,187,100	1,249,600
Population Served	862,600	925,600	988,600	1,051,600	1,114,700
Per Capita Consumption (L/person/day)	126	140	156	176	199
Non Domestic Rate (%)	18	18	18	18	18
Average Non-Revenue Water (%)	23	22	21	20	20
Daily Average Demand (m^3/day)	158,100	186,800	220,800	261,600	313,400
Peak Factor (Daily Max/Daily Average)*	1.321	1.321	1.322	1.322	1.322
Daily Maximum Demand (m^3/day)	208,800	246,800	291,900	345,800	414,200

*: peak factor (1.4) x adjusting coefficient

Source: JICA Survey Team

Table 4-10 Water Balance in Sfax Governorate (existing facilities only)

(m^3/day)		2015	2020	2022	2025	2030	2035
Available Water	North Water Transmission	119,000	30,900	0	0	0	0
	Jelma-Sbeitla GW Transmission	68,900	64,200	62,000	58,700	52,400	43,400
	Local Groundwater	42,400	42,400	42,400	42,400	42,400	42,400
	Total	230,300	137,500	104,500	101,100	94,900	85,800
Daily Maximum Water Demand		208,800	246,800	264,500	291,900	345,800	414,200
Balance		21,400	▲109,300	▲160,000	▲190,800	▲250,900	▲328,400

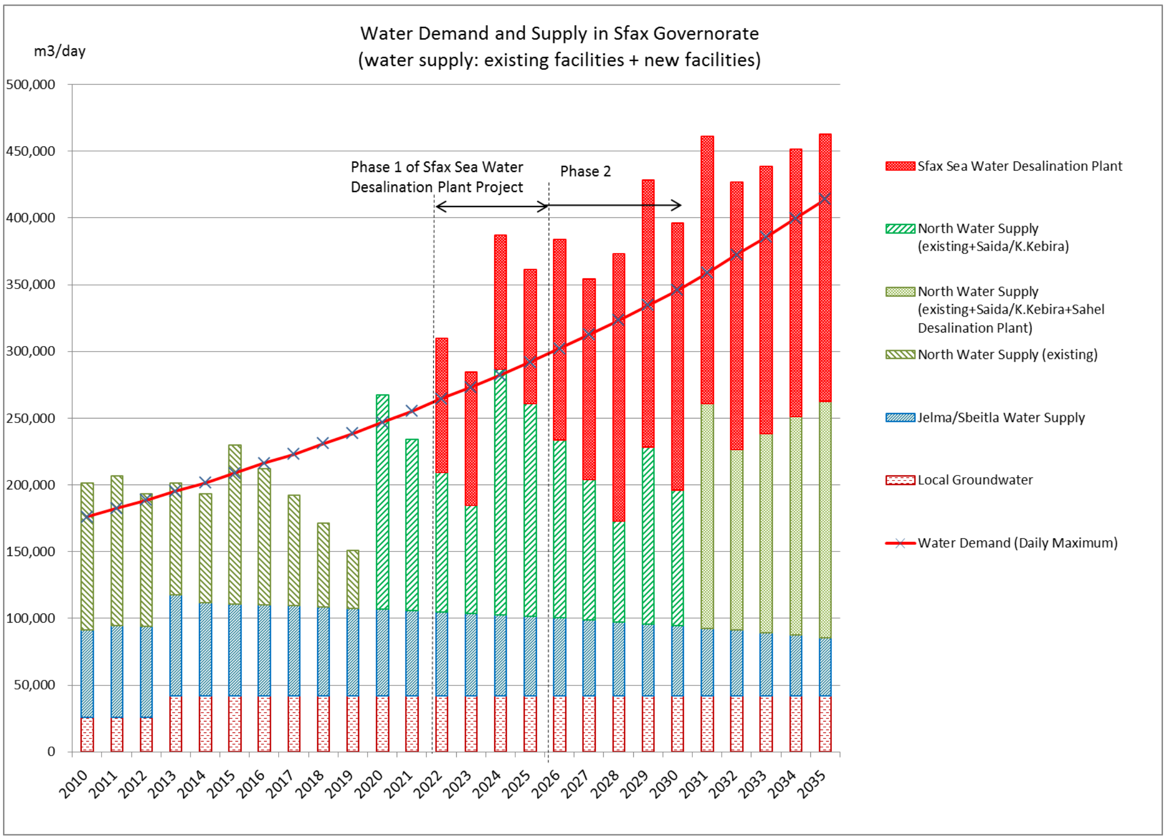
Note: Due to rounding, (available volume - demand) is not equal to Balance.

Source: JICA Survey Team

Table 4-11 Water Balance in Sfax Governorate (existing facilities + new facilities)

(m^3/day)		2015	2020	2022	2025	2030	2035
Available Water	Sfax Desalination Plant	0	0	100,000	100,000	200,000	200,000
	North Water Transmission	119,000	160,500	105,000	159,800	101,500	176,900
	Jelma-Sbeitla GW Transmission	68,900	64,200	62,000	58,700	52,400	43,400
	Local Groundwater	42,400	42,400	42,400	42,400	42,400	42,400
	Total	230,300	267,100	309,400	360,800	396,400	462,700
Daily Maximum Water Demand		208,800	246,800	264,500	291,900	345,800	414,200
Balance		21,400	20,300	45,000	69,000	50,600	48,500

Source: JICA Survey Team



Source: JICA Survey Team

Figure 4-4 Water Demand and Supply in Sfax Governorate (water supply: existing facilities + new facilities)

4.4 Water Demand and Supply in Greater Sfax

Water demand in the Greater Sfax is estimated as the population ratio between the Sfax Governorate and the Greater Sfax. Because the distribution data was not obtained, the demand was estimated from data between 2010 and 2012.

The Greater Sfax, where 2/3 of population in the Sfax Governorate lives, is the main urbanized area in the Sfax Governorate. In the future, the population in the Governorate is expected to increase. There are some special conditions in the Greater Sfax to be noted as follows.

1) On the way to the Greater Sfax, some amount of water from North Water Transmission System is distributed north of the Sfax Governorate. The remaining water is conveyed to the Greater Sfax.
2) On the way to the Greater Sfax, some amount of water from Jelma-Sbeitla Groundwater Transmission System in Sidi Bouzid Governorate, the west of the Sfax Governorate is distributed to the western part of the Sfax Governorate. The remaining water is conveyed to the Greater Sfax.
3) The Greater Sfax is the main urbanized area. However, the water is not supplied to the Greater Sfax with the highest priority. The concept on the equal treatment to the residents is applied.

Water demand and supply were reviewed with the conditions mentioned above. The results are presented in Tables 4-12 to 4-14, and Figures 4-5 and 4-6.

Table 4-12 Outline of Water Supply Plan in Greater Sfax

	Present (2012)	Yr 2025	Yr 2030	Yr 2035
1) Service Area	3,069 ha	3,069 ha	3,069 ha	3,069 ha
2) Population Served	631,900	737,900	782,100	826,300
3) Maximum Daily Water Supply	117,200 m^3/d 1,356 L/s	187,900 m^3/d 2,175 L/s	224,400 m^3/d 2,597 L/s	270,900 m^3/d 3,135 L/s
4) Average Daily Supply	83,700 m^3/d 969 L/s	134,200 m^3/d 1,553 L/s	160,300 m^3/d 1,855 L/s	193,500 m^3/d 2,240 L/s
5) Average Per Capita Supply	132 L/d/person	182 L/d/person	205 L/d/person	234 L/d/person
6) Non-domestic use (%)	18	18	18	18
7) Non-revenue Water (%)	24	22	21	20
8) Per Capita Consumption	91 L/d/person	126 L/d/person	144 L/d/person	165 L/d/person

Source: JICA Survey Team

Table 4-13 Water Balance in Greater Sfax (existing facilities only)

(m^3/day)		2015	2020	2022	2025	2030	2035
Available Water	North Water Transmission	95,200	24,700	0	0	0	0
	Jelma-Sbeitla GW Transmission	31,000	28,900	21,700	20,600	18,300	15,200
	Local Groundwater	25,100	26,100	26,100	26,100	26,100	26,100
	Total	151,400	78,700	46,800	45,700	43,500	40,300
Daily Maximum Water Demand		133,700	157,900	169,500	187,900	224,400	270,900
Balance		17,700	▲79,200	▲112,700	▲142,200	▲180,900	▲230,500

Source: JICA Survey Team

Table 4-14 Water Balance in Greater Sfax (existing facilities + new facilities)

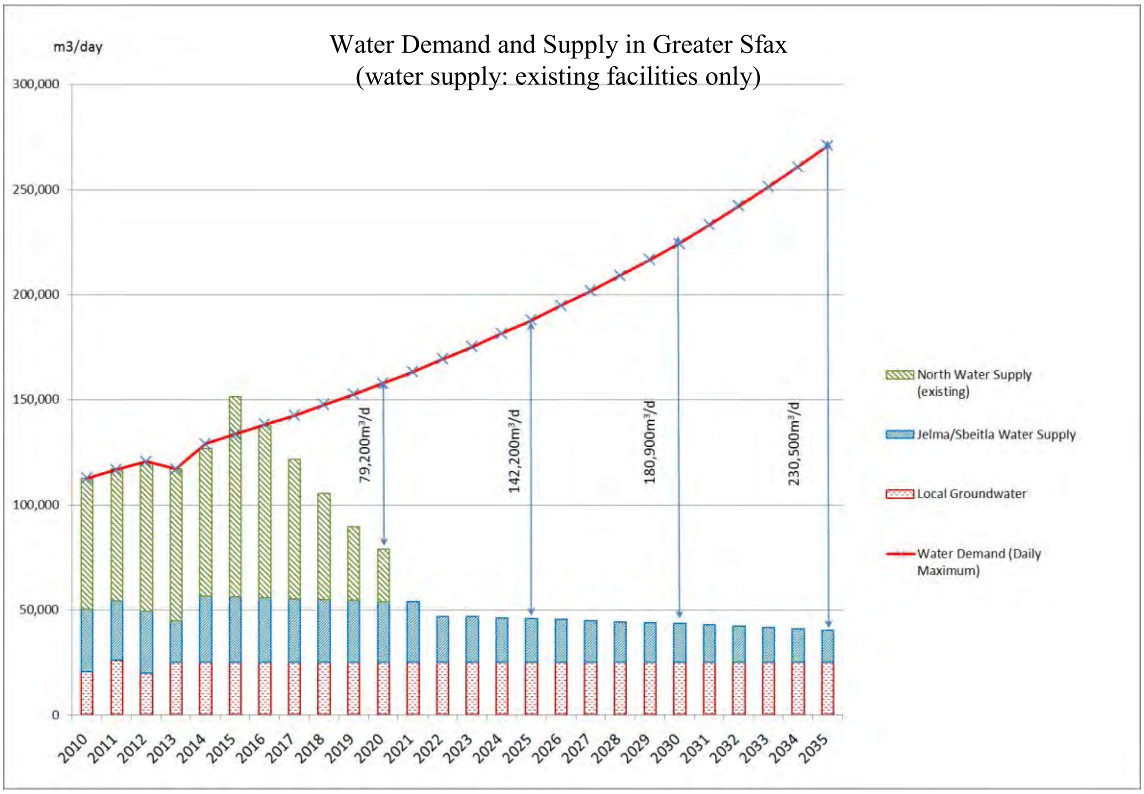
(m^3/day)		2015	2020	2022	2025	2030	2035
Available Water	Sfax Desalination Plant	0	0	100,000	100,000	200,000	200,000
	North Water Transmission	95,200	128,400	65,100	75,100	29,500	67,200
	Jelma-Sbeitla GW Transmission	31,000	28,900	21,700	20,600	18,300	15,200
	Local Groundwater	25,100	26,100	26,100	26,100	26,100	26,100
	Total	151,400	182,400	211,900	220,800	272,900	307,600
Daily Maximum Water Demand		133,700	157,900	169,500	187,900	224,400	270,900
Balance		17,700	24,500	42,400	32,900	48,500	36,700

Source: JICA Survey Team

Figure 4-5 indicates water balance of demand and the supply in the Greater Sfax in case the new facilities or the development of new water sources formulated by the Strategic Study are not implemented. Water supply for the existing facilities is estimated under the maximum conveyance condition. Under this condition, a large amount of water shortage is confirmed. The shortage will be at an amount of 79,200 m^3/d in 2020, 142,200 m^3/d in 2025, 180,900 m^3/d in 2030, and 230,500 m^3/d in 2035, respectively.

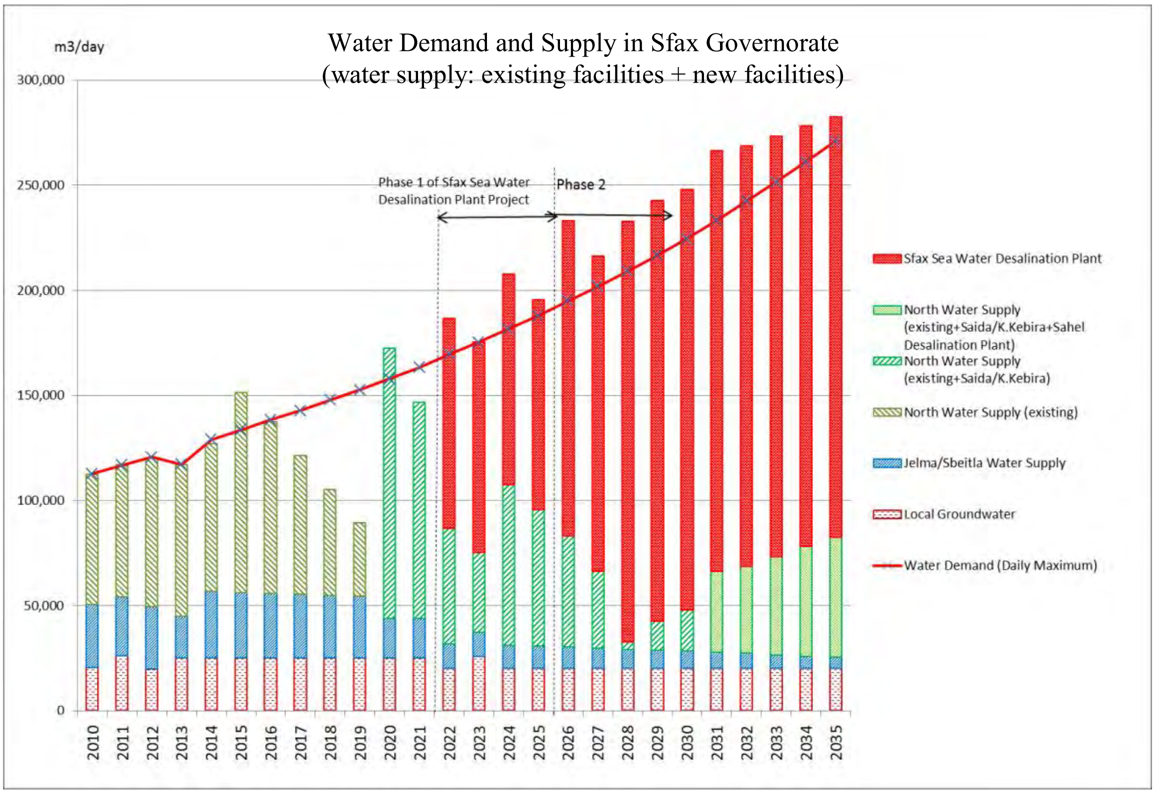
Figure 4-6 indicates the balance in case the new water sources developments formulated by the Strategic Study are implemented. The water supply volume shown in Figure 4-6 was assumed with the conditions that water volume equivalent to half of pumpage in the Greater Sfax is reduced from water supply of the North water transmission system and the same from the Jelma-Sbeitla groundwater transmission system,

As a result, water supply amount by the new facilities satisfies the demand. As mentioned before, however, shortage will still occur from 2017 to 2019.



Source: JICA Survey Team

Figure 4-5 Water Demand and Supply in Greater Sfax (water supply: existing facilities only)



Source: JICA Survey Team

Figure 4-6 Water Demand and Supply in Greater Sfax
(water supply: existing facilities + new facilities)

CHAPTER 5 STUDY ON SEAWATER DESALINATION PLANT

5.1 Basic Planning of Seawater Desalination Plant

5.1.1 Selection of Seawater Desalination Process

According to the required energy and the installation inventory, it is obvious that RO membrane process has more advantages than the other processes in Tunisia. Considering said advantages, the RO membrane process is selected for the proposed desalination plant.

5.1.2 Design Criteria of Seawater Desalination Plant

Table 5-1 summarizes the design values related to the water quality in this Project.

Table 5-1 Design Condition for Product Water

Items	SFAX, for design	Djerba (reference)	Reference
Produce water quality (TDS)	500mg/L	400mg/L	
Seawater salinity (TDS)	Less than 41,000mg/L	At 41,210mg/L	
Seawater temperature	Less than 25 °C	At 20 °C	
Guarantee period [*1] (after feeding water)	3 years[*2]	3 years	
Recovery ratio	45%	45%	
Boron	2.4 mg/L	1.2 mg/L	New drinking water standard NT09.14(2013) : 2.4mg/L
Guarantee period (after feeding water)	3 years	1 year	
Membrane replacement ratio per year	20%/year[*3]	-	
Production capacity per unit	25,000m^3/day/unit	25,000m^3/day/unit	
Water flux	13 L/m^2/h	13 L/m^2/h	
Electric power consumption	4.2 kWh/m^3	4.2 kWh/m^3	

Notes)

*1: Guarantee period for RO unit. It is not a defect liability period of the plant. The guarantee period of the equipment will start from the beginning of the guarantee test of the plant

*2: Referring to the specification of tender documents for Djerba Seawater Desalination Plant project, 3 years, which is common in the similar projects, was employed for the period.

*3: The value recommended by the manufacturers based on their experiences.

Source：JICA Survey team

5.2 Construction Site for Seawater Desalination Plant

The site for the plant is to be selected from seven sites, consisted of four sites selected by SONEDE at the beginning of the survey, and three sites proposed by JICA Survey Team after the survey started as shown in Table 5-2.

Table 5-2 Result of Site Selection for Desalination Plant

No	Location	Primary Selection		Secondary Selection		Evaluation of APAL	Final Judgement
		Result	Judgement	Priority order	Judgement		
1	El Amra Nord (Sfax)	Inferior					
2	El Amra Sud (Sfax)	Inferior					
3	Agareb (Sfax)		Pass to next stage	2	Consultation with APAL	Accept	Select
4	Chebba Sud (Mahdia)	Inferior					
5	Nakta (Sfax)		Pass to next stage	1	Consultation with APAL	Reject	
6	Chebba Nord (Mahdia)		Pass to next stage	3			
7	Mahres (Sfax)		Pass to next stage	4			

Source: JICA Survey Team

From the second evaluation, the top two sites were selected for the final evaluation. These two sites are located inside of Public Maritime Domain (DPM, French: Domain Public Maritime), where permission from APAL is required. The top ranked candidate site is located near the sandy beach used for tourism. According to APAL, permission to use the site for the plant installation will not be granted in order to conserve the beach. The other site does not have any plan. Neither is there any objection to construct the plant. Therefore, this site has been selected for the plant installation.

The exact site for the plant installation was officially identified after APAL studied the location in detail. The location is just the southwest side of the selected site. Based on this site, all facilities for the desalination plant have been planned. After approval of Environmental Impact Assessment (EIA) by ANPE, APAL will officially permit the site for utilization to set up the plant.

5.3 Seawater Intake

5.3.1 Basic Plan of Intake Facility

(1) Intake Method: The direct intake through pipeline is selected for the Project.

(2) Intake Point: The intake head and the brine discharge head are to be installed at 3,600 m (water depth of eight m at low tide) and 4,400 m (water depth of 10 m at low tide), respectively, away from the south of the desalination plant.

(3) Intake volume: 444,400m^3/day

(4) Length of intake pipeline: Length of the intake pipeline is 3,600 metres including 400 metres in land

(5) Pipeline head loss:
In order to avoid deep excavation at the coast, which will make construction works difficult and raise cost, excavation depth at the intake pit was set to be less than 10m below ground level. The bottom level of the intake pit will be around 8.5m below ground level in case the diameter of intake pipeline is 2m. Consequently, friction loss from the pipeline shall be less than about 1.8m.

(6) Number of intake pipelines: The basic approach is for the single intake pipeline.

(7) Pipe material: HDPE is selected for the Project.

(8) Sodium hypochlorite will be injected to prevent the growth of shellfish, oyster, seaweed, etc. inside of the pipe. The HDPE pipe with a diameter of 4-inch will be applied.

(9) Construction under the sea is highly dependent on the weather and special technology is needed as well. The interval of Phase 1 and with Phase2 is a short five years. In order to minimize the cost and to shorten the period of construction, the entire facility shall be constructed at this stage.

5.3.2 Estimation of Intake Pipe Diameter

The pipe diameter is calculated as;

- intake volume: 444,400 m^3/d
- total head loss: approximately 2 m (pipeline head loss : about 1.8m)
- roughness coefficient: 0.016
- Formula: Manning formula

As a result of the calculation, a diameter of 2500mm for HDPE is required in case of the single pipeline. Presently, not many manufacturers have experience in manufacturing large diameter of HDPE pipes. In case of the double pipeline, a diameter of 2000 mm is required, and there are manufacturers that have sufficient level of reliability and experience in the manufacture of said pipeline. Having a double pipeline is advantageous. When one pipeline malfunctions, the other pipeline is available for the intake, thus the plant can produce desalinated water continuously. In Phase 1, one pipeline can transmit the full capacity of the intake volume. Even though the cost is higher, the double pipeline is selected for the above reasons.

5.4 Brine Discharge

5.4.1 Basic Plan of Brine Discharge Facility

(1) Discharge system: underwater discharge - off shore discharge multi-nozzle type

(2) Brine discharge volume : 244,400 m^3/d

(3) Length of brine discharge pipeline

The total length of the brine discharge pipeline is 4.4 kilometres, which includes 0.4 kilometres in land, and 4.0 kilometres in the sea. The distance between intake and discharge towers is 800 metres.

(4) Pipeline head loss

Considering the loss at the discharge nozzle and in the pipe, the total head loss is approximately 3mH as precondition. Therefore, pipeline head loss shall be about 2.1m.

(5) Number of discharge pipeline

The basic approach is the single discharge pipeline.

(6) Pipe materials

HDPE is selected.

(7) Marine construction is considered as a special requirement. Based on this, the brine discharge pipeline is to be installed together with the intake pipeline.

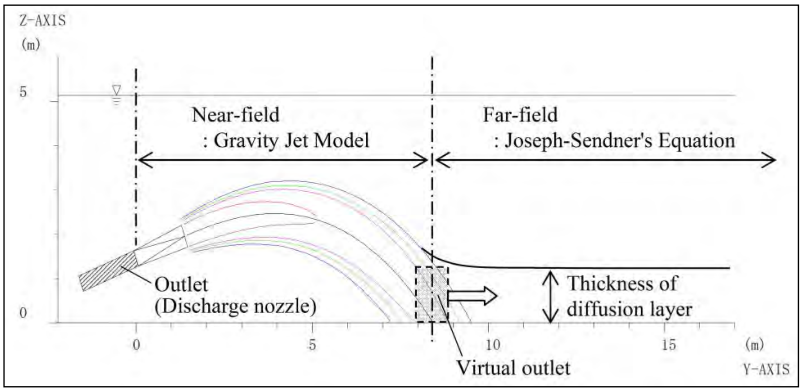
5.4.2 Estimation of Brine Discharge Pipe Diameter

Total head loss in the pipeline is assumed at approximately 3 mH as a precondition. Under this quality, few marine organisms are expected to adhere to the pipes. Based on this consideration, a coefficient of roughness is applied at 0.012[2]. As the result, a diameter of 1,800 mm is required for HDPE

5.4.3 Simulation on Dilution and Diffusion of Brine Discharge

(1) General

The salinity impact is 1.8 times higher (TDS: 70,500 ~ 74,100mg/L), compared to the raw seawater (TDS: 39,000 ~ 41,000mg/L). This has to be investigated for the surrounding condition by dilution and diffusion.



Source: Tokyo Kyuei Co., Ltd.

Figure 5-1 Image of Brine Diffusion

(2) Simulation result

1) Near Field: Application of "Gravity Jet Model"

Brine is discharged, and mixed with raw seawater at the difference of salinity or ΔS of 33.3 psu*, i.e.74,300mg/L. When reaching the seabed at 12 m from the discharge tower, brine is diluted until ΔS of 7.4 psu, i.e. 48,400mg/L. (*: psu - Practical Salinity Unit; 1000mg/L）

2) Far field: Application of "Joseph-Sendner's Equation"

The brine, reaching the seabed at 12 m from the discharge tower, is continuously diffused and diluted. In this zone, the diffusion of the salinity is expected as indicated in Table 5-3.

Table 5-3 Estimation of Salinity in Far Field

ΔS	Radius of influenced area[*1]	Estimated concentration at seabed (Seawater at discharge point: 41,000mg/L）	Influence to *Posidonia oceanica* [*2]
>4	12m (reaching point)	48,400	May die after long period
	170m	48,400～45,000	
>2	381m	45,000～43,000	Almost no influence
>1	742m	43,000～42,000	No influence

(*1) This distance is from the discharge nozzle. See Figure 5.4-10 and Figure 5.4-11.

(*2) According to ANPE, *Posidonia oceanica* die immediately by contact of salinity over 52,000mg/L, die at 52,000～50,000mg/L, and may die at 50,000～45,000mg/L after contacting for a long period. As additional information, Yolanda Fernandez-Torquemada et al. reported in Estuarine Coastal and Shelf Science that salinity over 46,000mg/L gives serous impact to death of *Posidonia oceanica*.

Source : JICA Survey Team

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[2] Manning's roughness coefficient is 0.010 for smooth wall surface of plastic pipes. Wall surface of HDPE pipe, however, is slightly rough, and seems to be larger than 0.010. In this survey, it was set at 0.012 based on the suggestion of the Tokyo Kyuei Co., Ltd. who has many experiences of designing and construction work of marine discharge pipeline.

(3) Conclusion

1) Some influence to *Posidonia oceanica* may be observed in the limited area near the discharge point. The salinity is diluted at TDS 45,000 mg/L or little influence to *Posidonia oceanica* at 170 metres from the discharge point.

2) The salinity assumed in this simulation is the maximum value. Usually the salinity is of lower concentration. Therefore, it is expected that the influence area is smaller than the result of the simulation.

5.5 Facility Layout Plan

5.5.1 Facilities at Desalination Plant Site

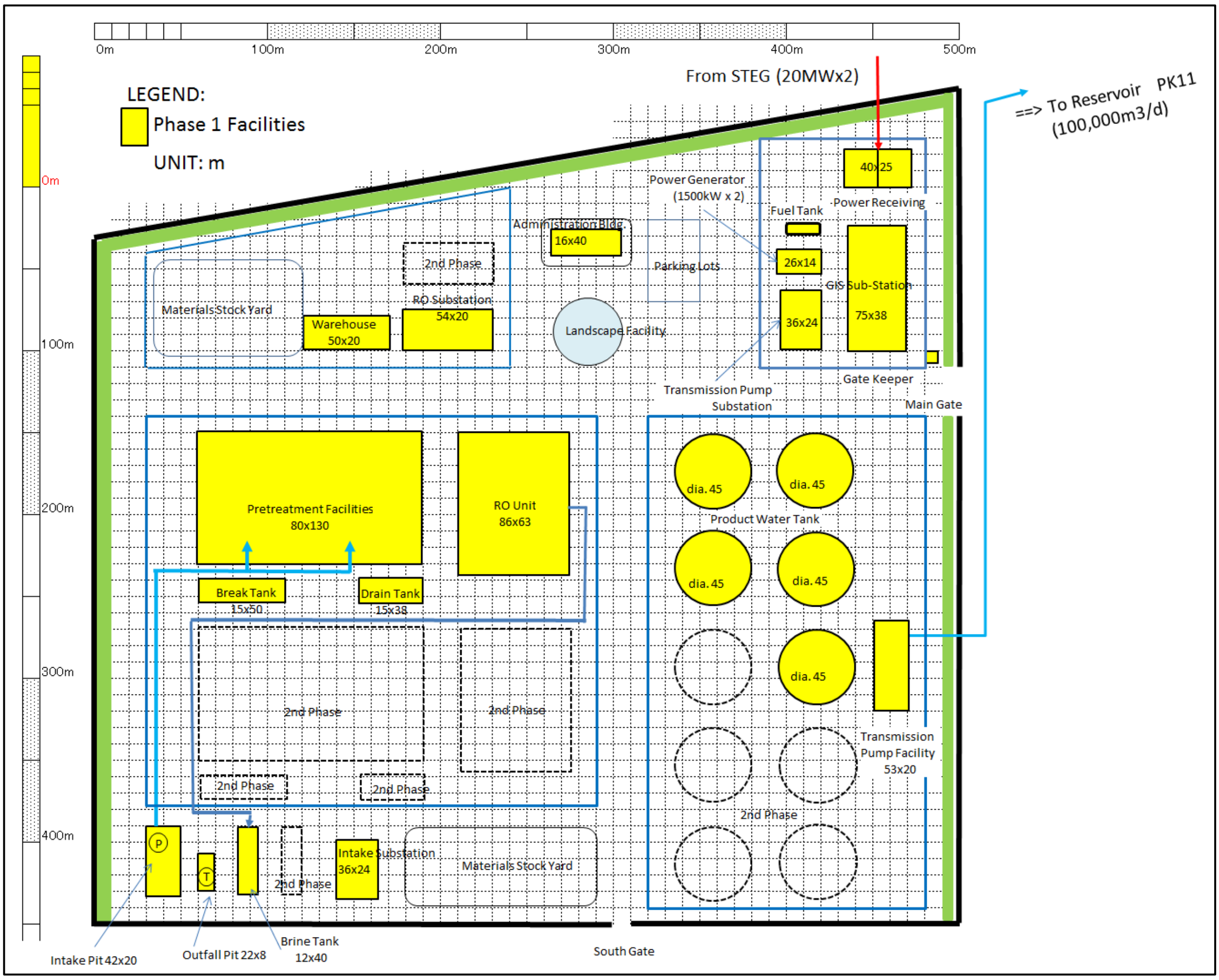
The facilities planned to be constructed in Phase 1 are summarized in Table 5-4.

Table 5-4 Components of Phase 1 Project

Facility	Contents
Seawater Intake Pipe	· Intake Volume: 222,200m^3/d (capable of flowing 444,400 m^3/d after the completion of Phase 2) · Pipe Material: HDPE · φ2000mm x 2, L=3.6km (Buried, off-shore; 3.2km, on-shore;0.4km) · Submerged Water Intake Head: 2
Seawater Desalination Plant	· Land Acquisition: Approximately 20ha · Desalination Method: Reverse Osmosis (RO) Membrane Method · Desalinated Water: 100,000m^3/d · RO Units: 25,000m^3/day × 4 units
Brine Discharge Pipe	· Discharge Volume: 122,200m^3/d (applicable to total capacity of 244,400 m^3/d in Phase 2) · Pipe Material: HDPE · φ1800mm, L=4.4km (Buried, off-shore; 4.0km, on-shore;0.4km) · Submerged Water Discharge Head: 1

5.5.2 Layout Plan

The layout of the facilities is presented in Figure 5-2.



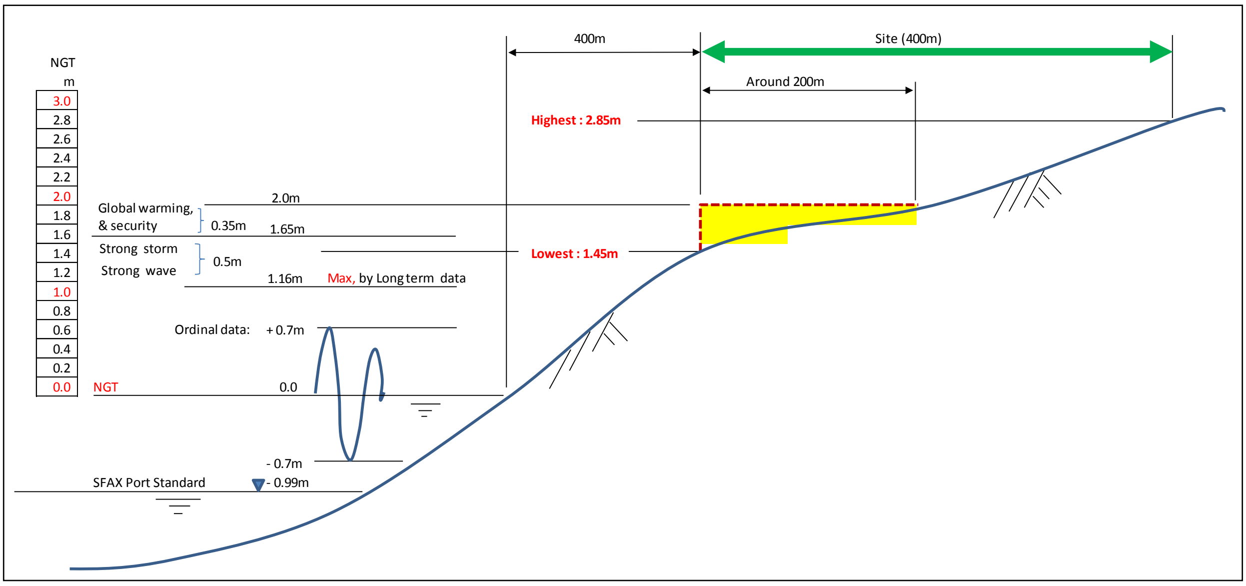
(Source: JICA Study Team)

Figure 5-2 Layout of Desalination Plant Facilities (Details)

5.5.3 Relationship between Seawater Level and Desalination Plant Site

When the highest height of the sea level is converted to NGT base, the height is calculated to be +1.16m NGT (=2.15-0.99).

However, when considering strong wind and extraordinary high waves, 0.5m is added. Due to future global warming, seawater level is expected to increase by 0.35m, and this is also considered, including other surplus factor. Thus, total +2m NGT is concluded to be safe height from sea level.



Source：JICA Survey Team

Figure 5-3 Relationship between Sea Level and Plant Site

CHAPTER 6 PLAN OF WATER SUPPLY FACILITIES

6.1 Water Transmission Network Plan

6.1.1 Planning Policy for Water Transmission Network Plan

1) Water Supply Area

Currently, SONEDE has implemented augmentation and rehabilitation of reservoirs, and the upgrading and the rehabilitation of the transmission and the distribution pipe networks. The distribution service area of the Greater Sfax in this survey corresponds with the plan established in 2003.

2) Water Quality Improvement

Through this Project, SONEDE has a desire to attain TDS concentrations of less than 1,500 mg/L and other parameters for achieving the parameters of the Tunisian drinking water regulations. The TDS concentration of desalinated water at the plant in this Project is 500mg/L. Based on this concentration and the production volume in phase, the final TDS concentration is targeted at less than 1500 mg/L in Phase 1, and less than 1200mg/L in Phase 2, respectively.

SONEDE desires to distribute water with the same TDS concentration to avoid complaints from the residents about partiality.

In this survey, it may be considered that a difference in water quality from the reservoir will be allowed to some extent due to the significant improvement of water quality comparing with the present status. Therefore, it is planned to minimize the difference of water quality among reservoirs with maximum utilization of existing pipe network to save investment cost. As a result, the difference between the highest and the lowest TDS concentrations will be less than 200% in Phase 1, and less than 180% in Phase 2.

3) Utilization of Existing Resources

In order to reduce the initial investment cost and operational cost, the capacities of the existing facilities will be maximized to include both the water sources and the transmission network.

6.1.2 Considerations on Water Transmission Network Plan

(1) Basic Policy for Water Transmission Plan after Installation of the Seawater Desalination Plant in Sfax (see Figure 6-1)

The water transmission plan was examined on the following conditions.

- Daily maximum water supply volume is utilized as the planning capacity for the facilities.
- The design transmission volume between sea water desalination plant and reservoirs or between reservoirs is determined in consideration of the rational water transfer system over the entire service area.
- In accordance with SONEDE's water service policy, the capacity of the reservoir is planned at 40% of the daily maximum water distribution volume[3].
- The basic approach for new reservoirs is planned at the existing reservoir sites. In addition, the new reservoirs are planned with the standard reservoir of SONEDE

(2) Planning Conditions for Transmission of Produced Water from the Seawater Desalination Plant

- The sea water desalination plant site is located at a lower altitude than the reservoir. Therefore, the water is transmitted by pumping.
- The transmission pump facility at the sea water desalination plant is installed at the same site as the plant. The pump facilities along the route of the transmission are installed at the site of the existing reservoirs.
- The reservoir directly transmitted to from the sea water desalination plant is the PK11 reservoir, which is a main facility of the water distribution in Sfax.
- Water transmission between reservoirs is carried out by pumping from PK11 to Bou Merra, from PK11 to PK10, from PK10 to PK14, and from PK14 to Sidi Salah EH[4].
- Water is transmitted by gravity from Sidi Salah EH Reservoir to Sidi Salah EB Reservoir.

(3) Planning Conditions for Water Transmission from the North Water Transmission System

- The water from the North Water Transmission System is basically transmitted to the Sidi Salah

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[3] No definite regulation or rule exists.

[4]: It was found through examination that it is most economical to transmit required water by relay pumping. Further, it was found that a large amount of water from all water sources shall be mixed at one place, and then be sent to each reservoir in order to lessen the difference of water quality at each reservoir. Because of this reason, a mixing tank is set at PK11 to mix water produced in the Sea Water Desalination Plant and the water from existing sources. By this method, land acquisition for reservoir and mixing tank will not be necessary during Phase 1.

EH Reservoir, the PK14 Reservoir, and the PK10 Reservoir.

- The water is also transmitted to the PK11 Reservoir by gravity though the existing pipeline to the PK10 and the PK11 Reservoirs.
- The Sidi Salah EB Reservoir will be operated from 2016. The water to the Sidi Salah EB Reservoir will be transmitted by gravity from the Sidi Salah EH Reservoir.

(4) Planning Conditions for Water Transmission from the Jelma-Sbeitla Groundwater Transmission System

- The water from the Jelma-Sbeitla Groundwater Transmission System is basically transmitted to the Bou Merra Reservoir and the PK11 Reservoir. Presently, most of water distributed from the Bou Merra Reservoir is taken from the well located in the site of the Bou Merra Reservoir after deferrization.
- There are pipelines, which can transmit the water from the Jelma-Sbeitla Groundwater Transmission System to reservoirs of PK10 and PK14, but are rarely utilized actually.

(5) Planning Conditions for Groundwater in the Greater Sfax

About 20 % of the current pumpage will be reduced. The equivalent flow of a 1/2 of pumpage will be reduced from water supply by the Jelma-Sbeitla Groundwater Transmission System. In addition, the equivalent flow of a 1/2 of pumpage will be reduced from the water supply by the North Water Transmission System.

In terms of water quality, the TDS concentration of less than 1500mg/l, which was requested by SONEDE, can be secured.

6.1.3 Water Transmission Plan for Greater Sfax

Following the policies and considerations stated in Section 6.1.2, the water transmission plan was formulated with a defined water transmission volume from each water source in each year until the target year.

The strategic plan of SONEDE includes water demand volume for the Sfax Governorate, but the plan of water volume for distribution at each reservoir is not included. In this survey, therefore, distribution volumes at each reservoir were planned based on the ratios of distribution volumes at each reservoir taken up in the “Plan of Distribution Networks and Distribution in Greater Sfax” and capacities of the existing reservoirs. Planned distribution volumes for each reservoir are as shown in Table 6-1.

Table 6-1 Distribution Volume by Reservoir

Daily Maximum (m^3/d)

Zone	Daily Max. (m^3/d)	2013	2022	2025	2030	2035
Low Distribution Zone	PK11	23,602	37,300	43,200	49,700	59,100
	PK10	42,899	48,300	50,100	61,700	73,200
	Sidi Salah EB	-	20,400	27,200	40,100	50,400
High. Distribution Zone	Bou Merra	4,081	13,100	15,100	18,900	23,100
	PK14	31,200	33,700	34,600	36,000	43,100
	Sidi Salah EH	15,248	16,700	17,800	18,000	21,900
All	Greater Sfax	117,030	169,500	188,000	224,400	270,800

Source: JICA Survey Team

Capacities of reservoirs were examined based on the distribution volumes shown in Table 6-1 to attain the target minimum capacity of reservoirs in Phase 1 at around 6 hours of daily maximum distribution volume[5], equivalent to 8.4 hours of daily average distribution volume as a minimum. The results are as shown in Table 6-2.

Table 6-2 Capacities of Reservoirs (m^3)

Zone	Reservoir	2013	2021	2025	2030	2035
Low Distribution Zone	PK11	22,000	22,000	22,000	22,000	**24,500**
	PK10	20,000	20,000	20,000	**30,000**	30,000
	Sidi Salah EB	-	5,000	5,000	**15,000**	**20,000**
High. Distribution Zone	Bou Merra	1,500	**6,500**	6,500	**9,000**	9,000
	PK14	10,000	10,000	10,000	**15,000**	**17,500**
	Sidi Salah EH	7,500	7,500	7,500	7,500	**10,000**
All	Greater Sfax	61,000	71,000	71,000	98,500	111,000

Source: JICA Survey Team

The TDS concentrations calculated based on the water source allocation plan are summarized in Table 6-3. The highest TDS concentration in Phase 1 is 1487 mg/L, and ratio between the highest and the lowest are less than 200%. Figure 6-1 presents the schematic diagram of water transmission plan for 2025, the last year of Phase 1.

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[5]: Since urgency and cost saving are requested for Phase 1, the minimum requirement for capacity is set at around 6 hours which is sufficient to buffer hourly fluctuation in a day. In Phase 2, it is planned to satisfy requirement, i.e. 40% of average daily distribution volume.

Table 6-3 Planned TDS Concentrations by Reservoir

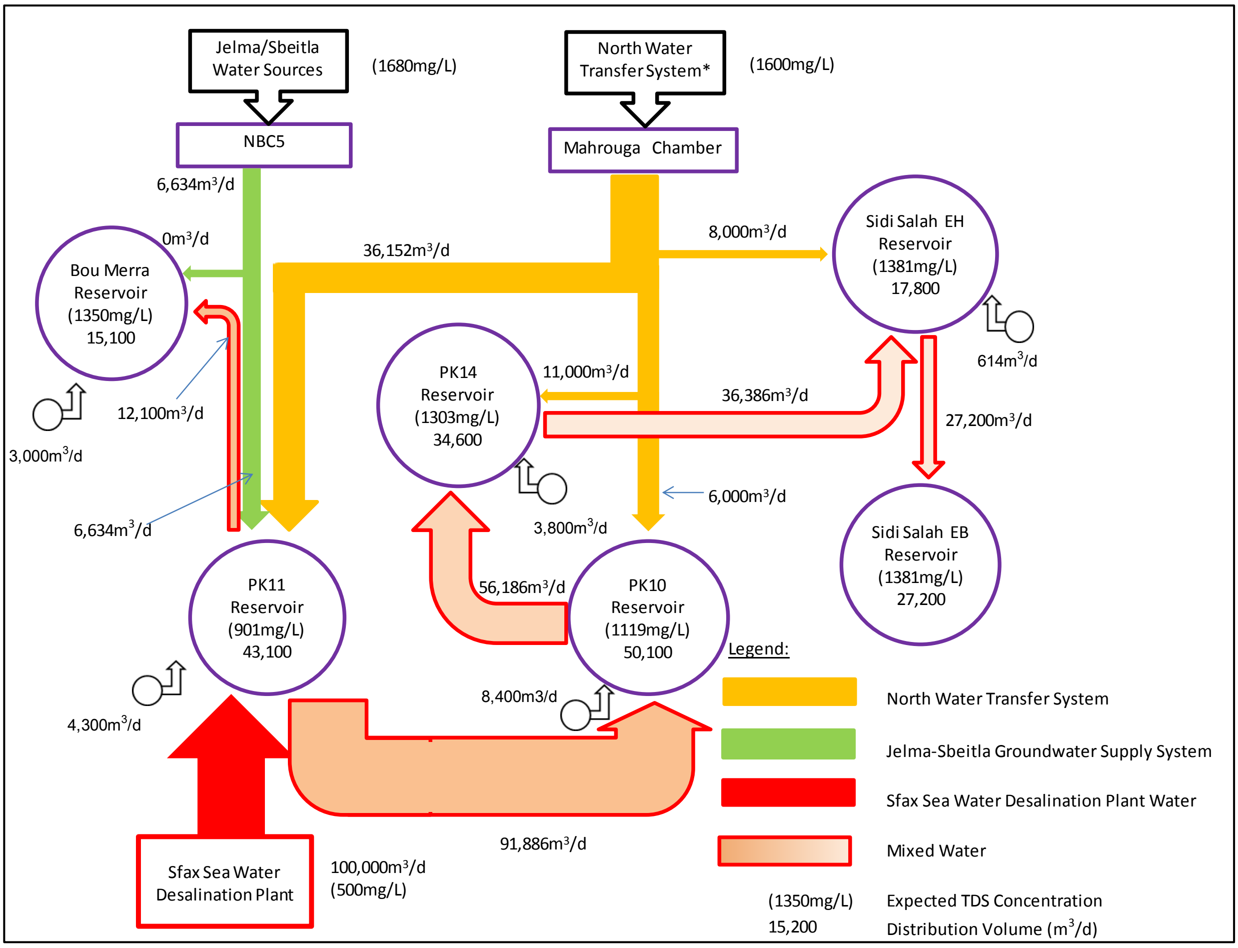
Unit: TDS mg/L、 Q m^3/day

TDS(mg/l)			Phase 1				
Reservoir	2020	2021	2022	2023	2024	2025	
PK11	1,800	1,861	733	888	866	901	
Bou Merra	2,293	2,243	1,289	1,464	1,344	1,350	
PK10	1,888	1,906	1,215	1,109	1,096	1,119	
PK14	1,822	1,820	1,396	1,283	1,293	1,303	
Sidi Salah EH	1,835	1,810	1,459	1,487	1,378	1,381	
Sidi Salah EB	1,835	1,810	1,459	1,487	1,378	1,381	
Highest TDS	2,293	2,243	1,459	**1,487**	1,378	1,381	< 1,487
Lowest TDS	1,800	1,810	733	888	866	901	
Highest/Lowest	127%	124%	**199%**	168%	159%	153%	< 199%
Desalination Q	0	0	90,000	100,000	100,000	100,000	

TDS(mg/l)	Phase 2-1					
Reservoir	2026	2027	2028	2029	2030	
PK11	709	648	599	587	596	
Bou Merra	1,171	1,102	1,040	1,013	1,003	
PK10	931	868	755	749	795	
PK14	1,126	1,066	863	930	964	
Sidi Salah EH	1,192	1,134	928	1,015	1,042	
Sidi Salah EB	1,192	1,134	928	1,015	1,042	
Highest TDS	**1,192**	1,134	1,040	1,015	1,042	< 1,192
Lowest TDS	709	648	599	587	596	
Highest/Lowest	168%	**175%**	174%	173%	175%	< 175%
Desalination Q	135,000	150,000	180,000	180,000	180,000	

TDS(mg/l)	Phase 2-2					
Reservoir	2031	2032	2033	2034	2035	
PK11	606	643	685	622	661	
Bou Merra	995	1,010	1,032	964	985	
PK10	803	831	860	796	830	
PK14	1,020	1,037	1,052	992	1,012	
Sidi Salah EH	1,089	1,119	1,129	1,072	1,087	
Sidi Salah EB	1,089	1,119	1,129	1,072	1,087	
Highest TDS	1,089	1,119	**1,129**	1,072	1,087	< 1,129
Lowest TDS	606	643	685	622	661	
Highest/Lowest	**180%**	174%	165%	172%	165%	< 180%
Desalination Q	180,000	180,000	180,000	200,000	200,000	

Source: JICA Survey Team



Source: JICA Survey Team

Figure 6-1 Desalinated Water Supply Plan in Greater Sfax (Year 2025)

The development plan of facilities till 2035 is as follows. Facilities which are underlined are those to be developed in Phase 1 of the Project. *Facilities written in Italic are those to be developed outside of the Project.* In the plan, the Seawater Desalination Plant, Saida reservoir, and Kalaa Kebira reservoir and water treatment plant are planned to be developed based on SONEDE's plan.

1) 2022: Just after start of operating Sfax Seawater Desalination Plant (Phase 1)

- *in 2020: Inauguration of Saida Reservoir, and Kalaa Kebira Reservoir and Water Treatment Plant (capacity; 1,500 L/sec = 129,600 m^3/d)*
- in 2022: Start of operation of Phase 1 of Seawater Desalination Plant in Sfax (capacity; 100,000m^3/d)
- in 2022: Start of operation of the transmission pipelines from the desalination plant to the 5 reservoirs, i.e. PK11, Bou Merra, PK10, PK14, and Sidi Salah EH.
- by 2022: Capacity augmentation of 5,000m^3 at Bou Merra (total capacity; 6,500m^3)

2) 2022 to 2025: Target year of Phase 1 for Sfax Seawater Desalination Plant Construction Project, Preparation of Phase 2 project (See Figure 6-1)

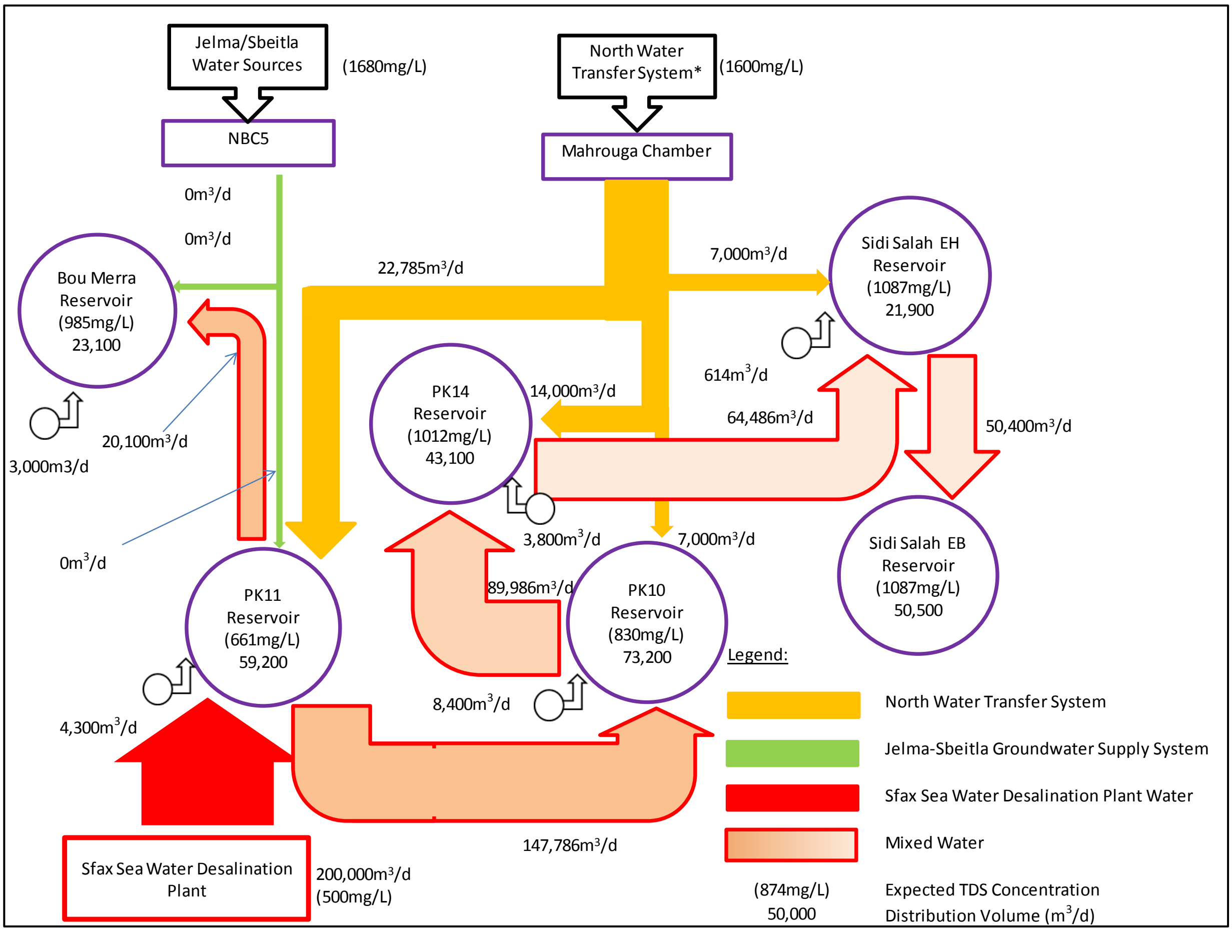
- *by 2024: Capacity augmentation of Kalaa Kebira Water Treatment Plant (total capacity; 3,000L/sec = 259,200m^3/d)*
- by the end of 2025: Capacity augmentation of 100,000m^3/d at Sfax Sea Water Desalination Plant (total capacity; 200,000m^3/d. It is necessary to examine phased augmentation.)
- by the end of 2025: Capacity augmentation of 2,500m^3 at Bou Merra (total capacity; 9,000m^3)
- by the end of 2025: Capacity augmentation of 5,000m^3 at PK10 (total capacity; 25,000m^3)
- by the end of 2025: Capacity augmentation of 5,000m^3 at PK14 (total capacity; 15,000m^3)
- by the end of 2025: Capacity augmentation of 10,000m^3 at Sidi Salah EB (total capacity; 15,000m^3)

3) 2026 to 2030: Just before start of operating the Sahel Seawater Desalination Plant

- *by 2029: Capacity augmentation of Kalaa Kebira Water Treatment Plant (total capacity; 4,000L/sec = 345,600 m^3/d)*
- by 2030: Capacity augmentation of 5,000m^3 at PK10 (total capacity; 30,000m^3)
- by 2030: Capacity augmentation of 5,000m^3 at Sidi Salah EB (total capacity; 20,000m^3)

4) 2031 to 2035: Target year of this survey (See Figure 6-2)

- *by 2031:* Inauguration *of Sahel Sea Water Desalination Plant (capacity; 50,000m^3/d)*
- by 2032: Capacity augmentation of 2,500m^3 at PK14 (total capacity; 17,500m^3)
- by 2032: Capacity augmentation of 2,500m^3 at Sidi Salah EH (total capacity; 10,000m^3)
- by 2033: Capacity augmentation of 2,500m^3 at PK11 (total capacity; 24,500m^3)
- *by 2035: Sequential capacity augmentation of 200,000m^3/d at Sahel Sea Water Desalination Plant (total capacity; 250,000m^3/d)*



Source: JICA Survey Team

Figure 6-2 Desalinated Water Supply Plan in Greater Sfax (Year 2035)

In this water transfer network plan and regarding the seawater desalination plant, facilities constructed in Phase 1 and Phase 2 will be operated from 2022 and 2026, respectively, fiving ample time for procedures required for Japanese Yen Loan Project. Between 2022 and 2026, and after 2026, the expansion or new installation of reservoirs and desalination plant shall be implemented. The expansion of Bou Merra Reservoir is required by 2021. Therefore, Phase 1 of the Project, in which facilities to be installed under Japanese Yen Loan Project, will consists of; i) Phase 1 facility of Sfax sea water desalination plant, ii) transmission pipelines from the desalination plant to reservoirs, iii) receiving/mixing chambers receiving the desalinated water or mixed water, iv) a reservoir, v) pumping facilities transmitting the desalinated water to each reservoir, and auxiliary facilities required at facilities mentioned in i) to v). With regard to distribution pipelines, it was judged that enhancement of distribution pipelines is not necessary in Phase 1 of the Project because the development of distribution pipelines has been implemented in accordance with the “Plan of Distribution Networks and Distribution in Greater Sfax”. Also, the distribution plan in this survey followed the principles in said Plan.

The years mentioned in the plan are based on the SONEDE's Plan subject to change in accordance with the Project implementation schedule to be established.

6.2 Water Transmission Facilities

(1) Transmission Pump

The transmission pumps, transmitting the desalinated water reserved at the product water tank to reservoirs, are installed at the pump house of the sea water desalination plant. In Phase 1, 3 pumps (2 for regular use, 1 for standby) capable of transmitting a volume of 100,000 m^3/d are to be installed.

In the pump house, a space for installation of pumps in Phase 2 is reserved. The size of the space is the same as Phase 1 since both phases have the the same volume of the transmission. In consideration of energy efficiency and to avoid the replacement of pumps, the two pumps selected for Phase 1 are the variable-speed drive (VSD) type.

After reviewing the elevation of the desalination plant and each reservoir, the volume of the water transmission, and the diameters of the transmission pipeline, the specification of the pumps are selected as follows:

- Transmission Pumps

  Phase 1: flow rate; 34.8m^3/min/pump, total head; 95m, output; 800kW x 2 pumps (＋1 pump for standby), total 3pumps (2pump: variable-speed drive (VSD))

  Phase 2: flow rate; 34.8m^3/min/pump, total head; 95m, output; 800kW x 2 pumps (＋1 pump for standby), total 3pumps (2pumps: variable-speed drive (VSD))

(2) Transmission Pipeline

The transmission pipeline will be installed to transmit the desalinated water and mixed water; i) from the transmission pump facility at the Sfax Seawater Desalination Plant to the PK11 Reservoir, ii) from the PK11 Reservoir to the Bou Merra Reservoir, iii) from the PK11 Reservoir to the PK10 Reservoir, iv) from the PK10 Reservoir to the PK14 Reservoir, and v) the PK14 Reservoir to the Sidi Salah EH Reservoir.

Diameters of the pipelines were decided considering transmitted flow and pump head as presented in Table 6-4. Materials of pipes were examined, and Ductile Cast Iron Pipe was selected for the Project.

Table 6-4 Diameters of Transmission Pipelines

Section	Distance (km)	Flow (m^3/d)*	Diameter (mm)
Desalination Plant—PK11	26.3	200,000	1400
PK11—Bou Merra	2.9	20,100	400
PK11—PK10	6.1	147,786	1000
PK10—PK14	4.8	89,986	800
PK14—Sidi Salah EH	9.4	64,686	800

*: Maximum flow till 2035

Source: JICA Survey Team

(3) Intermediate Pumping Stations

It is necessary to install the intermediate pumping stations at PK10, PK11, and PK14 for transmission; i) from PK11 to Bou Merra, ii) from PK11 to PK10, iii) from PK10 to PK14, and iv) from PK14 to Sidi Salah EH. The number of pumps

Table 6-5 Intermediate Pumping Stations

Pump station	Flow rate (m^3/d, max.)	Flow rate (m^3/min./unit)	Total head (m)	Output (kW/unit)	Phase 1 Number (standby)	Phase 1 VSD	Phase 2 Number (standby)	Phase 2 VSD
Desalination plant — PK11	100,000	34.8	(72)	(600)	3(1)	2	-	-
	200,000	34.8	95	800	3(1)	2	3(1)	2
PK11 — Bou Merra	12,100	4.2	(49)	(75)	3(1)	2	-	-
	20,100	7.0	63	132	3(1)	2	-	-
PK11 — PK10	93,973	21.8	(21)	(160)	4(1)	3	-	-
	147,786	34.2	34	355	4(1)	3	-	-
PK10 — PK14	59,773	20.8	(39)	(250)	3(1)	2	-	-
	89,986	31.2	51	450	3(1)	2	-	-
PK14 — Sidi Salah EH	36,386	12.6	(24)	(110)	3(1)	2	-	-
	64,686	22.5	38	250	3(1)	2	-	-

Legend: Upper line: Phase 1, Lower line: Phase 2
Source : JICA Survey Team

(4) Measures against Water Hammer

Water hammer phenomenon might occur in the transmission pipeline in the event of shutoff of the transmission pumps at the desalination plant due to power interruptions and blackouts etc., especially as a large amount of water is transmitted to the inland reservoirs with a high water level of 59 m through pumping. Measures against the water hammer phenomenon will be necessary because it could damage the pipeline.

An impact on the water hammer phenomenon is also analysed for the other sections between; i) PK11 and Bou Merra, ii) PK11 and PK10, iii) PK10 and PK14, and iv) PK14 and Sidi Salah EH. As presented in Table 6-6, the water hammer phenomenon can be prevented by flywheels or an air chamber to be installed at the pump facilities. A device which functions to equalize the pressure in the transmission pipe with that of the atmosphere will be needed at the highest point in the section between PK10 and PK14

Table 6-6 Measures against Water Hammer

Section	Flow rate (m^3/d, max)	Countermeasure	Dimension (diameter x height)	Quantity	Distance from source side	Flywheel	Necessary moment of inertia WR^2(N-m^2)
Plant Site —PK11	200,000	One-way surge tank	φ10m x15m	2	Approx,13km,16 km	Need	2,400x4
PK11 —Bou Merra	20,100	Air chamber	φ1.5m x1.7m	1	inside pump facility	No need	—
PK11—PK10	147,786	No need	—	—	—	Need	1,300x3
PK10—PK14	89,986	No need	—	—	—	Need	2,700x2
PK14 —Sidi Salah EH	64,686	No need	—	—	—	Need	2,500x2

Source : JICA Survey Team

(5) Reservoir

It will be necessary to construct an additional reservoir at the site of Bou Merra with a capacity of 5,000m^3.

- Capacity augmentation of Reservoir：5,000m^3 by Phase 1 project at Bou Merra

(6) Receiving-Mixing Chamber

In each reservoir, one receiving chamber will be installed as indicated in Table 6-7. In these chambers, the desalinated water or the mixture of the desalinated water with the water from the other sources transmitted by pumping will be mixed with the water from the existing water sources.

Table 6-7 Receiving-Mixing Chambers

Reservoir	Receiving Volume	Water Resource	Internal Dimensions* (m) & Retention Time
PK11	227,086 m^3/day	North Water Jelma-Sbeitla Groundwater Groundwater in Sfax Desalinated Sea Water	9.0W x 15.0L x 5.0D 4.3 minutes
Bou Merra	23,100 m^3/day	Groundwater in Sfax Mixed Water in PK11	4.0W x 3.0L x 5.0D 3.7 minutes
PK10	163,186 m^3/day	North Water Groundwater in Sfax Mixed Water in PK11	7.0W x 10.0L x 5.0D 3.1 minutes
PK14	107,786 m^3/day	North Water Groundwater in Sfax Mixed Water in PK10	7.0W x 7.0L x 5.0D 3.1 minutes
Sidi Salah EH	72,300 m^3/day	North Water Groundwater in Sfax Mixed Water in PK14	6.0W x 5.0L x 5.0D 3.0 minutes

*: Planned with maximum water depth of 5m and minimum retention time of 3 minutes. PK11 has planned to have sufficient capacity to receive the water volume equivalent to water demand of entire Greater Sfax to have flexibility of change of water transmission plan.

Source：JICA Survey Team

6.3 Plan of Phase 1 of the Project

The facilities planned to be constructed in Phase 1 except the Seawater Desalination Plant and its related facilities are summarized in Table 6-8.

Table 6-8 Components of Phase 1 Project

Facility	Contents
Pumping Station	・ Transmission Pumping Station x 1 (at Desalination Plant Site) ・ Intermediate Pumping Station x 3 (at PK10, PK11 and PK14 Reservoir Site)
Transmission Pipe	・ Pipe Material: Ductile Iron Pipe ・ φ1400mm: L=26.3km (Desalination Plant to PK11 Reservoir) ・ φ1000mm: L=6.1km (PK11－PK10 Reservoir) ・ φ800mm: L=4.8km (PK10－PK14 Reservoir) ・ φ800mm: L=9.4km (PK14－Sidi Salah EH Reservoir) ・ φ400mm: L=2.9km (PK11－Bou Merra Reservoir) ・ Total Length: about 49.5km

Facility	Contents
Water Hummer Prevention Measures	・ Desalination Plant – PK11 Reservoir One-way Surge Tank 10m (dia.) x 15m (water depth) x 2, Necessary Site Area: 20m×30m×2 sites ・ PK11– Bou Merra Air Chamber φ1.5m x1.7mL×1 (at PK11 site) ・ Flywheels of each pumps
Reservoir	To augment Bou Merra Reservoir by additional capacity of 5,000m^3 within the existing precincts
Receiving/Mixing Chamber	Five receiving/mixing chambers. One each at following reservoir site: PK11: 9.0W x 15.0L x 5.0D Bou Merra : 4.0W x 3.0L x 5.0D PK10: 7.0W x 10.0L x 5.0D PK14: 7.0W x 7.0L x5.0D Sidi Salah EH: 6.0W x 5.0L x 5.0D (internal dimensions: W; width, L; length, D; depth, unit: m)

Source： JICA Survey Team

CHAPTER 7 ELECTRIC FACILITY PLAN

7.1 Necessary Power Supply

The required power is 38.1 MW. For the plan, 40 MW is applied for the design.

35 MW (sea water desalination plant) + 3.1 MW (transmission pumps) = 38.1 MW

7.2 Availability of Electricity for Seawater Desalination Plant

In response to SONEDE’s inquiry letter, STEG answered that the required 40MW of power is possible to be supplied to the desalination plant. The JICA Survey Team has also confirmed this same possibility of the power supply of 40 MW to the plant considering the power supply situation in Tunisia. The reception of 150 kV is considered to raise the possibility of the supply.

7.3 Electrical Facility Plan

(1) Sea water desalination plant

1) Receiving power facility plan

- After discussion with STEG, the receiving system is expected to be for a three-phase, three-line 150kV 50Hz, high voltage two-line (loop system).
- Against possible power failures, power generators will be installed. However, the frequency of the power failure is not expected to occur frequently. Therefore, the capacity of the generator will be of the minimum requirement for ease of O&M.
- The receiving power facilities consist of primary and secondary units. The primary unit is to be installed at the entrance of the site. The secondary units are to be installed at four places at the

intake site, the seawater desalination plant (Phase 1), the seawater desalination plant (Phase 2), and the transmission facility.

- Extension of the required transmission power line is to be executed from the 150 kV trunk line of STEG, which is responsible for the electrical works in Tunisia. SONEDE will pay the cost for the extension work to STEG. The cost of the work is estimated to be 7,283,000 TND.

2) Power generator

A generator will be designed for the transmission pump with minimum required O&M purpose on the other facilities. The type will be selected for a diesel generator with a radiator. The capacity of the generation will be at 2,000 kVA in order to operate the two transmission pumps planned in Phase 1.

3) Operation and control facility

The operational system is basically automatic from the control centre. However, all facilities will be designed for manual operation as well by installing a manual control panel. In addition, the remote control for main loading facilities such as intake and transmission pumps is designed from a central monitoring centre.

4) Instrumentation facilities

The instrumentation facilities will be installed at the required locations.

5) Operation and control facility

By installing SCADA, a control centre at an administration building staff can monitor and operate the main facilities. In addition, the centre can conduct; i) data management of the operational conditions such as flow rate and other parameters, and ii) preparation of daily or monthly reports.

(2) Pump facility

1) Outline

Three pumps will be installed at the desalination plant to transmit water produced in the plant. Other three pump facilities will be provided at three locations. The pump facility at the desalination plant and reservoirs mentioned above is described in detail in Table 7-1.

Table 7-1 Outlines of Pump Facility

Reservoir	Pump facility (new)	Remarks
Production tank at sea water desalination plant (new installation): New: 25,000m^3 （Phase 1） Expansion:25,000m^3 (Phase 2)	To PK11 reservoir Phase 1: 34.8m^3/min x 2 (+1) Phase 2: 34.8m^3/min x 2 (+1)	Head: 95m VSD control: 2 units VSD control: 2 units

Reservoir	Pump facility (new)	Remarks
PK11 reservoir Existing 22,000m^3	To Bou Merra reservoir Phase 1: 7.0m^3/min x 2 (+1) Phase 2: -	Head: 63m VSD control: 2 units
	To PK10 reservoir Phase 1: 34.2m^3/min x 3 (+1) Phase 2: -	Head: 34m VSD control: 3 units
Bou Merra reservoir Existing: 1,500m^3 Expansion: 5,000m^3 (Phase 1) Expansion: 2,500m^3 (Phase 2)	-	-
PK10 reservoir Existing: 20,000m^3 Expansion: 10,00m^3 (Phase 2)	To PK14 reservoir Phase 1: 31.2m^3/min x 2 (+1) Phase 2: -	Head: 51m VSD control: 2 units
PK14 reservoir Existing: 10,000m^3 Expansion: 5,00m^3 (Phase 2)	To Sidi Salah High reservoir Phase 1: 22.5m^3/min x 2 (+1) Phase 2: -	Head: 38m VSD control: 2 units
Sidi Salah High reservoir Existing: 7,500m^3	-	-
Sidi Salah Low reservoir New: 5,000m^3 (out of this project) Expansion: 15,000m^3 (Phase 2)	-	-

2) Receiving power facility plants

The transmission pumps will be installed at the PK11, the PK10, and the PK14 reservoirs. The power supply to the reservoirs is 30 kV from one power line reception together with the transformers. Generators, however, will be installed in order to transmit water continuously. One transformer will be installed with a secondary voltage of 400 V. During power cuts or malfunctioning of the transformer, the generator can be utilized for the power supply. At the Bou Merra, the Sidi Salah EH, and the Sidi Salah EB reservoirs, low voltage power is supplied due to the power requirement of the instrumentation panels and equipment.

3) Power generators

The selected generators are a diesel type with a radiator. The capacity of each generator is listed in Table 7-2.

Table 7-2 Capacity of Generators

Reservoir	Capacity of Generator
PK11	2,500 kVA
PK10	1,250 kVA
PK14	750 kVA

4) Operation and control facilities

At the reservoirs, a power control panel will be selected for installation as the power loading points are not excessive. The operation system will basically be automatic and determined by the water level of the reservoirs. However, a manual system will also be designed to be used when required from the control room.

5) Instrumentation facilities

The instrumentation facilities at the reservoirs are mainly for the measurement of inflow rates, reserved volume, and water levels. In this project, EC is measured continuously at the outlet of the reservoirs due to an issue on TDS. The water level of the reservoirs is measured by throw-in type (pressure type) water gauges, as they are both simple and highly accurate. The residual chlorine at the reservoir will be measured in principle by manual analysis. Chlorine metres, however, will be installed in order to cope with an emergency situation.

6) Monitoring and control facilities

The monitoring and control facilities at the control room are being designed to obtain data of; i) the water levels and flow rates at each reservoir, ii) the operational condition of the pumps, and iii) when required raise alarms through telemeter and wireless communication. This data communication will be integrated into SCADA. A wireless UHF system will be installed.

7.4 Construction Cost for Extension of 150kV Distribution Power Line

The construction cost for the extension of the 150 kV distribution power line (Aerial wire) is presented in Table 7-3. This construction will be implemented by STEG. The full amount of the work is required to be paid for by SONEDE. The construction period should be reviewed carefully since it is necessary that it be completed before test running of the seawater desalination plant. STEG estimated the construction cost of power cable construction as 7,283,000TND, including primary equipment such as circuit breaker and secondarily for construction supervision..

Table 7-3 Construction Cost for Extension of Distribution Power Line

Item	Condition
Extension Length (km)	15
Nos. of Lines	2 lines (duty + backup)
Construction Cost of Extension (TND)	7,283,000

Source: Reply to SONEDE by STEG

7.5 Phase 1 Project for Electrical Facilities

Phase 1 project for electrical facilities are summarized in Table 7-4.

Table 7-4 Summary of Phase 1 Project

Facility	Specification
Sea water desalination plant	
Substation facility	・ three-phase, three line, 150kV 50Hz, high voltage two-line (loop system) ・ Primary substation facility: regular 1 unit, standby 1 unit, total 2 units, primary voltage 150 kV, secondary voltage 30 kV ・ Secondary substation facility 1 regular - standby: 2 banks system, secondary voltage of transformer: 400 V ・ Secondary substation facility 2

	regular - standby: 2 banks system, secondary voltage of transformer: 6 kV
Generator	・ diesel type with a radiator: capacity 2000 kVA
Facility	Specification
Operation and control facility	・ small loading: control centre ・ large loading: individual power control panel
Instrumentation facility	・ intake flow: electromagnetic flow meter ・ transmission flow: electromagnetic flow meter ・ transmission pressure: diaphragm type pressure gage ・ water level at water treatment plant, reservoir: throw-in type (pressure type) water gage ・ EC at raw water: electric resistance ・ pH at transmission water: glass electrode type ・ Residue Chlorine at transmission water: polarograph type ・ Turbidity at transmission water: permeation scattered light type ・ Temperature: thermocouple type
Monitoring and control facility	・ SCADA system
Pump facility	
Substation facility	・ high voltage one power line of 30kV ・ transformer 1 unit, secondary voltage 400 V
Generator facility	・ diesel type with a radiator: capacity 2500 kVA, 1250 kVA, 750 kVA
Operation and control facility	・ power control panel
Instrumentation facility	・ TDS: EC meter ・ water level: pressure type ・ Inflow: Electro Magnetic Flow Meter ・ Transmission: Electro Magnetic Flow Meter
Monitoring and control facility	・ SCADA system

CHAPTER 8 SOCIO-ENVIRONMENTAL CONSIDERATIONS

8.1 Project Category

JICA classifies this Project as falling into the B category of its following four categories:

8.2 Terms of Reference of the EIA

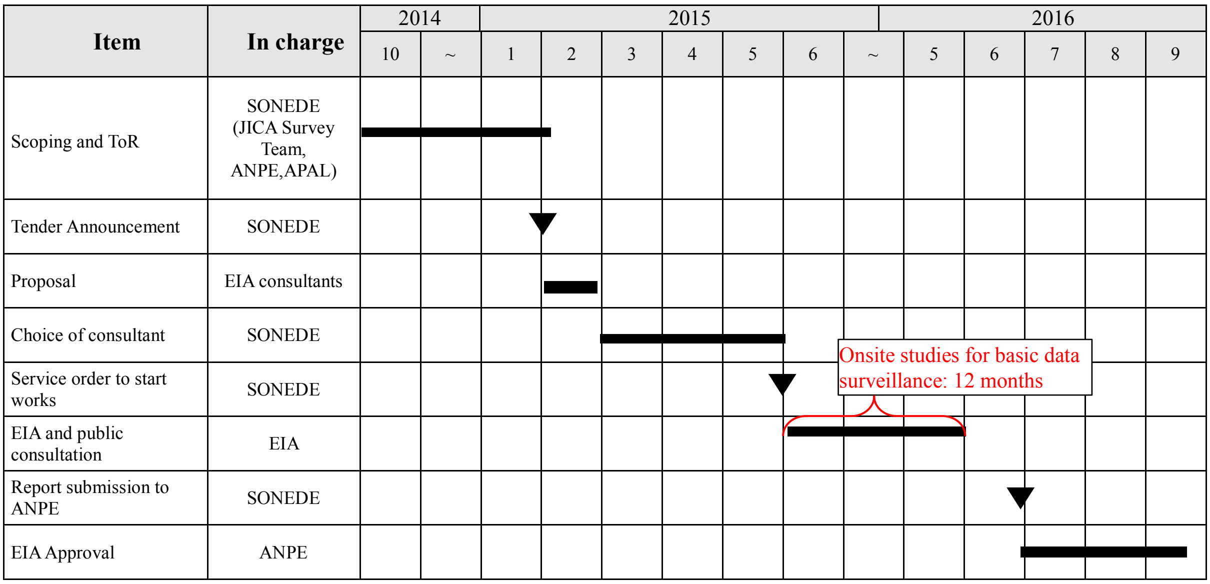
Based on the results of the scoping exercise, the JICA Survey Team prepared and submitted a draft of the Terms of Reference (TOR) for the EIA to be conducted by local consultant. Based on this draft, SONEDE discussed the matter with APAL and ANPE and agreed with them to finalize the TOR. The JICA Survey Team then finalized the TOR and submitted it to SONEDE, and the latter sought the concurrence ANPE and APAL. Having received the concurrence, SONEDE held a bidding and contracted the EIA to a local consultant. Work was on-going as of June 2015. The summary of the EIA's TOR was developed based on the scoping study given in the following table:

Table 8-1 Summary of the EIA's Main Terms of Reference

Objective	Point to study	Study Method
Approach and framework of EIA study	1. Legal and institutional framework of EIA 2. EIA methodology, approach, planning, and personnel	1-Refer to EIA scoping report 2-Refer to EIA Terms of reference
Define the baseline of the natural and social environment	1. Description of the receiving environment : Project area, land and marine physical and biological natural environment 2. Description of the society: population, healthcare, gender effects.	1-Collect and summarize available data and reports 2-Additional studies on site of the marine environment: ➢ Water quality (including plankton) ➢ Description of marine grasses ➢ Description of the ecosystem ➢ 4 sampling points. 2 points at the level of the Project (A and B on the figure) and 2 points on pilot areas (C and D). ➢ Sampling in summer and in winter 
Project description	1. Description of the Project's components 2. Project's materials inventory (input/output) 3. Construction and operation methods	1- Refer to the report of the Project's preparatory study (This report)
Evaluation of the Project's variants and the Project site	1. Project variants 2. Project site options	1- Refer to the report of the Project's preparatory study (This report) 2-Conduct site visits
Evaluation of impacts on the natural and social environments	1. Evaluate impacts with regard to the Project's components (during construction and during operation) 2. Areas impacted by the discharge of brine and impact on the marine environment	1-Consult reference documents, check each item. 2- Calculate the area affected by the brine discharge 3-Consult documents concerning the relation between salinity and toxicity in the marine environment
Mitigation measures and compensation of related costs	1. Suggest appropriate mitigation and compensation measures for each impact 2. Evaluate costs and suggest an organization for the implementation of measures	1-Based on the evaluation of site conditions and impact characteristics, elaborate appropriate mitigation measures. 2-Design compensation measures complying with the relevant laws and regulations in force. 3-Jointly with SONEDE, define costs and organization to implement and enforce compensation measures.
Monitoring plan	1. Design of a monitoring plan: items to monitor, applicable standards, concerned institutions, costs, implementation organization	1-Definition of supervision modes for each item to monitor 2- Jointly with SONEDE, design a monitoring plan

Objective	Point to study	Study Method
Consultation with stakeholders and with the population	1. Consultation with stakeholders reflecting the results of the Project 2. Information of the local populations	1- Hold meetings with stakeholders in Sfax in order to explain the characteristics and the impacts of the Project. Refer to the stakeholders meeting already held during the preparatory study. Evaluate different proposals and reflect them in the Project implementation. 2- Hold information meetings with the local population in order to explain the Project characteristics and impacts.

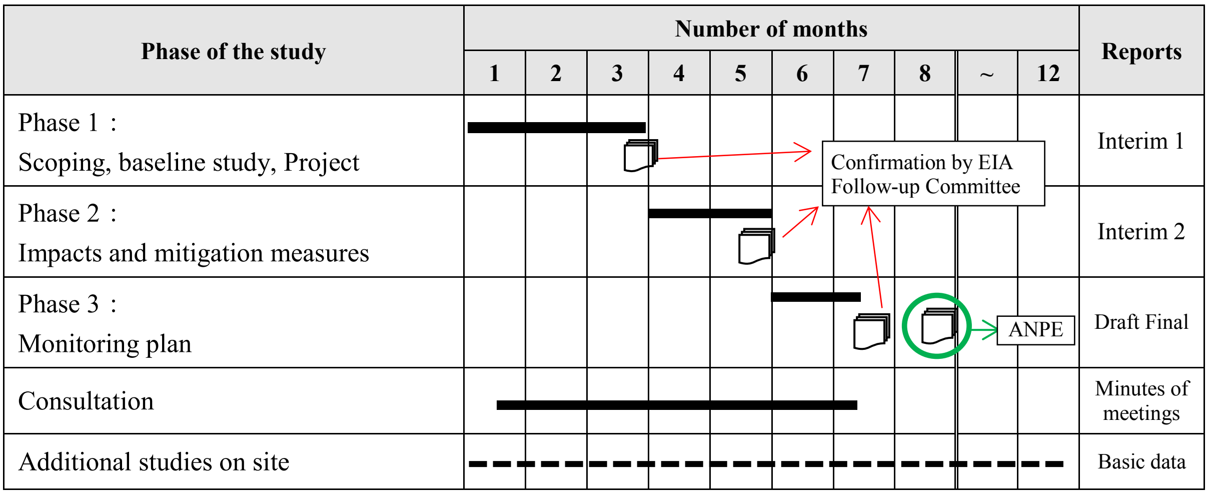
The provisional schedule for the execution of the scoping study, preparation of the terms of reference and the EIA is shown in Figures 8-1.



Source: JICA Survey Team

Figure 8–1 Provisional Schedule for Scoping, TOR and EIA

The execution of EIA is detailed in Figure 8-2.



Source: JICA Survey Team

Figure 8–2 EIA Execution Plan (proposal)

Since every phase and intermediate report will be checked by the EIA Follow-up Committee, we may expect that the final approval by ANPE will only raise a few additional comments or little reservations.

8.3 Results of Socio-Environmental Investigations

Further to the scoping results, characterizing impacts related to brine discharge was subject to a simulation exercise. Data related to marine grass, *Posidonia oceanica,* in the Project's surrounding areas have also been collected and analysed.

A social survey was conducted in order to assess the satisfaction rate in terms of drinking water service and impacts on society. Finally, a meeting with representatives of the British Gas company (hereafter referred to as BG) was organized in order to identify possible impacts of this Project on fishing activities. Results are collected in Table 8-2.

Table 8-2 Results of Socio-Environmental Investigations

Criteria	Investigations Results
Water pollution	**Simulation of brine dispersion** In order to assess the impact of brine discharge into the natural environment, amounting to about 73,000 mg/L TDS at the level of the discharge head, the JICA Survey Team studied the dispersion of brine in surrounding sea water. To do this, a two-layer model was utilised: 1. First a gravitational jet model at the level of the nearby field (ten meters around the discharge tower): this model takes into consideration the immediate dilution at the level of the circulating jet mixed with surrounding water. It gives information about the form of the jet, the falling point and the evolution of concentration in the jet. It also takes into consideration the form, the inclination of the nozzle, the number of nozzles and the speed of discharge. 2. Then a model for dissemination in remote areas at 2 dimensions following the equation developed by Joseph Sendner : the model is based on the concentration of the jet at the level of the falling point calculated by the nearby field model, and calculates the progressive dilution of salinity through dispersion throughout a plane area. It takes in consideration the total quantity of water discharged as well as the water height and the shape of the dispersion area. This type of simulation is largely used at the level of the pre-project preparatory studies for conventional or nuclear thermal power plants (floating jet), and for desalination stations (falling jet), and is based on several references. The model was also applied by research laboratories, and suitability and accuracy of it was confirmed. Calculation conditions for this Project Simulation was based on unfavourable conditions in the summer period (highest salinity of the environment) as shown in Table 8.8-2. Discharge quantity : 244 ;400 m^3/day (maximal capacity, Phase 2) Discharge speed : 3m/s Number of nozzles : 4 Diameter of the nozzle : 0.55m Angle of the nozzle from horizontal line : 45deg Height of discharge from the ground (nozzle centre) : 1.3m Current velocity : 0.01m/s (*1) *(*1) in the absence of more accurate data, we used the pejorative hypothesis of minimal current.* Discharge angle : 180deg (*2) *(*2) Since discharge is slightly heavier than sea water, it tends to flow on the highest slope. Based on this phenomenon, a discharge tower of 180deg. is adopted.*

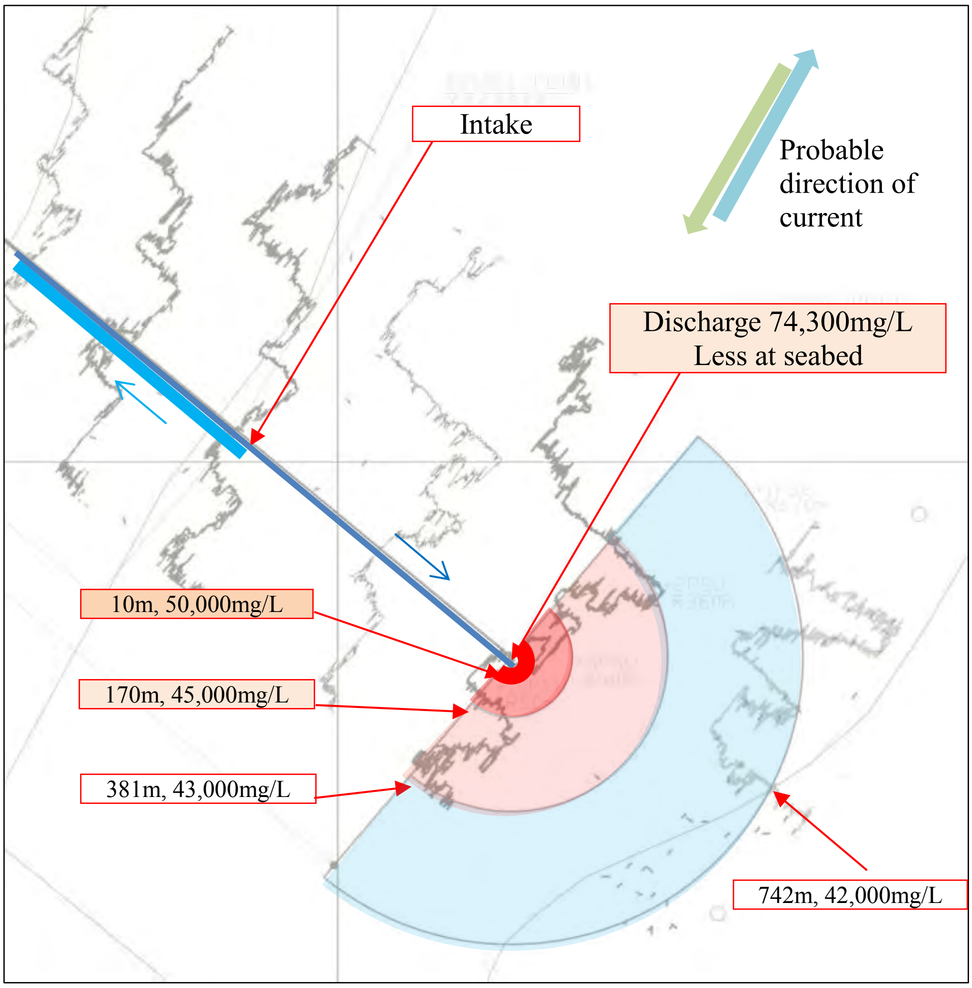
Criteria	Investigations Results

Table 8-3 Temperature and Salinity

Month		Jan - Mar	April - June	July August	Sep.-Nov.	December
		Winter	Spring	Summer	Fall	Winter
Sea water temper.	C	15	25	30	25	15
Discharge temper	C	15	25	30	25	15
Sea water salinity	mg/L	39,000	40,000	41,000	40,000	39,000
Discharge salinity	mg/L	70,800	72,500	74,300	72,500	70,800
Difference	psu	31.8	32.5	33.3	32.5	31.8

Source: JICA Survey Team

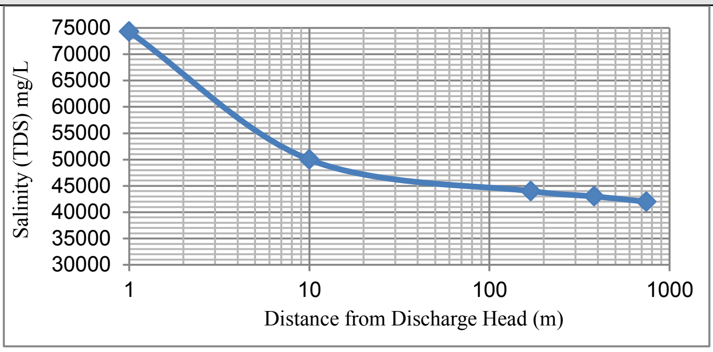
Results are shown in figure below in the following figures:



Source: JICA Survey Team

Figure 8–3 Results of the Brine Dispersion Simulation

Salinity according to distance from the discharge tower is shown in the graph below:

Criteria	Investigations Results
	 Source: JICA Survey Team **Figure8–4 Salinity according to Distance to the Discharge Head**
Natural habitats	**Baseline of *Posidonia oceanica*** Data concerning the state of *Posidonia oceanica* and *Cymodoc*ae in the Governorate of Sfax were provided by INSTM (L. Ben Mustapha) based on a 2008 World Bank Study. The SIG Analysis of these data shows the following facts: In the Governorate of Sfax, the current conditions of *Posidonia oceanica* is as follows : ▪ Coverage area : about 130,000 ha (green area above, including surveyed areas) ▪ Average coverage rate (low hypothesis) : 40% => sea grass area = 0.4x130,000 = 52 000 ha ▪ Average coverage rate (high hypothesis) : 60% => sea grass area = 0.6x130,000 = 78,000 ha **Relation between the salinity rate and *Posidonia oceanica* survival** The relationship between the salinity rate and the survival of *Posidonia oceanica* was studied in Fernandez-Torquemada, Y., Sanchez-Lizaso "Effects of salinity on leaf growth and survival of the Mediterranean sea-grass *Posidonia oceanica*", 2005. According to this source, survival of this sea grass is not possible when salinity exceeds 50000 mg/L in TDS. However, we may consider that as of 45000 mg/L in TDS, the environment would have long term damage. This shows the impact of the Project on sea grasses, *Posidonia oceanica*: ▪ Impact due to the construction of the intake and discharge pipes: 34 m (width of excavation) x 4000 m (average length of pipeline) x 80% (sea grass coverage rate at the level of the pipeline) = 11.2 ha (note: partial recovery is possible above the pipeline in coming years) ▪ Impact due to the discharge of salinity: salinity (TDS)< 45000mg/L => radius > 200m => impacted area : 3.1416×200^2 / 2×80%= 5ha (the choice of the coverage rate at 80% is pejorative for this calculation as it increases the impacted area) <u>Desalination effects in the Gulf of Gabes</u> In the Gulf of Gabes, 4 sea water desalination projects are in progress : ▪ Sfax (this Project) : 200,000m^3/day at the end of the project ▪ Djerba : 75,000m^3/day at the end of the project ▪ Zarat : 100,000m^3/day at the end of the project ▪ Kerkennah : 6,000m^3/day at the end of the project This represents therefore a total of 381,000m^3/day at the level of the Gulf of Gabes by horizon year 2030. If we consider that the Gulf of Gabes covers a total area of about 12,000km^2 and if we also consider an average annual evaporation of 1788m/year (ref. National Meteorology Institute), then the daily evaporated water volume would be 12,000,000,000m^2 x 1.788m / 365 day = 58,800,000m^3/day. Water desalination would then represent at the end of projects 381,000 / 58,800,000 = 0.6% of the evaporation all over the Gulf of Gabes (by deliberately not calculating additional inputs of soft water discharged by purification stations). Therefore, except the influences at discharge point, its influence on ecology system in the Gulf of Gabes is quite small. The nearest seawater desalination plant planned is the Kerkennah plant 40km from the Sfax plant, Therefore, discharge water from both plants will not merge and their combined influence on ecology system is negligible because of sufficient dilution effects.
Subsidence means, poverty,	**Coastal fishing activities in the vicinity of the desalination station's site** In 2004, fishing in the Governorate of Sfax represented 47% of the national overall activity, while the port of Sfax represents the largest fishing port in Tunisia (with an annual production of about 15,000 tons).

<table>
<tr><th>Criteria</th><th>Investigations Results</th></tr>
<tr><td>vulnerability</td><td>Fishing methods used in Sfax are shown in the following table:

Table 8-4 Fishing Methods in the Sfax Region
<table>
<tr><th>Method</th><th>Boats</th><th>Target</th><th>Area</th><th>Status</th></tr>
<tr><td>Coastal shell collection</td><td>-</td><td>Crustaceans, molluscks</td><td>Beach, littoral</td><td>Authorized</td></tr>
<tr><td>Line fishing</td><td>Sail boats or with engines
(1 to 2 fishermen)</td><td>cuttlefish, sea bream</td><td rowspan="5"><i>Posidonia oceanica</i>
(depth 2 to 10m)

Sfax-Kerkennah Channel
(depth +10m)</td><td>Authorized</td></tr>
<tr><td>Net fishing (static)</td><td>Sail boats or with engines
(2 to 5 fishermen)</td><td>Octopus, cuttlefish, shrimps, sea bream, flounder</td><td>Authorized</td></tr>
<tr><td>Trapping</td><td>Sail boats or with engines
(1 to 2 fishermen)</td><td>Octopus, mullet</td><td>Authorized</td></tr>
<tr><td>Fishing with turning seine</td><td>Motor boats
(6 to 8 fishermen)</td><td>Tuna, sardine</td><td>Authorized
(depth.+20m)</td></tr>
<tr><td>Mini-trawl fishing (« kiss »)</td><td>Sail boats or with engines
(1 to 6 fishermen)</td><td>Octopus, cuttlefish, shrimps, sea bream, flounder</td><td>forbidden</td></tr>
</table>
Source : SMAPIII report, City of Sfax (Impact study : report on marine environment)

Impact of the construction of intake and discharge pipes on fishing activities, the example of British Gas (referred to as BG)
The gas plant of British Gas is located in the vicinity of the project site.
The following observations can be made about gas pipelines linking offshore extraction platforms to the plant:
1) According to the pipelines' coordinates, they neither cross the desalination station's proposed site nor sea pipelines:
2) When laying a new pipeline in 2008, the following problems emerged:
1. Since the orientation of sail boats is conditioned by the wind, the limit set for the construction of the pipeline will no longer allow access to a certain fishing areas;
2. Collection of shells is practiced in the project area by local women. As turbidity increased during excavation works offshore, the quality of the shells dramatically dropped reducing sales;
3) In order to act on these issues, BG set up a compensation system summarized as follows:
1. During the construction phase of the initial 5 kilometres of the pipeline, payment of a monthly compensation to populations affected by the Project;
2. For boats or vessels: 300 TND for the captain and 150 TND for crew members;
3. About 30 TND for women shell collectors.
4) Four staff members of BG devoted 30% of their time for 6 months to settle these issues.

We expect similar works for the construction of intake and discharge pipes. In order to prevent these issues, it is necessary to consult with fishermen and with the local population, explain the construction method and define an appropriate compensation programme.</td></tr>
<tr><td>Historical and cultural heritage</td><td>The nearest archaeological ruins No. 115.052 is 290m from the site.
The law related to conservation of ruins is No. 94-35 (24.2.1994). Clause 69 of the law enables stopping construction work for six months in case new ruins are discovered to enable survey of any newly discovered archaeological ruins.</td></tr>
</table>

Source: JICA Study Team

8.4 Evaluation of Impacts

Based on results of Section 8.3 above, the different impacts of the Project were evaluated for each evaluation component as described in Table 8-5.

Table 8-5 Evaluation of Impacts : Seawater Desalination Plant

Categories		Impact criteria	Evaluation		Confirmation		Justification
			Construct. phase	Operation phase	Construct. phase	Operation phase	
Pollution	1	Air pollution / dust	C	D	D	D	**During construction:** - Large scale earth works and pavement works are not being planned, and areas surrounding the plant site are mainly farmlands, road and beach. Since only dust will be produced, no significant specific impact is therefore expected.
	2	Water pollution	C-	C-	D	D	**During construction :** - Turbidity will temporarily increase due to offshore excavation works, however since turbidity is generated by existing sediments, there is no additional pollution of sea water (impacts on fishing activities are described below) **During operation:** - Since discharges are diluted, salinity drops to +1000mg/L（or +2%） of the natural salinity at about 750m from the discharge head, the situation is therefore not dangerous for human activities. (Concentrations of Na and Cl in Tunisian Standards for Water discharge to Sea, NT106-002, shown in Table 8.11-1, are “No Limit”). (Impacts on natural habitats are described below). - Taking in consideration the nominal capacity of the 4 sea water desalination stations planned in the Gulf of Gabes, the accumulated water intake volume will be 0.6% of water losses through evaporation at the level of the Gulf. There is therefore no significant impact at this level.
Natural environment and natural risks	10	Natural habitats	B-	C-	B-	B-	**During construction :** - Due to excavation works in the sea, 11.2 ha of *Posidonia oceanica* will be lost, which will have an impact on the marine environment. However, when compared with the 52,000 ha of sea grasses living along the Sfax coast, this impact is rather limited and partial recovery will be possible in the long term above the pipelines. - The coverage rate of sea grasses in the pipelines area ranges between 60% and 80%. The deposit of excavated materials in the area may generate additional loss of sea grasses. This is why the impact depends on the choice of the deposit site for the 101,600 m^3 excess excavated material. **During operation :** - The final impact area of discharged water is estimated at about 5.0 ha, however, compared to the 52,000 ha of sea grasses living along the coast of Sfax, the impact is relatively limited.
	11	Hydrology	C-	D	D	D	**During construction :** - After excavation, pipes will be taken to the site by floating them and then they

Categories		Impact criteria	Evaluation		Confirmation		Justification
			Construct. phase	Operation phase	Construct. phase	Operation phase	
							will be laid at the bottom of the sea trench and buried, so there will be no impact on marine currents.
Human and social environment	14	Means of subsidence, poverty, vulnerability	C-	D	B-	D	**During construction :** - Based on the British Gas experience, it is possible that the construction of pipelines impacts fishing activities.
	16	Local economy/Employment	B+	B+	B+	B+	**During construction :** - Local employment will increase; - Possibility for sub-contracting services with local providers **During operation :** - Possibility for operators' positions at the plant - Possibility for sub-contracting services with local providers
	18	Water resources	D	B+/C+	D	B+/D	**During operation :** - No impact on health by change of water supply system because no relationship between the water supply and diseases has definitely been proved.
	19	Public infrastructures and public services	D	B+	D	B+	**During operation :** - The Project will improve the quantities and quality of drinking water
	22	Local conflicts of interest	D	B+	D	B+	**During operation:** - The Project facility will be located in the Greater Sfax area. The subject area of the Project is the whole Greater Sfax. - As this seawater desalination Project will ease the water supply situation in the central area of Tunisia, it will have a positive effect on any impacts of any local conflicts.
	23	Historical and cultural heritage	C-	D	D	D	**During construction :** - As shown on Figure 8.8-9, there are currently no archaeological ruins at the desalination plant site. The route for the transmission pipeline was once excavated for road construction, and therefore, the possibility of discovery of new archaeological ruins is very low. Areas for foundation works of power transmission towers are small, i.e. four piles which are 0.8m in diameter. In addition, it is possible to change the route to avoid any archaeological ruins if they exist. - As results of geotechnical drilling works have shown no hard stratum in the Project area, the probability of archaeological ruins is very limited.
	25	Gender	D	C+	D	D	**During operation :** - Though the increase of water supply volume by the Project will allow create the possibility of an extension of the water supply area; as the rate of connection to drinking water supply in Sfax is already very high, the improvement of the water supply service may have only little positive impacts on

Categories		Impact criteria	Evaluation		Confirmation		Justification
			Construct. phase	Operation phase	Construct. phase	Operation phase	
							existing women's conditions.
	28	Professional health /safety on the worksite	D	C-	D	D	**During operation :** - SONEDE's operating stations already use similar chemical products, so the staffs have good and appropriate experience in managing any leaks and related hazards.
Others	30	Trans-border effects and climatic changes	D	C-	D	D	**During operation :** - Power consumption in Tunisia for the year 2013 was 14,379 GWh (https://www.steg.com.tn), the power consumption by the station: 143 GWh will therefore represent 1% or less of the national consumption figures, the increase of CO_2 emissions will then be very limited at the national level.

A+/-:	Significant positive/negative impact is expected.
B+/-:	Positive/negative impact is expected to some extent.
C+/-:	Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D:	No impact is expected.

Table 8-6 Evaluation of Impacts : Transmission Pipeline

Categories		Impact criteria	Evaluation		Confirmation		Justification
			Construct. phase	Operation phase	Construct . phase	Operation phase	
Pollution	1	Air pollution/dust	C	D	D	D	**During construction:** -Large scale earth works and pavement works are not being planned, and the pipeline route is mainly surrounded by farmland and roads. Since only dust will be produced, no significant specific impacts therefore are expected.
Natural environment and natural risks	12	Morphology and geology	C-	D	D	D	**During construction :** - The construction and laying of transmission pipes will generate 60,000m^3 of excess excavated material. However a large part can be reused on the site of the desalination station, which requires backfilling. On the other hand, several deposit sites nearby Sfax are also available; there will therefore be no big impact on existing soils.
Human environment and society	16	Local economy / Employment	B+	B+	B+	B+	**During construction :** - Local employment will increase; - Possibility for sub-contracting services with local providers **During operation :** - Possibility for sub-contracting services with local providers
	17	Use of soils and local resources	C-	D	B-	D	**During construction :** - In general, pipes will be laid in the right of way areas of existing roads. However, some land acquisition will be necessary in several areas and for surge tank areas.
	19	Public infrastructures and social services	D	B+	D	B+	**During operation :** - The Project will improve the quantities and quality of drinking water

Categories		Impact criteria	Evaluation		Confirmation		Justification
			Construct. phase	Operation phase	Construct . phase	Operation phase	
	21	Repair of benefits, social equity	B+	B+	B+	B+	**During construction, and During operation:** - The Project facility will be located in the Greater Sfax area. The subject area of the Project is the whole Greater Sfax.
	22	Local conflicts of interest	D	B+	D	B+	**During operation:** - The Project facility will be located in the Greater Sfax area. The subject area of the Project is the whole Greater Sfax. - As this seawater desalination Project will ease the water supply situation in the central area of Tunisia, it will only positively affect the impacts of any local conflicts.

Table 8-7 Evaluation of Impacts : Power Transmission Line

Categories		Impact criteria	Evaluation		Confirmation		Justification
			Construct. phase	Operation phase	Construct. phase	Operation phase	
Pollution	1	Air pollution/dust	C-	D	D	D	**During construction:** - Approximately 40 power transmission towers will be constructed. The work requires an excavator crane and a transportation vehicle only. Large scale earth works are not being planned, and sites are mainly surrounded by farmland. Since only dust will be produced, no significant specific impacts are therefore expected.
Human and social environment	14	Subsidence means, poverty, vulnerability	C-	D	B-	D	**During construction:** - Land acquisition of 10 m x 10m each for power transmission pylons. Including additional space for construction work, there is a high possibility of impacts on farmlands. Cutting-off of olive trees will be needed.
	17	Use of soils and local resources	C-	D	B-	D	**During construction:** - Land acquisition of 10 m x 10m each for power transmission towers. Including construction work space, there is a high possibility of impacts on farmlands.
	24	Landscape	D	C-	D	D	**During operation:** - The seawater desalination plant site is 10km from the Thyna archaeological park, and also far from the Medina located in Sfax city. Therefore, no impact is expected on landscape of tourist spots. It is expected that the power transmission route will be located in areas surrounded by farmland, and therefore no serious impact on landscape is expected.

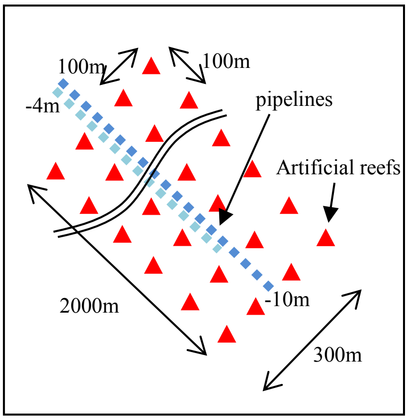
8.5 Mitigation Measures and Implementation Costs

For each impact identified and evaluated in Section 8.4 above, the following mitigation measures are suggested:

Table 8-8 Suggestion of Mitigation Measures

<table>
<tr><th>No.</th><th>Impact</th><th>Mitigation measures</th><th>Implementation entity</th><th>Monitoring entity</th><th>Costs</th></tr>
<tr><td colspan="6">During construction</td></tr>
<tr><td>1</td><td>Loss of sea grass during excavation of intake and discharge pipes (~12ha)</td><td>
In order to efficiently protect sea grasses and related ecosystems, it is possible to lay down artificial reefs all over the Project area. Reefs will also protect against mini-trawl fishing. This technique to valorise resources is already implemented by the DGPA in the Gulf of Gabes.

An example of the installation of reefs along pipelines in this Project is suggested below :



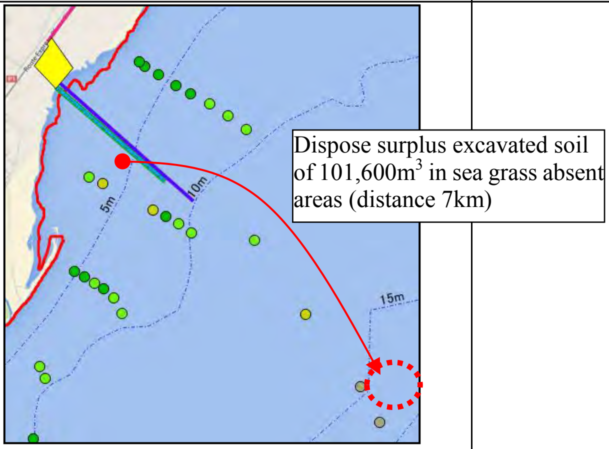
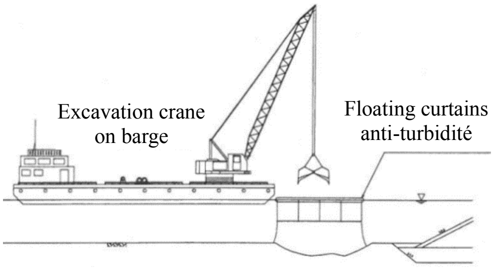
Source : JICA Survey Team

Figure 8-5 Artificial Reefs Installation Plan (example)

Therefore, there will be 4x21=84 reefs, each reef will be made up of eight concrete blocks each weighing one ton. Hence a total of 84×8ton＝672ton or 280m^3 of concrete. Reinforcement bar weighs about 100kg/m^3 or 28ton. The cost of 1m^3 of concrete is 477USD and installed reinforcement bar costs 673USD/ton. The total estimated cost is about 280x477 + 28x673 = 152,000USD for a protected area of 60ha.

Examination results :

Mitigation measures against the negative influences to sea grasses meadows are; 1) artificial planting, and 2) artificial reef installation. Based on the experience in Gabes Bay Artificial Reefs Project, implementation of 2) is judged to be practical, thus it was selected as the mitigation measure of choice against negative influences on sea grass meadows by the Project.
</td><td>Construction company</td><td>SONEDE / INSTM / ANPE</td><td>JPY 18.18 Millions (USD 152,000)</td></tr>
<tr><td>2</td><td>Impact of the deposit of excess excavated materials (~50,000m^3)</td><td>Excavated material in excess should be deposited in areas with no sea grasses growing as shown on the map below.</td><td>Construction company</td><td>SONEDE / INSTM / ANPE</td><td>JPY 60.76 Millions (USD 508,000)</td></tr>
</table>

No.	Impact	Mitigation measures	Implementation entity	Monitoring entity	Costs
		 Source : JICA Survey Team **Figure 8-6 Sea Deposit Plan (example)** Transportation and depositing costs will be about 5USD/m^3, total costs will then amount to 101,600m^3 × 5USD/m^3 = 508,000USD. Note : A detailed study about sea weed coverage in the area may suggest further reducing this distance.			
3	Impact of the construction of pipelines works on fishing activities	After explaining in detail the construction methods of pipelines to the local fishermen, anti-turbidity measures may be implemented and where required a suitable financial compensation plan put in place. An example of an anti-turbidity protection system is shown below. Considering unitary costs practiced in Japan, a protection along the pipeline would amount to about JPY 200 million.  Source : Equipe d'enquête JICA **Figure 8-7 Anti-Turbidity Protection (example)** The closest fishing port to the project area is Mahres at about 10 km to the Project's south-west (photo below). We consider that 20 boats and 100 women collectors are impacted by fishing activities in the pipeline area, and that the period required for excavations in the coastal area would be about six months, and about one year for the laying of pipes. Based on the BG example, the following estimates can be made for compensations: 12 months × 20 boats × (300TND + 2 × 150TND) + 6 months × 100 individuals × 30TND = 162,000TND.	Explanations of anti-turbidity methods and measures: Construction company Compensation : SONEDE	SONEDE / UTAP	Anti-turbidity measures : JPY200 millions Compensations : JPY9.89 millions (TND 162,000)

No.	Impact	Mitigation measures	Implementation entity	Monitoring entity	Costs
4	Land acquisitions for transmission pipeline and power transmission line	The acquisition of lands and compensations will be made according to Tunisian Law n. 2003-26.	Legal and acquisitions department at SONEDE and STEG	SONEDE / MOA	See Chapter 9
During operation					
5	Permanent impact of discharge on sea grass	The impact on sea grass meadows is not avoidable around the discharge head. As an off-set measure, it is recommended to apply mitigation measures at a place different from the discharge head location. The measures are; 1) artificial plantation of sea grass, and 2) installation of artificial reefs. Due to the same reasons as those stated above, installation of artificial reefs is recommended. The installation plan is shown in Figure 8-5. Required cost is USD152,000. In addition, due to the permanent character of impacts, it is necessary to regularly monitor sea grasses. A monitoring plan is suggested in Section 8.6.	-	-	Included in No.1

Source : JICA Survey Team

Mitigation measures suggested above represent an investment of about JPY 290 million excluding land acquisitions as shown in Table 8-9. This cost is considered as a part of the project cost. Assuming that the total project cost is JPY 50 billion, the said mitigation cost will be equivalent to 0.6% of the total cost.

Table 8-9 Cost for Mitigation Measures

Mitigation Measures	Cost	Cost (equivalent Yen) (USD1=JPY119.6) (TND1=JPY61.02)	Item
Artificial Reef	USD152,000	JPY18,179,000	Construction Cost
Deposit of Surplus Material	USD508,000	JPY60,757,000	Construction Cost
Turbidity Prevention	JPY200 million	JPY200,000,000	Construction Cost
Compensation to Fisheries	TND162,000	JPY9,890,000	Compensation

8.6 Monitoring Plan

This Project mainly impacts the marine environment, it is therefore necessary to monitor the state of sea grass and sea water quality. In Tunisia, standard NT106-002 regulates discharges within the natural environment.

Monitoring water quality during the construction of pipelines will be based on the monthly measurement of turbidity (as well as pH, temperature and electric conductivity) along the pipelines (one location) and at the level of the beach (one location). Once operation starts, water quality will be measured at the level of the discharge site to check items of the standard cited above (twice a year for the first year and once a year in the two following years at one location).

Table 8-10 Monitoring Plan

Environmental aspect	Criteria	Site	Frequency	Entity in charge
Construction phase				
Water quality	Turbidity, pH, Temperature, electric conductivity	Along the pipeline and along the coast Total 2 locations	Every month	SONEDE
Natural habitats (*Posidonia* oceanica)	Criteria of Table 8-11	2 sites near the pipeline and 1 site near deposit area Total 3 locations	Twice a year	SONEDE (+INSTM)
Operation phase				
Water quality	NT106-002 Water Quality Standard concerning Discharges to Sea	Near discharge tower 1 location	Twice in the first year, once a year in the two following years	SONEDE
Natural habitats (*Posidonia oceanica*)	Criteria of Table 8-11	Artificial Reef, Water discharge point, 200m from discharge, 1000m from discharge Total 4 locations	Four times in the first year, and twice a year in the two following years	SONEDE (+INSTM)

Source : JICA Survey Team

Table 8-11 Monitoring Parameters of Posidonia oceanica

Parameter	Observation
Sea grass pressure (Grass)	L: % of leafs with herbivores
Coverage by invasive algae	T: % cover of algae such as *C. racemosa* on 3 transects along 20 m
Sea grass covering (Cover)	T: % spots of live sea grass over 3
Dead mat cover	T: % dead mats on 3 transects over 20 m
Density of transect beams	T: Number of live beams per quadrant of 40x40 cm taken randomly
Plagiotrope rhizomes (Pl rhi)	T: % per quadrant (3) of 40x40 cm taken randomly
Beam biomass	Dry weight of leaves without epiphytes (gr/beams)
Surface of leafs by beam (Shoot FS)	L: (LAI) surface area of leaves (cm^2 shoot21)
Length and width of leafs (Leaf L)	L: average per type of leaves and by beam (cm)
Others	

Source : INSTM, Ben Mustapha

In order to efficiently submit monitoring results, the Monitoring Form may be used.

8.7 Stakeholders Meeting

While Tunisian legislation does not formally state the need and obligation of consultations with stakeholders in the execution of projects, this practice is already common and it is also recommended in the JICA Guidelines. In order to take into consideration the opinions of all parties concerned by the Project, a meeting with stakeholders was suggested by the Project's steering committee.

This meeting was held once the Project components were defined. The purpose was to explain the Project's outlines as well as the scoping works related to the EIA. Participants represented concerned organizations (ANPE, APAL, ONAS, ANGED, etc.), local authorities (the City of Sfax, the Governorate, Fisheries related groups, Farming related group) as well as nongovernmental organizations. The policy regarding land acquisition and compensation was also explained verbally. An advance announcement was previously carried out by posting a printed poster on the notice boards of SONEDE, the universities, and governorate offices.

The following comments are reflected in the Project as follows:

- Several institutions are already involved in the EIA preparation (ANPE, APAL, INSTM, etc.), but during the EIA implementation phase, the Sfax University and the local branches of ANPE, APAL and INSTM may be involved.
- The BG experience implies the launch during construction of collaboration channels with local fishermen and UTAP to explain construction methods and eventually define a compensation plan.
- The Project development is supported by measures to improve the present system while evaluating it in a global and integrated way.

During the EIA implementation phase (in 2015), meetings with stakeholders will be held and meetings to inform the general population will also be held in different communities affected by the Project. It is appropriate to hold the explanatory meetings at the places where land acquisition will be conducted or construction affected area, i.e. Mahres (on place), Agareb (two places), and Sfax South (two places). At the explanatory meetings, it is required to explain and discuss about contents of the Project including power transmission line, implementation schedule, land acquisition procedure, compensation plan, and cut-off-date regarding compensation.

CHAPTER 9 LAND ACQUISITION AND RESETTLEMENT

9.1 Needs for Land Acquisition and Resettlement

The need for land acquisition and resettlement for this Project are summarized in Table 9-1. This Project will not require the displacement of people and will not require large scale land acquisition.

Table 9-1 Needs for Land Acquisition and Resettlement

Component	Use	Land acquisition and procedure requirements	Resettlement requirements
Intake pipe Discharge pipe Desalination plant (RO Process)	Maritime public domain (public land)	The use of the maritime public domain is conditioned by a special authorization	None
Transmission pipeline	Generally in the right of way areas of existing roads (public lands) with the possibility to acquire some private lands (underground)	Normal procedure with the permission of the authority in charge of road networks or the road operators. Possibility of having to acquire lands in some areas	This Project was designed so as to avoid the resettlement of people by adjustment of the outline of pipes and the location of structures if necessary.
Pumping station	Within the desalination plant area or in current reservoirs sites (public or SONEDE's lands)	None	

Component	Use	Land acquisition and procedure requirements	Resettlement requirements
Water hammer/surge tank	According to the final choice of sites, possibility of having to acquire private land	Possibility of having to acquire lands	
Distribution reservoirs	Within sites of existing reservoirs	None	
Power transmission line	Farmland (Private)	Possibility of having to acquire lands. SONEDE will possess the lands.	

Source: JICA Study Team

In this study, land parcels to acquire and the impacted agricultural patrimony (olive trees) are estimated as shown in Table 9-2:

Table 9-2 Property and Patrimony Damage related to Water Transmission Pipelines

<table>
<tr><th colspan="8">Real estate property</th></tr>
<tr><th rowspan="2">Item</th><th rowspan="2">Community</th><th rowspan="2">Type</th><th colspan="4">Area</th><th rowspan="2">Total (m^2)</th></tr>
<tr><th>Length (m)</th><th>Width(m)</th><th colspan="2">Area (m^2)</th></tr>
<tr><td>No.1</td><td>Mahres</td><td>Industry</td><td>275</td><td>8</td><td colspan="2">2,200</td><td>2,200</td></tr>
<tr><td>No.2</td><td>Agareb</td><td>Farming</td><td>1,320</td><td>8</td><td colspan="2">10,560</td><td>10,560</td></tr>
<tr><td>No.3</td><td rowspan="7">Sfax South</td><td>Industry</td><td>155</td><td>8</td><td colspan="2">1,240</td><td rowspan="7">17,294</td></tr>
<tr><td>No.4</td><td>Industry</td><td>100</td><td>8</td><td colspan="2">800</td></tr>
<tr><td>No.5</td><td>Farming</td><td>970</td><td>8</td><td colspan="2">7,760</td></tr>
<tr><td>No.6</td><td>Industry</td><td>205</td><td>8</td><td colspan="2">1,640</td></tr>
<tr><td>,No.7</td><td>Farming</td><td>31</td><td>17</td><td colspan="2">527</td></tr>
<tr><td>No.8</td><td>Farming</td><td>31</td><td>17</td><td colspan="2">527</td></tr>
<tr><td>B12</td><td>Farming</td><td>600</td><td>8</td><td colspan="2">4,800</td></tr>
<tr><th colspan="8">Structures</th></tr>
<tr><th>Item</th><th>Community</th><th>Type</th><th colspan="4">Length (m)</th><th>Total (m)</th></tr>
<tr><td>Table 9.3.1,No.1</td><td>Mahres</td><td>Wall</td><td colspan="4">275</td><td>275</td></tr>
<tr><td>Table 9.3.1,No.2</td><td>Agareb</td><td>Wall</td><td colspan="4">150</td><td>150</td></tr>
<tr><td>Table 9.3.1,No.3</td><td rowspan="4">Sfax South</td><td>Wall</td><td colspan="4">155</td><td rowspan="4">810</td></tr>
<tr><td>Table 9.3.1,No.4</td><td>Wall</td><td colspan="4">100</td></tr>
<tr><td>Table 9.3.1,No.5</td><td>Wall</td><td colspan="4">350</td></tr>
<tr><td>Table 9.3.1,No.6</td><td>Wall</td><td colspan="4">205</td></tr>
<tr><th colspan="8">Farming Patrimony</th></tr>
<tr><th>Item</th><th>Community</th><th>Type</th><th>length(m)</th><th>Width(m)</th><th>Area(m^2)</th><th>Number</th><th>Total</th></tr>
<tr><td>Table 9.3.1,No.2</td><td>Agareb</td><td rowspan="5">Olive trees
(25/ha)</td><td>1,320</td><td>15</td><td>19,800</td><td>50</td><td>50</td></tr>
<tr><td>Table 9.3.1,No.5</td><td rowspan="4">Sfax South</td><td>970</td><td>15</td><td>14,550</td><td>37</td><td rowspan="4">61</td></tr>
<tr><td>Table 9.3.1,No.7</td><td>31</td><td>17</td><td>527</td><td>2</td></tr>
<tr><td>Table 9.3.1,No.8</td><td>31</td><td>17</td><td>527</td><td>2</td></tr>
<tr><td>Figure 9.3.3 (B12)</td><td>600</td><td>13</td><td>7,800</td><td>20</td></tr>
</table>

Source: JICA Survey team

The required land for 40 power transmission towers is about 4,000 m^2. For construction work to be carried out, however, an area of 20m x 20m is required on a temporary basis. Therefore, compensation shall cover the area of 10m × 10m + 20m × 20m ＝500 m^2 for each transmission tower. For total of 40 towers, 40 towers × 500 m^2/tower = 20,000 m^2, and therefore, 2ha × 25 tree/ha = 50 olive trees logged will be the subject of compensation. Regarding compensation for the land under the power line, its subject area will be 10m x 15km = 15ha, and 375 olive trees. Compensation for it will be quite small because farming activities can be continued. As stated previously, the cost for land acquisition and compensation will be shouldered by SONEDE.

All in all, the land acquisition area is 3.41ha at maximum including those for power transmission line, and compensation is necessary for the fence of 1,235metres, and 536 olive trees as shown in Table 9-3.

Table 9-3 Summary of Land Acquisition and Compensation for Water and Power Transmission Facilities

Subject	Water Transmission Pipeline			Power Line	Total
	Mahres	Agareb	Sfax South		
Land (m^2)	2,200	10,560	17,294	4,000	**34,054**
Structures (wall, m)	275	150	810	-	**1,235**
Olive Trees (tree)	-	50	61	50+375	**536**

Source: JICA Survey team

9.2 Costs and Funding

(1) Costs related to acquisitions

Costs related to acquisitions are evaluated based on Table 9-2. Unit costs for olive trees and other fruit trees are estimated at 120 TND/tree based on another expropriation file submitted by the Juridical and Real Estate Affairs Department of SONEDE. Wall is estimated at 50TND/m. Land price is estimated based in the data provided by the Juridical Section of SONEDE Sfax Branch.

The square meter costs of lands along the transmission pipeline were provided by SONEDE's General Department in Sfax.

Table 9-4 Land Acquisition and Compensation Costs for Transmission Facilities

Land						
Item	**Community**	**Type**	**Area (m^2)**	**U. Price$^{1)}$ (TND)**	**Total (TND)**	**Total (TND)**
Table 9.3.1,No.1	Mahres	Industry	2,200	25	55,000	55,000
Table 9.3.1,No.2	Agareb	Farming	10,560	30	316,800	316,800
Table 9.3.1,No.3	Sfax South	Industry	1,240	35	43,400	549,250
Table 9.3.1,No.4		Industry	800	35	28,000	
Table 9.3.1,No.5		Farming	7,760	35	271,600	
Table 9.3.1,No.6		Industry	1,640	35	57,400	
Table 9.3.1,No.7		Farming	527	25	13,175	
Table 9.3.1,No.8		Farming	527	25	13,175	
Figure 9.3.3 (B12)		Farming	4,800	25	120,000	
Power Transmission Tower	Based on STEG's Plan$^{2)}$	Farming	4,000	30	120,000	120,000
Structures						
Item	**Community**	**Type**	**Length(m)**	**Price**	**Total**	**Total**
Table 9.3.1,No.1	Mahres	Wall	275	50	13,750	13,750
Table 9.3.1,No.2	Agareb	Wall	150		7,500	7,500
Table 9.3.1,No.3	Sfax South	Wall	155		7,750	40,500
Table 9.3.1,No.4		Wall	100		5,000	
Table 9.3.1,No.5		Wall	350		17,500	
Table 9.3.1,No.6		Wall	205		10,250	
Agricultural assets						
Item	**Community**	**Type**	**Number**	**Price**	**Total**	**Total**
Table 9.3.1,No.2	Agareb	Olive trees (25/ha)	50	120	6,000	6,000
Table 9.3.1,No.5	Sfax South		37		4,440	7,320
Table 9.3.1,No.7			2		240	

Table 9.3.1,No.8			2		240	
Figure 9.3.3 (B12)			20		2,400	
Power Transmission Tower	Based on STEG's Plan		425		51,000	51,000

Note 1): price in 2014
Note 2): Mahres, Agareb, Sfax South
Source: JICA Survey team

For each community, the total costs amount to 68,750TND in Mahres, 330,300TND in Agareb, 597,190TND in Sfax South, with a combined total of 996,240TND. The above costs are including the costs for land asset, structure and crops assets, based on market prices in the region and can such be considered as full replacement costs.
SONEDE will also shoulder the following costs for land acquisition and compensation for power transmission line; TND 120,000 (land acquisition) + TND 51,000 (olive) = TND 171,000.

(2) Compensations to fishing activities

As described in Table 8.10-2, the compensation cost for fishing activities amounts to TND 162,000.

(3) Budget and funding for social considerations

The total budget necessary for compensations to expropriation and to fishing activities amounts to 993,620 + 171,000 + 162,000 = TND 1,326,620. Since this Project is being implemented by SONEDE, funding will be provided by SONEDE and may be charged for the budget of the Juridical and Real Estate Affairs Department.

9.3 Monitoring Implementation Follow-up Form

The Project's overall schedule depends on the enforcement of social considerations including land acquisition and compensation relating to power transmission line, therefore follow up must be conducted by PIU using the follow up form.

9.4 Explanation to Residents about Power Transmission Line

In addition to the support for the stakeholders meeting, the JICA Survey Team also supported SONEDE to explain and collect the opinions of residents about power transmission line for the desalination plant. Collection of residents' opinions was carried out by distribution of explanation papers and questionnaire survey.

Contents of the distributed papers are; general map, questionnaire, outlines of the Project, and policies of land acquisition and compensation relating to construction of the power transmission line.

Since the Sfax Governorate office is the sole responsible authority for administrative issue in the Sfax Governorate under Ministry of Interior of Tunisia, SONEDE could not contact each region, but did so through the governorate office. SONEDE sent the questionnaire to the governorate office and requested the office to deliver the questionnaire to representatives of each region. The answer was that there had been no objection from Sfax Ville, West Sfax, and Thyna, and the governor also had no objection about the Project. It may be considered that no objection to construction work of the power transmission line at present.

Social survey will be conducted by SONEDE at the time of detailed design of the power transmission line by STEG. Subject area and residents will be identified through the survey, and then, the land required to be acquired and amount of compensation will be identified. Further, SONEDE will hold explanation meeting with residents in the subject areas to explain about policies for land acquisition and compensation and to confirm that there is no opposition to the Project.

CHAPTER 10 IMPLEMENTATION PLAN

10.1 Project Purpose

The purpose of the Project is to improve and enhance the living condition of Tunisia, particularly for the residents of Greater Sfax by increasing and stabilizing water supply capacity and improving water quality through the construction, installation and operation of a seawater desalination plant.

10.2 Project Outline

In this Project, the facilities to be installed are i) a sea water desalination plant with a capacity of 200,000 m^3/d and facilities required for the operation, ii) transmission pipes from the sea water desalination plant to the existing reservoirs, iii) transmission and intermediate pump stations, and appurtenant facilities for the operation, iv) reservoirs, v) electricity facilities which will receive power from the distribution network of STEG.

The outline of the overall plan and Phase 1 project is as follows:

Table 10-1 Outlines of the Project

Facilities	Overall plan	Phase I project (for Yen loan)
Lot 1		
Sea water intake pipe (Procurement/Construction)	Intake: 444,400m^3/d, length: 3.6 km (buried pipe in sea bed), diameter of pipe: 2,000 mm x 2 lines, HDPE pipe	(Construction of overall plan) Intake: 222,200m^3/d, length 3.6 km (Buried, off-shore; 3.2km, on-shore; 0.4km), pipe diameter 2,000mm x 2 lines, HDPE pipe
Sea water desalination plant (Procurement/Construction)	Production amount: 200,000 m^3/d, RO membrane, recovery: 45%, production water: TDS < 500mg/L, transmission pump facilities	(Facility construction for production of 100,000m^3/d) Production: 100,000m^3/d, RO membrane, recovery: 45%, TDS concentration of produced water: less than 500mg/L, transmission pump facility
Brine discharge pipe (Procurement/Construction)	Discharge: 244,400m^3/d, length: 4.4 km (buried pipe in sea bed), diameter: 1800 mm, HDPE pipe, brine of TDS: about 73,000mg/L	(Construction of overall plan) Discharge: 122,200m^3/d, length: 4.4km (Buried, off-shore; 4.0km, on-shore;0.4km), diameter: 1800mm, HDPE pipe, concentrated water of TDS: about 73,000mg/L

Facilities	Overall plan	Phase I project (for Yen loan)
Lot 2 Transmission pipeline materials (Procurement) Note: divided to 2 lots depends on pipe diameters	Necessary pipes for transmission pipe of Lot 4	(Procurement for overall plan) Pipes necessary for transmission pipeline of Lot 4, ductile cast iron pipe, diameter: 400 - 1,400 mm, length: about 49.5km Sub-lot: 2-1 : dia. 1400mm and 100mm 32.5km Sub-lot: 2-2 : dia. Less than 100mm 17.0km
Lot 3 Valves and other equipment materials (Procurement)	Necessary valves and other equipment for transmission pipe of Lot 4	(Procurement for overall plan) Valves necessary for transmission pipeline of Lot 4 of diameter 400 - 1400 mm and length about 49.5km
Lot 4 Transmission pipelines (Construction) Water hammer prevention facilities (Procurement/Construction)	Ductile cast iron pipe, diameter: 400 - 1400 mm, length: 49.5 km Construction of one-way surge tanks at 2 locations along transmission pipelines, and installation of flywheels and other devices at pump stations	(Construction of overall plan) Ductile cast iron pipe, diameter: 400 - 1400mm, length: 49.5km (Construction of overall plan) Construction of one-way surge tanks at 2 locations along transmission pipelines, and installation of flywheels and other devices at all pump stations
Lot 5 Reservoirs (Procurement/Construction)	New reservoirs with a capacity of 45,000 m^3 in total at existing reservoirs' site, receiving water and mixing chambers at 5 locations	(Construction of facilities necessary for Phase 1) New reservoir of 5,000 m^3 at existing reservoir (Bou Merra), and receiving and mixing chambers at 5 locations PK11: 9.0W x 15.0L x 5.0D Bou Merra : 4.0W x 3.0L x 5.0D PK10: 7.0W x 10.0L x 5.0D PK14: 7.0W x 7.0L x5.0D Sidi Salah EH: 6.0W x 5.0L x 5.0D m, W:width, L:length, D: water depth
Lot 6 Intermediate pump stations (Procurement/Construction)	Three locations at the existing reservoirs' site	(Civil and Architectural works: construction of overall plan, Mechanical and Electrical woks: installation of facility necessary for Phase 1) Three locations at existing reservoirs' site
Lot 7 Power receiving line (Procurement/Construction)	Power receiving line from power line of STEG to sea water desalination plant	(Construction of overall plan) Power receiving line from power line of STEG to sea water desalination plant. SONEDE is willing to include the cost for STEG's technical support into Lot 7. The said support will be for the work of power receiving and transformation in Lot 1 and for power connection work of facilities in Lot 6.

10.3 Consulting Services

It is recommended that the consulting services be provided in detailed design including the preparation of tender documents (Lots 1 to 6), tender assistance, and construction supervision. The following is a summary of the consulting services.

(1) Subject for Consulting Services

All lots (Lots 1 to 7)

(2) Period of consulting services

- Detailed design stage: 12 months
- Tender assistance stage: 15 months
- Construction supervision stage: 60 months for Lot 1 (36 months for construction work, 12 months for performance test, and 12 months for defect liability period)

Total: 87 months (including defect liability period)

(3) Required Man-months of consultants

Required man-months for the consulting services are as follows:

Table 10-2 Required Man-Months for the Consulting Services

unit: man-months

Type	Detailed Design	Tender Assistance	Construction Supervision	Total
Foreign Professional	77.0	36.0	190.5	303.5
Local Professional	84.0	16.0	406.5	506.5
Local Supporting Staff	149.0	61.0	491.0	701.0
Total	310.0	113.0	1,088.0	1,511.0

(4) Cost of consulting services

The cost of consulting services is Japanese Yen 2,486 million that consists of foreign currency of Japanese Yen 951 million and local currency of TND 25 million, and base cost. The details are indicated in Table 10-3.

Table 10-3 Cost of Consulting Services

US$ 1.= Yen 119.6
TND 1.= Yen 61.02

Item	Unit	Qt'ty.	Foreign Portion Yen		Local Portion TND		Combined Total (Yen)
			Rate	Amount ('000)	Rate	Amount ('000)	Amount ('000)
A Remuneration							
1 Professional (A)	M/M	303.5	2,895,000	878,633	0	0	878,633
2 Professional (B)	M/M	506.5	0	0	16,000	8,104	494,506
3 Supporting Staff (C)	M/M	701.0	0	0	12,000	8,412	513,300
Subtotal of A		1,511.0		878,633		16,516	1,886,439
B Direct Cost							
1 International Airfare	Trip	103	650,000	66,950			66,950
2 Domestic Airfare	Trip	0					0
3 Domestic Travel	Trip	103			250	26	1,571

	Item	Unit	Qt'ty.	Foreign Portion Yen		Local Portion TND		Combined Total (Yen)
				Rate	Amount ('000)	Rate	Amount ('000)	Amount ('000)
4	International Travel Expenses	Trip	103	50,000	5,150			5,150
5	Accommodation / Per Diem for A	Month	304			8,000	2,428	148,157
6	Accommodation / Per Diem for B	Month	507			4,800	2,431	148,352
7	Accommodation / Per Diem for C	Month	0					0
8	Vehicle Rental w/Driver and Fuel	Month	297			10,000	2,970	181,229
9	Office Rental	Month	63			4,000	252	15,377
10	International Communications	Month	77			1,000	77	4,699
11	Domestic Communications	Month	75			500	38	2,288
12	Office Supply	Month	75			1,000	75	4,577
13	Office Furniture and Equipment	LS	1			40,000	40	2,441
14	Report Preparation	Month	77			2,000	154	9,397
15	Topographic Survey	LS	1			100,000	100	6,102
16	Soil Investigation	LS	1			50,000	50	3,051
17	Water Quality Analysis	LS	1			3,000	3	183
	Subtotal of B				72,100		8,643	599,523
	Total				950,733		25,159	2,485,962

10.4 Project Cost and Financial Plan

The total project cost is JPY 52,587 million, JPY 26,696 million is foreign currency portion and TND 424 million is local currency portion. The eligible cost in the total project cost is JPY 44,013 million. The procurement items and the breakdown of foreign currency portion and local currency portion are shown in Table 10-4.

The conditions of project cost calculation are as follows:

1) Unit Prices Basis: May 2015
2) Exchange Rate: TND1.000 = JPY61.02, USD 1.00 = JPY119.6 (as of May 2015)
3) Physical Contingency: Project cost 5%, Consultant Fee 5%
   Set the lowest level of general scope (5% ~ 10%) because the size of the Project is large
4) Price Escalation: Project cost LC: 1.5% FC: 1.8%
   Consultant Fee LC: 1.5% FC: 1.8%
   LC is considered CPI inflation rate and foreign currency exchange rate.
5) Tax: VAT 18% (Construction/procurement), 12% (Consultant)
6) Import Tax: Imports from EU, EFTA and neighbouring countries are 0%. From other countries, customs value is different for each item, and various procedures fees and taxes associated with customs clearance are charged. It is tax-free if it is certified as public works. SONEDE plans to carry out this procedure. It is set at 0.36% in this survey.
7) Administration cost: 3% of the total project cost from experience with similar project
8) Interest during Construction (IDC): Project Cost 1.7%, Consultant Fee 0.01% (interest of the loan)
   It is expected that the Tunisian government prefer cash payment; therefore, IDC is not included in the loan amount but the total project cost.

9) Front End Fee: 0.2% of loan

(0.1% will retroactively be applied instead of 0.2% in the event that all disbursements are completed within the original disbursement period)

10) Categorization of Local Currency Portion (LCP) and Foreign Currency Portion (FCP)

Unit costs of construction work and procurement are categorized into LCP and FCP based on the information and data obtained from local contractors, SONEDE's experiences, and quotation from manufactures.

Table 10-4 Project Cost (Phase 1)

unit: FC,Total; million JPY, LC: million TND

Item		FC	LC	Total
A. ELIGIBLE PORTION				
I)	Procurement / Construction	22 165	312	41 174
	Lot1: Construction of Sea Water Desalination Plant (ICB) *PQ, Design Build	14 163	191	25 826
	Lot2-1: Procurement of Pipes 1000mm & 1400mm (ICB)	2 189	4	2 432
	Lot2-2: Procurement of Pipes less than 1000mm (ICB)	436	1	484
	Lot3: Procurement of Valves & Other Equipment (LCB)	511	1	568
	Lot4: Construction of Transmission Pipeline (ICB)	40	48	2 940
	Lot5: Construction of Reservoir (LCB)	0	5	307
	Lot6: Construction of Pumping Stations (ICB) *Design Build	1 565	14	2 405
	Lot7: Construction of Power Supply Line (STEG)	0	7	444
	Base cost for JICA financing	18 904	270	35 406
	Price escalation	2 206	26	3 807
	Physical contingency	1 055	15	1 961
II)	Consulting services	1 095	29	2 839
	Base cost	951	25	2 486
	Price escalation	82	2	196
	Physical contingency	49	1	128
Total (I + II)		23 260	340	44 013
B. NON ELIGIBLE PORTION				
a	Procurement / Construction	0	0	0
	Base cost for JICA financing	0	0	0
	Price escalation	0	0	0
	Physical contingency	0	0	0
b	Land Acquisition	0	1	88
	Base cost	0	1	81
	Price escalation	0	0	3
	Physical contingency	0	0	4
c	Administration cost	0	22	1 323
d	VAT	0	60	3 647
e	Import Tax	0	1	80
f.	Interest during Construction	3 348	0	3 348
	Interest during Construction (Construction)	3 347	0	3 347
	Interest during Construction (Consultant)	2	0	2
g.	Front End Fee	88	0	88
Total (a+b+c+d+e+f+g)		3 436	84	8 574
C. TOTAL (A+B)		26 696	424	52 587
D. JICA finance portion (A)		23 260	340	44 013

TND1.000 = JPY61.02, USD 1.00 = JPY119.6

Notes: Total may not equal to summation of each item due to rounding off.

Source: JICA Survey Team

The total amount of the JICA ODA loan eligible items is 44,013 million JPY which is 83.7% of total project cost 52,587 million JPY. Since the ceiling ratio of the coverage of a loan over total cost of the Project for Tunisia is 85%, all of the JICA ODA loan eligible items shall be covered by the JICA ODA loan. Loan ratio and yearly financial plan are shown below.

Table 10-5 Loan Coverage Ratio

Unit: million JPY

Total Project Cost	ODA Loan	Own Fund	Loan Ratio
52,587	44,013	8,574	83.7%

Table 10-6 Annual Disbursement

Unit: million JPY

Year	Project Cost	ODA Loan	Own Fund
2015	88	0	88
2016	0	0	0
2017	725	610	115
2018	364	283	80
2019	6,238	5,571	667
2020	10,976	9,579	1,397
2021	10,769	9,292	1,477
2022	10,082	8,541	1,541
2023	9,668	8,083	1,584
2024	2,809	1,900	909
2025	869	153	716
Total	52,587	44,013	8,574
Ratio	100.0%	83.7%	16.3%

Source: JICA Survey Team

10.5 Procurement Process

10.5.1 Employment of Consultants

The consultants employed for the Japanese ODA loan project will be selected through ICB with processes in accordance with the guidelines of JICA as follows:

1) Preparation of Shortlist
2) Request for Proposals
3) Submission of proposals
4) Opening and evaluation of technical proposal
5) Opening and evaluation of financial proposal
6) Contract negotiation, award of contract

10.5.2 Procurement of Contractors

The Phase 1 project is separated into seven lots in which takes into consideration the facilities' component and the category of procured items. Regarding construction projects, the design-build contact is appropriate for Lots 1 and 6, and BoQ contract, or unit price contract is appropriate for Lots 2 to 5.

1) Lot 1: Seawater desalination plant

- Procurement and construction of seawater intake, seawater desalination plant, discharge pipe for concentrated seawater, and transmission pump facilities.
- Selection of contractors by the design-build contract through International Competitive Bidding (ICB).
- After construction work, the contractor shall conduct a Guarantee Test for 12 months.

2) Lot 2: Procurement of transmission pipeline material

- Procurement of pipe materials for transmission pipeline
- Selection of a supplier for the material's procurement through ICB
- This lot is divided to two sub-lots in order to keep the competiveness as follows:
  Sub-lot 2-1; dia. 1400 mm and 1000 mm
  Sub-lot 2-2; dia. less than 1000 mm
- Tender for Sub-lot 1 and Sub-lot 2 will be conducted at same time. Tenderer can submit the tender for one of two sub-lots or both.

3) Lot 3: Procurement of valves and the other equipment for transmission pipeline

- Procurement of valves and related equipment regarding transmission pipelines
- Selection of a supplier for the materials' procurement through Local Competitive Bidding (LCB)

4) Lot 4: Construction of transmission pipe

- Construction of transmission pipe at a length of 49.5 km, and water hammer prevention facilities at two locations
- Selection of a contractor by the BoQ contract through ICB

5) Lot 5: Construction of reservoirs

- Construction of a reservoir, and five receiving/mixing chambers at existing five reservoir sites
- Selection of a contractor by the BoQ contract through LCB

6) Lot 6: Construction of pump facility

- Construction of pump facility at three locations
- Selection of a contractor by the design-build contract through ICB

7) Lot 7: Construction of receiving power line

- Construction of receiving power line from power distribution network of STEG for supplying power to sea water desalination plant
- Construction will be executed under the direct contracting between SONEDE and STEG, who will take charge of construction. The construction cost is considered as the project cost and is eligible to the Japanese ODA loan.
- SONEDE is willing to include the cost for STEG's technical support into Lot 7. The said support will be for the work of power receiving and transformation in Lot 1 and for power connection work of facilities in Lot 6. The required cost for said support for Lot 1 is counted in Lot 7. The cost for said support for Lot 6, however, is not counted in the project cost because the work for Lot 6 will be the one for relatively low tension voltage, which will not be like the one for the desalination plant, and SONEDE has carried out such work for many construction works in the past. Even though SONEDE shall consult with STEG about said work, it was judged that the cost for said support will not be large to be counted as a part of the project cost.

Employment method of consultants, procurement method of construction works, and the project costs of each lot are presented in Table 10-7.

Table 10-7 Employment Method of Consultants and Type of Bid

Lot	Contents	Type of Bid	Type of Contract	Base Cost*		Procurement of Consultant				Type of SBD$^{\#}$
				TND (1000TND)	equiv. Yen (1000Yen)	Detailed Design	Preliminary Design	Tender Assistance	Construction Supervision	
Lot 1:	Seawater Desalination Plant Construction Work	PQ-ICB	Design-Build	423,245	25,826,438	-	JICA Loan	JICA Loan	JICA Loan	1. 2
Lot 2-1:	Pipe Materials Procurement (1400 & 1000)	ICB	BOQ	39,860	2,432,246	JICA Loan	-	JICA Loan	JICA Loan	3
Lot 2-2:	Pipe Materials Procurement (Less than 1000)	ICB	BOQ	7,931	483,946	JICA Loan	-	JICA Loan	JICA Loan	3
Lot 3:	Valve and Other Materials Procurement	LCB	BOQ	9,301	567,541	JICA Loan	-	JICA Loan	JICA Loan	-
Lot 4:	Transmission Pipeline Installation	ICB	BOQ	48,179	2,939,856	JICA Loan	-	JICA Loan	JICA Loan	4
Lot 5:	Reservoir Construction Work	LCB	BOQ	5,023	306,503	JICA Loan	-	JICA Loan	JICA Loan	-
Lot 6:	Pump Facility Construction Work	ICB	Design-Build	39,420	2,405,399	-	JICA Loan	JICA Loan	JICA Loan	2
Lot 7:	Power Supply Service Line Construction Work	Direct Contracting w/ STEG		7,283	444,409	STEG	-	-	STEG**	4
CS:	Consulting Services	Short-List	Time-based	40,740	2,485,962	JICA Loan		JICA Loan	JICA Loan	5
	Total			620,982	37,892,300					

Notes. * : Price Escalation and Physical Contingency are excluded . Exchange Rate: 61.02 Yen/TND

**: Watched by Consultant

SBD$^{\#}$: Standard Bidding Documents of JICA to be applied
1: Standard Prequalification Documents, JICA
2: Standard Bidding Documents-EQUIPMENTS (Plant), JICA
3: Standard Bidding Documents-BIENS (Goods), JICA
4: Standard Bidding Documents-TRAVAUX（Works）, JICA
5: Standard Request for Proposals、JICA

Source: Minutes of Discussion of Sfax Sea Water Desalination Plant Construction Project between JICA, Government of Tunisia and SONEDE, 6 February 2015

10.6 Project Implementation Schedule

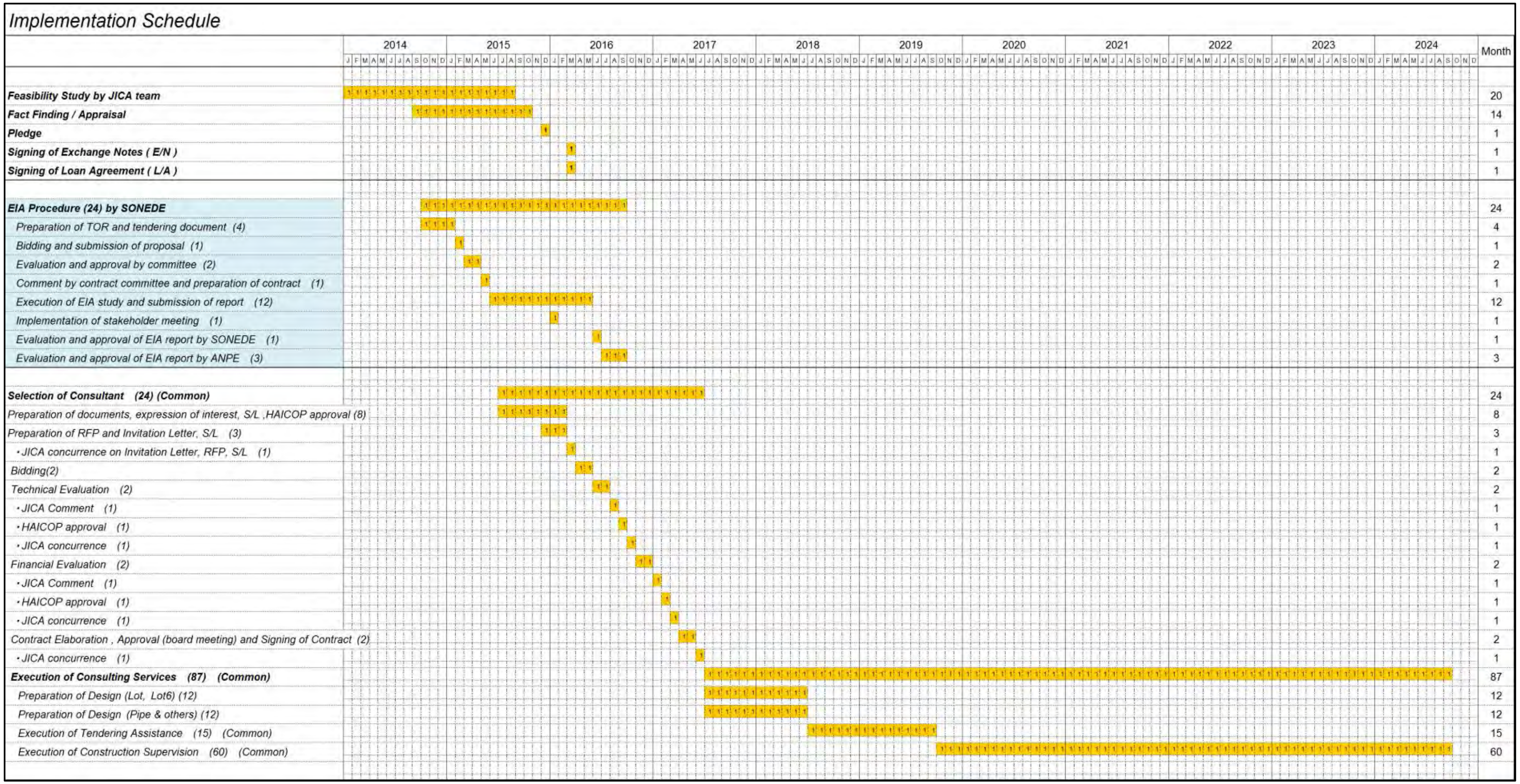
Table 10-8 and Figure 10-1 present the process of the Japanese ODA loan project with time schedule. The stage of the Project is separated as before construction and during construction. Table 10-8 indicates the schedule of Lot 1 as a critical path of the Project.

Table 10-8 Outline of Project Implementation Schedule

Project activity	Required period (month)	Expected time
1. Pledge of a loan project (possible to commence the document process between implementation organization and JICA)		2015.12
2. Exchange of Notes for a Loan Project		2016.3
3. Loan Agreement		2016.3
4. EIA Study	12	2015.6 - 2016.5
5. Approval of EIA		2016.9
6. Selection of Consultants	24	2015.7 – 2017.6
7. Consulting Services (for Lots 1 to 7)	87	2017.7 – 2024.9
7.1 Detailed (conceptual) Design (Lots 1 to 6)*	(12)	2017.7 – 2018.6
7.2 Tender Assistance (Lots 1 to 6)	(15)	2018.7 – 2019.9
7.3 Construction Supervision (Lots 1 to 7)	(60)	2019.10 – 2024.9
8. Selection of Contractor (Lot 1)	23	2017.11 – 2019.9
9. Construction Work (Lot 1) (including Performance Test**)	48	2019.10 – 2023.9
10. Handing-over, Commissioning (Lot 1)		2023.10
11. Defect Liability Period (Lot 1)	12	2023.10 – 2024.9

*: For Lots 1 and 6, conceptual or basic design and preparation of bidding documents which correspond to design-build contract. For Lots 2 and 3, preparation of bidding documents for procurement of equipment and materials. For Lots 4 and 5, detailed design and preparation of bidding documents which corresponds to construction work contract. Preparation of prequalification documents and evaluation of submitted PQ documents will also be conducted during this period for Lot 1.

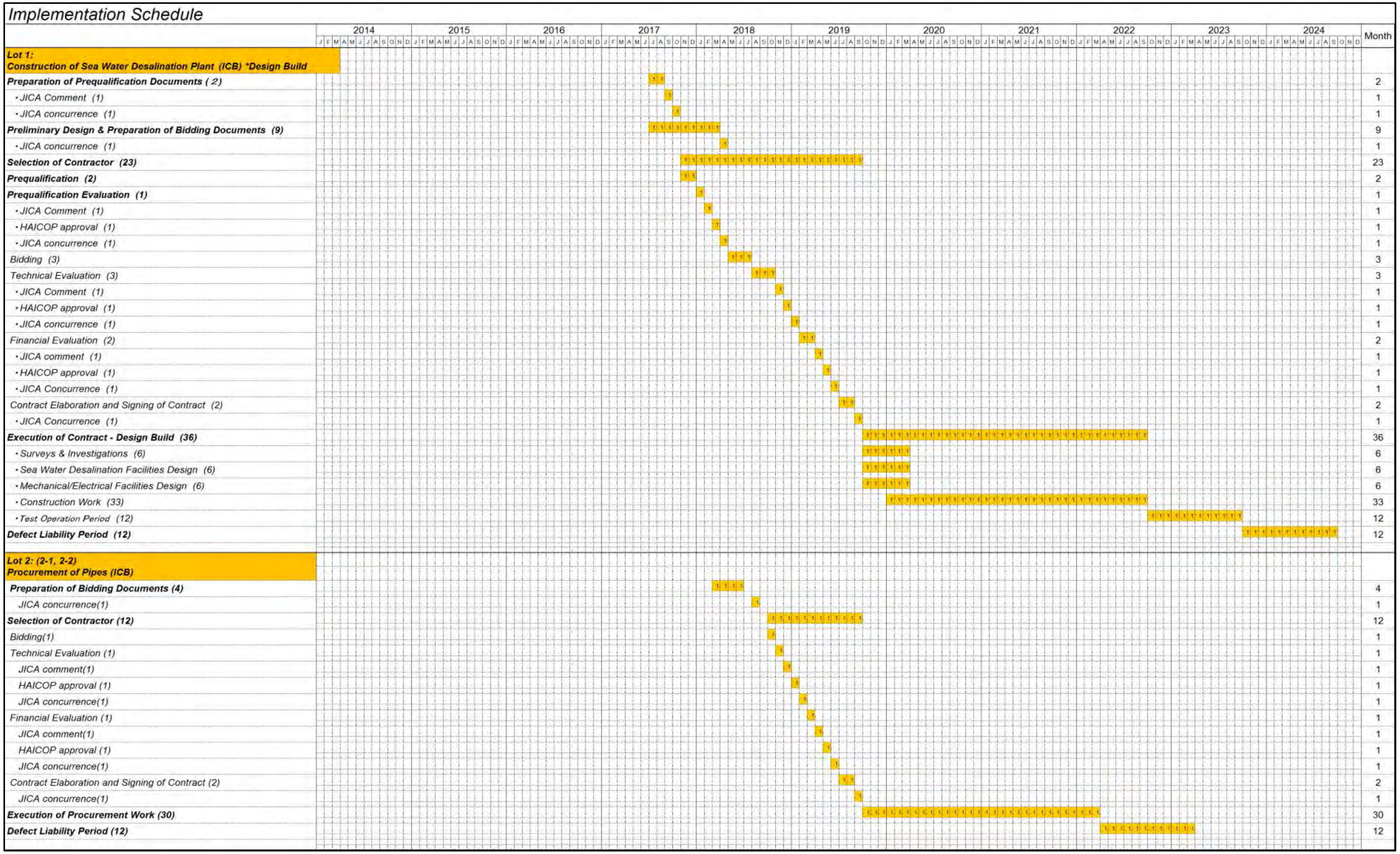
**: Performance Guarantee Test to be conducted by the Contractor after completion of construction work. Tentative hand-over to SONEDE will be done before the start of test. Costs required for power, chemicals and remuneration will be included in the construction cost. Power cost and chemicals cost, however, will be treated as provisional sum which shall be put in tender under the fixed conditions specified in the tender documents and be settle during the test based on the actual expenditure. Duration of the test will be 12 months and the facilities will be handed over to SONEDE after completion of the test. Defect liability period shall be extended 12 months after handing-over to SONEDE. .



Implementation Schedule

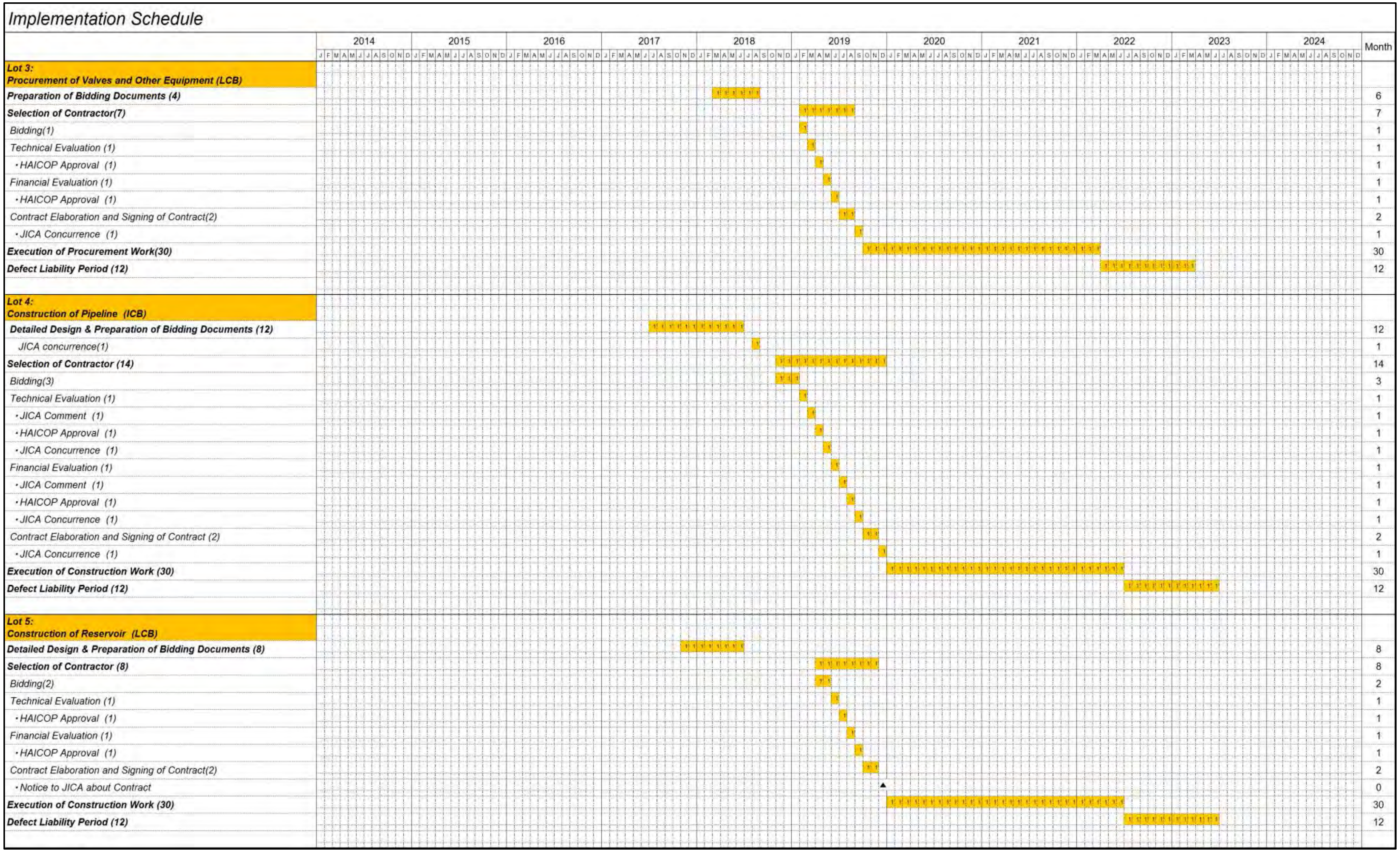
	Month
Feasibility Study by JICA team	20
Fact Finding / Appraisal	14
Pledge	1
Signing of Exchange Notes (E/N)	1
Signing of Loan Agreement (L/A)	1
EIA Procedure (24) by SONEDE	24
Preparation of TOR and tendering document (4)	4
Bidding and submission of proposal (1)	1
Evaluation and approval by committee (2)	2
Comment by contract committee and preparation of contract (1)	1
Execution of EIA study and submission of report (12)	12
Implementation of stakeholder meeting (1)	1
Evaluation and approval of EIA report by SONEDE (1)	1
Evaluation and approval of EIA report by ANPE (3)	3
Selection of Consultant (24) (Common)	24
Preparation of documents, expression of interest, S/L ,HAICOP approval (8)	8
Preparation of RFP and Invitation Letter, S/L (3)	3
・JICA concurrence on Invitation Letter, RFP, S/L (1)	1
Bidding(2)	2
Technical Evaluation (2)	2
・JICA Comment (1)	1
・HAICOP approval (1)	1
・JICA concurrence (1)	1
Financial Evaluation (2)	2
・JICA Comment (1)	1
・HAICOP approval (1)	1
・JICA concurrence (1)	1
Contract Elaboration , Approval (board meeting) and Signing of Contract (2)	2
・JICA concurrence (1)	1
Execution of Consulting Services (87) (Common)	87
Preparation of Design (Lot, Lot6) (12)	12
Preparation of Design (Pipe & others) (12)	12
Execution of Tendering Assistance (15) (Common)	15
Execution of Construction Supervision (60) (Common)	60

Figure 10-1 Implementation Schedule (1/4)



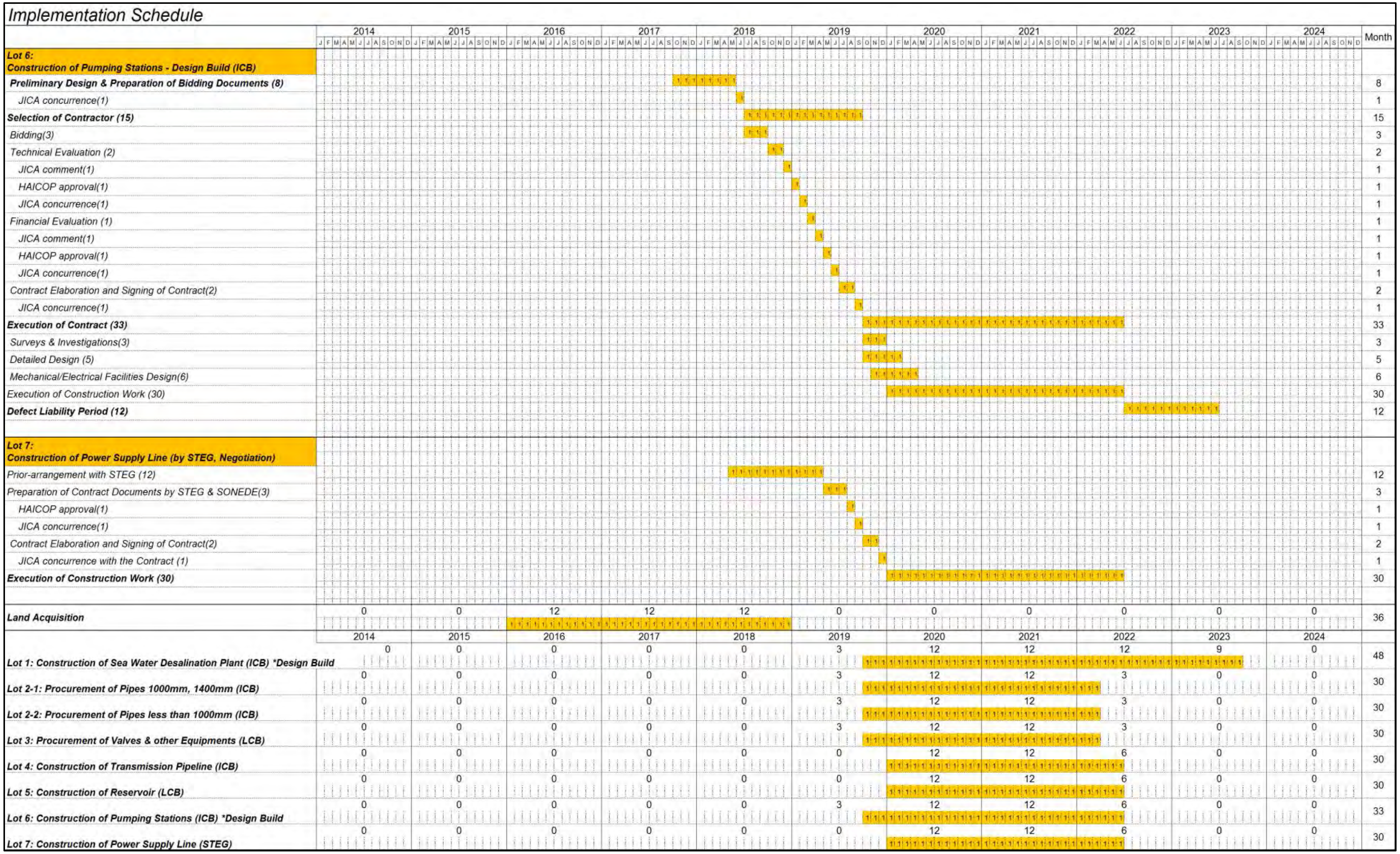
	Month
Lot 1: Construction of Sea Water Desalination Plant (ICB) *Design Build	
Preparation of Prequalification Documents (2)	2
・JICA Comment (1)	1
・JICA concurrence (1)	1
Preliminary Design & Preparation of Bidding Documents (9)	9
・JICA concurrence (1)	1
Selection of Contractor (23)	23
Prequalification (2)	2
Prequalification Evaluation (1)	1
・JICA Comment (1)	1
・HAICOP approval (1)	1
・JICA concurrence (1)	1
Bidding (3)	3
Technical Evaluation (3)	3
・JICA Comment (1)	1
・HAICOP approval (1)	1
・JICA concurrence (1)	1
Financial Evaluation (2)	2
・JICA comment (1)	1
・HAICOP approval (1)	1
・JICA Concurrence (1)	1
Contract Elaboration and Signing of Contract (2)	2
・JICA Concurrence (1)	1
Execution of Contract - Design Build (36)	36
・Surveys & Investigations (6)	6
・Sea Water Desalination Facilities Design (6)	6
・Mechanical/Electrical Facilities Design (6)	6
・Construction Work (33)	33
・Test Operation Period (12)	12
Defect Liability Period (12)	12
Lot 2: (2-1, 2-2) Procurement of Pipes (ICB)	
Preparation of Bidding Documents (4)	4
JICA concurrence(1)	1
Selection of Contractor (12)	12
Bidding(1)	1
Technical Evaluation (1)	1
JICA comment(1)	1
HAICOP approval (1)	1
JICA concurrence(1)	1
Financial Evaluation (1)	1
JICA comment(1)	1
HAICOP approval (1)	1
JICA concurrence(1)	1
Contract Elaboration and Signing of Contract (2)	2
JICA concurrence(1)	1
Execution of Procurement Work (30)	30
Defect Liability Period (12)	12

Figure 10-1 Implementation Schedule (2/4)



	Month
Lot 3: Procurement of Valves and Other Equipment (LCB)	
Preparation of Bidding Documents (4)	6
Selection of Contractor(7)	7
Bidding(1)	1
Technical Evaluation (1)	1
・HAICOP Approval (1)	1
Financial Evaluation (1)	1
・HAICOP Approval (1)	1
Contract Elaboration and Signing of Contract(2)	2
・JICA Concurrence (1)	1
Execution of Procurement Work(30)	30
Defect Liability Period (12)	12
Lot 4: Construction of Pipeline (ICB)	
Detailed Design & Preparation of Bidding Documents (12)	12
JICA concurrence(1)	1
Selection of Contractor (14)	14
Bidding(3)	3
Technical Evaluation (1)	1
・JICA Comment (1)	1
・HAICOP Approval (1)	1
・JICA Concurrence (1)	1
Financial Evaluation (1)	1
・JICA Comment (1)	1
・HAICOP Approval (1)	1
・JICA Concurrence (1)	1
Contract Elaboration and Signing of Contract (2)	2
・JICA Concurrence (1)	1
Execution of Construction Work (30)	30
Defect Liability Period (12)	12
Lot 5: Construction of Reservoir (LCB)	
Detailed Design & Preparation of Bidding Documents (8)	8
Selection of Contractor (8)	8
Bidding(2)	2
Technical Evaluation (1)	1
・HAICOP Approval (1)	1
Financial Evaluation (1)	1
・HAICOP Approval (1)	1
Contract Elaboration and Signing of Contract(2)	2
・Notice to JICA about Contract	0
Execution of Construction Work (30)	30
Defect Liability Period (12)	12

Figure 10-1 Implementation Schedule (3/4)



Implementation Schedule

	Month
Lot 6: Construction of Pumping Stations - Design Build (ICB)	
Preliminary Design & Preparation of Bidding Documents (8)	8
JICA concurrence(1)	1
Selection of Contractor (15)	15
Bidding(3)	3
Technical Evaluation (2)	2
JICA comment(1)	1
HAICOP approval(1)	1
JICA concurrence(1)	1
Financial Evaluation (1)	1
JICA comment(1)	1
HAICOP approval(1)	1
JICA concurrence(1)	1
Contract Elaboration and Signing of Contract(2)	2
JICA concurrence(1)	1
Execution of Contract (33)	33
Surveys & Investigations(3)	3
Detailed Design (5)	5
Mechanical/Electrical Facilities Design(6)	6
Execution of Construction Work (30)	30
Defect Liability Period (12)	12
Lot 7: Construction of Power Supply Line (by STEG, Negotiation)	
Prior-arrangement with STEG (12)	12
Preparation of Contract Documents by STEG & SONEDE(3)	3
HAICOP approval(1)	1
JICA concurrence(1)	1
Contract Elaboration and Signing of Contract(2)	2
JICA concurrence with the Contract (1)	1
Execution of Construction Work (30)	30

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Month
Land Acquisition	0	0	12	12	12	0	0	0	0	0	0	36
Lot 1: Construction of Sea Water Desalination Plant (ICB) *Design Build	0	0	0	0	0	3	12	12	12	9	0	48
Lot 2-1: Procurement of Pipes 1000mm, 1400mm (ICB)	0	0	0	0	0	3	12	12	3	0	0	30
Lot 2-2: Procurement of Pipes less than 1000mm (ICB)	0	0	0	0	0	3	12	12	3	0	0	30
Lot 3: Procurement of Valves & other Equipments (LCB)	0	0	0	0	0	3	12	12	3	0	0	30
Lot 4: Construction of Transmission Pipeline (ICB)	0	0	0	0	0	0	12	12	6	0	0	30
Lot 5: Construction of Reservoir (LCB)	0	0	0	0	0	0	12	12	6	0	0	30
Lot 6: Construction of Pumping Stations (ICB) *Design Build	0	0	0	0	0	3	12	12	6	0	0	33
Lot 7: Construction of Power Supply Line (STEG)	0	0	0	0	0	0	12	12	6	0	0	30

Figure 10-1 Implementation Schedule (4/4)

10.7 Operation and Maintenance Cost

The estimate of the operation and maintenance cost includes all necessary costs for the operation and maintenance of the seawater desalination plant based on the existing desalination plants. Depreciation is not included because there is no cash involved.

The operation and maintenance cost of this seawater desalination plant and the related water supply systems is 36,990,400 TND/yr. or 1.013 TND/m^3 for desalinated water production of 100,000 m^3/day as shown in Table 10-9.

Table 10-9 Annual Cost for Operation and Maintenance

Unit: TND/yr.

Facility	Power	Chemical	RO Membrane	Personnel	Other	TOTAL
Seawater desalination plant	24,893,400	2,717,000	2,898,000	570,000	1,703,000	32,781,400
Water supply facility	1,840,000	0	0	75,000	195,000	2,110,000
Intermediate pump facility	1,438,00	0	0	195,000	466,000	2,099,000
TOTAL	28,171,400	2,717,000	2,898,000	840,000	2,364,000	36,990,400

Source: JICA Survey Team

10.8 Project Implementation Structure

10.8.1 Borrower

The borrower of the loan is the Government of Tunisia. The administrative contact is the Ministry of Development, Investment and International Cooperation.

10.8.2 Implementing Entity of the Project

Implementing entity of the Project will be SONEDE. The Research Central Department will be in charge of planning and designing. The New Project Central Department will be in charge of construction. In addition, some experts will participate in the Project in the field of finance as supporting staff.

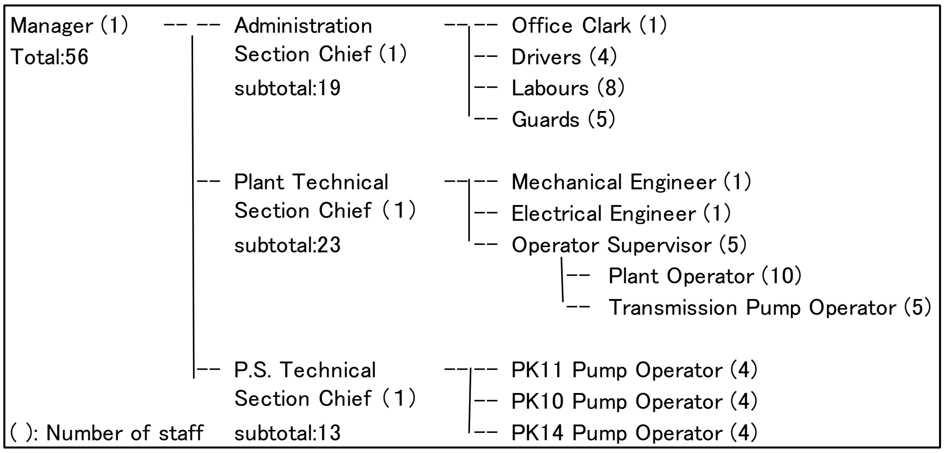
During the planning and designing stages, both the headquarters divisions and the Central-South Branch of the Research Central Department will participate in implementing the Project. The headquarters divisions are; the Water Treatment Process Division, the Civil Engineering Division, the Hydrology Division, the Topography Division, the Division of Bidding Preparation and Monitoring, and the Department of Desalination and Environmental Impact (DDEI). The divisions of the Research Central Department Central-South Branch are; the South-East Hydrology Division, the Equipment Division of Central and South Region, and the Civil Engineering Division.

At the construction stage, both the headquarters division and the South Branch of the New Project Central Department will participate in the project implementation. The headquarters division is the Division of Monitoring Project and Market. The divisions of the New Project Central Department South Branch are; the Hydrogeology Division, the Technical Division, the Land Division, the Site Management Division, and the Evaluation and Survey Division.

It is the common practice in large-scale projects to establish the Project Implementation Unit (PIU) inside SONEDE for project coordination to facilitate smooth implementation of the Project. It has been internally agreed upon that the PIU organized in the construction project of Djerba desalination plant funded by AFD and KfW will be in charge of both the Project and the project of Gabes desalination plant expected to be financed by KfW.

10.8.3 Operation and Maintenance Entity

Figure 10-2 presents the organization plan of operation and maintenance group for the project facilities.



Source: JICA Survey Team

Figure 10-2 Organization for O&M of Sfax Seawater Desalination Plant and Intermediate Pumping Facilities

10.9 Economic and Financial Analysis

The results of financial analysis (FIRR) and economic analysis (EIRR) are discussed below.

10.9.1 FIRR

FIRR is calculated based on the project cost, operation and maintenance costs, and benefit in the evaluation period.

(1) Opportunity cost of capital

Opportunity cost of capital is set at 4.77% based on the average interest rate of the Tunisian Central Bank in May 2015.

(2) Calculation of FIRR

Net income becomes negative by calculating the current water tariff and the operation and maintenance cost of sea water desalination plants based on the above-mentioned conditions. If negative, FIRR cannot be calculated. However, the current tariff in Tunisia is relatively lower than the disposable income of 4%, a reference rate of international organizations. Since the tariff is planned to be increased continuously, the sensitive analysis is made for several patterns of the tariff. The following is the table of cash flow and the result of FIRR calculation.

Project Cost

Use of following costs presented in Table 10-4.

- I) Procurement / Construction, and II) Consulting Services with Physical Contingency of 5% (not counted in case no burden of CAPEX)
- Administration Cost (counted even in case no burden of CAPEX)
- Land Acquisition (counted even in case no burden of CAPEX)
- VAT (counted even in case no burden of CAPEX)
- Price Escalation and IDC are not counted.

Operation & Maintenance Cost

The amount presented in Table 10-9 was used and considered as fixed cost is 10%, and 90% of it is adjusted in proportion to produced water volume.

Operation and Maintenance Cost =36,990,400 x (0.1+0.9x (annual water production / (100,000 x 365)))

O&M cost for the period of the performance test, i.e. one year from October 2022, is included in the construction cost. Therefore, O&M cost for 2023 is accounted for three months, or from October to December.

Sales (Revenue)

Sales amount is calculated as multiplication of water production[6]. Water production during the one year performance test from October 2022 was counted as sales. The water tariff increase is planned to be increased gradually in five years from 2022. After year 2026, it is assumed that the facilities of the first phase are fully operational.

(3) Sensitivity analysis

The sensitivity is analysed for two cases. One is a case including the project cost (FIRR with CAPEX). The other is a case excluding project cost (without CAPEX). In actuality, SONEDE will cover only the operation and maintenance costs. Therefore, a result of FIRR without CAPEX is the practical value. The calculation results are presented in Table 10-10.

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[6] Average daily water production (maximum daily production / 1.4) x 365 days

Table 10-10　Calculation of FIRR

Unit: JPY

Tariff Level (Project)[*1]	0.382TND/m^3	1.154TND/m^3	1.258TND/m^3	2.022TND/m^3	3.035TND/m^3
Tariff Level (SONEDE)[*2]	0.382TND/m^3	0.418TND/m^3	0.423TND/m^3	0.458TND/m^3	0.505TND/m^3
Calculation Base	Without CAPEX	Without CAPEX	Without CAPEX	With CAPEX	With CAPEX
Project Cost	4,680,560,928	4,680,560,928	4,680,560,928	44,467,475,906	44,467,475,906
Operation & Maintenance[*3]	49,017,529,664	49,017,529,664	49,017,529,664	49,017,529,664	49,017,529,664
Sales[*4]	18,322,625,771	53,712,005,950	58,479,487,218	93,456,296,903	139,939,239,263
Gross profit[*3]	▲35,375,464,822	13,915,358	4,781,396,625	17,132,499	46,454,233,693
FIRR (%)	－	0.02%	4.79%	0.00%	4.77%

*1: In case tariff increase for water supplied by desalinated water.
*2: In case tariff increase on all water supplied by SONEDE. Refer to 10.9.1 (4)
*3: Total for 36 years
*4: Water sales for production water for project life of 36 years.
Source: JICA Survey Team

FIRR is negative when the water tariff is 0.382TND/m^3. However, FIRR becomes 0.02% when the tariff is 1.154 TND/m^3. If the tariff is raised to 1.258 TND/m^3, FIRR becomes 4.79%, which exceeds the opportunity cost of capital. In case of including CAPEX, if the tariff is raised to around 3.035 TND/m^3, FIRR equals to the capital opportunity cost.

Table 10-11　Sensitivity Analysis of FIRR (Tariff Level)

Tariff (TND/m^3)	1.154	1.200	1.258	1.500	1.750	2.022	2.250	2.500	2.750	3.035
FIRR without CAPEX	0.02%	2.41%	4.79%	11.85%	17.18%	21.96%	25.44%	28.86%	31.95%	35.16%
FIRR with CAPEX	-10.54%	-9.05%	-7.67%	-4.14%	-1.86%	0.00%	1.29%	2.53%	3.63%	4.77%

Source: JICA Survey Team

(4) Impact to the entire business of SONEDE

Table 10-12 presents a water tariff in case tariff increase is applied over the whole water distributed by SONEDE. For example, in order to cover O&M cost and make FIRR positive without CAPEX, water tariff shall be increased to 0.418TND/m^3 by 2026 from 0.382 TND/m^3 at present. For exceeding the opportunity cost of capital (4.77%) without CAPEX, the tariff level shall be increased to 0.423 TND/m^3 by 2026. In the calculating the FIRR, it is assumed that water tariff is increased to the required level gradually for five years from the present level as presented in Table 10-12.

Table 10-12　Comparison of Water Tariff between the Cases of Desalinated Water and SONEDE's Distributed Water

Unit:TND/m^3

Water Tariff	Condition	Year	2021	2022	2023	2024	2025	2026
0.413	No Initial Cost Covering O&M cost FIRR＞0	Tariff*	0.382	0.388	0.394	0.401	0.407	0.413
		I. Rate**	8.1%（1.57%/p.a.）					
0.418	Without CAPEX Covering O&M cost FIRR＞0	Tariff*	0.382	0.389	0.397	0.404	0.411	0.418
		I. Rate**	9.4%（1.81%/p.a.）					

Water Tariff	Condition	Year	2021	2022	2023	2024	2025	2026
0.423	Without CAPEX Covering O&M cost FIRR＞Opportunity Cost of capital 4.77%	Tariff*	0.382	0.390	0.398	0.406	0.415	0.423
		I. Rate**	10.7%（2.05%/p.a.）					
0.458	With CAPEX Covering O&M cost FIRR＞0	Tariff*	0.382	0.397	0.412	0.428	0.443	0.458
		I. Rate**	19.9%（3.69%/p.a.）					
0.505	With CAPEX Covering O&M cost FIRR＞Opportunity Cost of capital 4.77%	Tariff*	0.382	0.407	0.431	0.456	0.480	0.505
		I. Rate**	32.2%（5.72%/p.a.）					

*: Average water tariff for water newly produced by the Project plus whole water distributed by SONEDE, 1,551,000 m^3/day (566,071,000 m^3/year) is the subject.

**: Increase Rate between the tariff in 2021 and the one in 2026.

10.9.2 EIRR

EIRR is calculated with a factor of economic costs and economic benefits converted into the monetary value of social benefits.

(1) EIRR

EIRR, which is calculated based on the benefit determined above, is 12.08%. This value is higher than the social discount rate of 10%. Sufficient economic benefits can be expected from the Project. The result of calculation and cash flow statement are shown in Table 10-13

The cash flow was made based on the following:

Project Cost

Use of following items from Table 10-4.

- ・Applied with Physical Contingency of 5% to (I) Procurement / Construction and (II) Consulting services
- ・Administration Cost
- ・excluding Price escalation, Land Acquisition, VAT and IDC
- ・use of SCF of 0.98 for Foreign Currency

Operation & Maintenance Cost

- ・The amount in Table 10.8-1 converted to JPY is used. It is assumed that 10% of it is fixed cost and 90% of it varies in proportion to water production volume.

Benefit (Economic Price of water)）

- ・Based on the social survey, 4.488 TND/m^3 is assumed as the benefit of economic water price for water volume produced by the Seawater desalination plant[7].

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[7] Annual water production = Daily Average Water Production x 365 days, Daily Average Water Production = Daily Maximum Water Production / 1.4

Table 10-13 Calculation of EIRR

UNIT: JPY

Total Cost	Project Cost	40,983,078,860
	Operation and Maintenance Cost	49,017,529,664
Total Benefit	Benefit (Economical benefit)	215,266,870,311
Gross Profit		125,266,261,787
EIRR (%)		12.08%

Source: JICA Survey Team

(2) Sensitivity analysis

The sensitivity is analysed for an increase of the project cost at 10%, a decrease of the economic benefit at 10 %, and a delay of the benefit by one year. EIRR becomes 12.08% in base case, which exceeds the social discount rate of 10%. As a result, sufficient economic benefits are expected. EIRR in other conditions also exceeds the social discount rate of 10%. For the other condition, sufficient economic benefits are also expected.

Table 10-14 Sensitivity Analysis of EIRR

Case	BASE	CAPEX +10%	Benefit -10%	1 year Delay
EIRR	12.08%	10.93%	10.47%	10.79%

Source: JICA Survey Team

10.10 Operation and Effect Indicators

As an operations indicator, water supply volume, rate of facility utilization, and the water quality are selected. In addition, the operation of the desalination plant will be effective in reducing TDS concentration of distributed water. SONEDE is willing to reduce it lower than 1500 mg/L, which is possible, and will be set as the operations indicator.

Table 10-15 Monitoring Indicators of the Project

Indicator	Method of establishing the indicator	Timing	Baseline (2013)	Target (2025*)
Water Supply Volume (m^3/d)	Maximum daily water supply volume = (the maximum volume among daily water supply volume in a year)	Yearly	-	100,000m^3/d (maximum capacity of the seawater desalination plant)
Rate of Facility Utilization (%)	Rate of Facility Utilization (maximum) = (maximum daily water supply volume)/ (capacity of the facility) × 100	Yearly	-	100% (maximum utilization rate)
Water Quality	TDS Concentration of each Reservoir	Yearly	1,852 -2,257 mg/L	Less than 1,500 mg/L

* : 2 years after completion of facilities in 2023.

Source: JICA Survey Team

CHAPTER 11 CONFIRMATION OF VIABILITY AND RISK ANALYSIS

The necessity for installing a seawater desalination plant installation was examined in Chapter 4. In constructing the plant, there are some issues on finance, environment, and power supply. This chapter discusses these issues as well as mitigation of risks associated with the issues presented.

11.1 Concern about Financial Aspect

The initial costs in the construction of seawater desalination plant will be shouldered by the government of Tunisia. SONEDE is not required to consider the payment of the initial cost from its account, but the operation and maintenance cost shall be borne by SONEDE from its own revenue. The O&M cost of the desalination plant is higher compared with the common water treatment process. Without implementing measures to increase revenue, SONEDE will not able to shoulder the increased expenditure for operation and maintenance of the desalination plant.

SONEDE has applied the uniform water tariff rate to all users in the nation. If all the customers of SONEDE cover the increased cost brought by this Project, the required water tariff is 0.413 TND/m^3. The required increase will be approximately 0.031TND/m^3 or 8.1% of present tariff. The percentage of the water tariff against the disposable income is 0.67% after the increase.

11.2 Concern about Social and Environmental Aspect

There are two categories of environmental issues caused by implementation of the Project, i.e. concerns under the sea and on ground.

Since intake and discharge pipelines will be installed under the seabed, the pipe installation will directly impact the aquatic environment. Seagrasses are observed to grow by the seafront of the proposed site for the desalination plant, which means that other marine creatures inhabit the area. In the field investigation, no other remarkable sea creatures were observed except for the presence of seagrasses.

In the interview survey, the environmental authority responded there would be no particular concern, but the issue will still be clarified when the EIA will be implemented. Since the intake and the discharge pipelines will be installed under the seabed, the seagrasses habitat will temporary be disturbed during the construction period. It is necessary to reduce the impacts during the construction work, and if required, transplanting of the seagrasses from the construction site will be done. After construction, the area will be restored to its original state.

The sea water desalination plant is to be installed at non-utilized open space facing the coast, so a big impact to the environment will not be expected. However, there will be construction vehicles plying the roads. The transmission pipelines are to be installed along main roads covering a long distance, thus pipeline construction work is seen to seriously affect traffic. Efforts shall be made to minimize the effect on traffic.

With the identification of impacts of the Project and measures by EIA, appropriate mitigation measures will be undertaken to lessen its adverse impacts.

11.3 Concern about Power Supply Aspect

Power demand of the proposed sea water desalination plant is assumed at 40MW in the final stage of the Project. SONEDE inquired STEG of the availability of 40MW power supply, which requires the payment of a new power distribution system including a substation.

11.4 Concern about Delay of the Project

If the implementation schedule of the Project is delayed, water shortage in the Greater Sfax, which is anticipated to occur from 2017 will continue until the completion of the Project.

There will be various causes of delay of the schedule. There are many procedures to be followed for implementation of the Project, and any small delay of each procedure will become a big delay in the end. Approval or permission for implementation by related authorities for construction work such as permission for pipe installation work under roads are usually delayed. In the Project, it is expected that the PIU to be established in SONEDE will take strong leadership and approach to related authorities together with cooperation with related sections of SONEDE.

On the Saida Seawater Desalination Plant Construction Project, the first phase of the Project of Saida Reservoir and Kalaa Kebira Reservoir & Water Treatment Plant is expected to be completed by 2020, and completion of the second phase by 2024. If that project is delayed, water shortage in the Greater Sfax will be in more serious because water to be supplied by the said project will be much more than that supplied from the Sfax Seawater Desalination Plant.

11.5 Risks and Mitigation Measures

Table 11-1 Financial Risks and Mitigation Measures

Financial Risks	Cause of Risks	Mitigation Measures
Initial cost of sea water desalination facility	• Increase in construction cost	• Increase the burden of the government • Review of construction work
Operation and maintenance cost of sea water desalination facility	• Increase the amount of water supply due to the high unit cost production process	• Consideration of tariff increase • Review of the supplies and personnel expenses • Reduction of operating expenses, including the use of outsourcing • Decrease in the utilization rate of the high unit cost production process with water-saving[8]
Opposition of residents to the tariff increase	• Rapid rate increase	• Explanation to residents and public relations on a review on water tariff • Information to residents about the benefits of

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[8] The operation rate of the Chatan Sea Water Desalination Plant in Okinawa, Japan with a capacity of 40,000 m^3/day was 25% on average for 10 years from when it started operation in 1997 to 2006. In 2011 it was 12.3%. The reasons of its low operation rate are; high power consumption at 6.17 kWh/m^3, and other water resource development after its completion.
Umi-no-nakamichi Nata Sea Water Desalination Plant in Fukuoka, Japan with a capacity of 50,000 m^3/day was 78% in 2011 due to drought of surface water and water shortage caused by other works. However, not only that year but also other years, the plant had high operation rate of 60% to 83%/ since the start of its operation in 2005. Though the high power consumption at 5.87 kWh/m^3,is much higher than that of the nearby Ushikubi Water Treatment Plant at 0.18 kWh/m^3, this plant keeps high operation rate because of lack of water supply capacity originated from surface water.

		the seawater desalination plant • Information to residents about water-saving measures
Socio-Environmental Risks	Cause of Risks	Mitigation Measures
Social impact • Impact on life of residents during construction • Legal action if the residents do not agree with the construction of the desalination plant	• Lack of social awareness for water supply development plan • Lack of public relations • Failure of negotiation • Impact on economic activities (For instance: impact of intake/discharge pipes to fishery activities, noise at pump station, traffic congestion caused by construction)	• Verification of the necessity of the Project • Explanation to residents and public relations • Installation of transmission pipes or pump stations along roads, or public land avoiding residential areas, and technical and economic applicability • Securing sufficient budget for land acquisition
Impact on the natural environment • Non-approval of the EIA • Impact on the economic activities	• Impact of intake and discharge pipes on marine environment (change in salinity, change in current, excavation for pipe installation, etc.) • An increase in sewage by an increase in water supply, and pollution expansion at public waters	• Selection of the site with less or insignificant impact to marine environment • Optimization of design by simulating intake/discharge pipe operation • Verification of impact on economic activities with change in the natural environment • Promotion of sewerage development plan
Power Supply Risks	Cause of Risks	Mitigation Measures
Power failure	• Lack of emergency generators • Accidents	• To intensify generating facilities (below: measures at the plant) • Two-line power receiving system • To receive power from high voltage line • To secure large capacity of production water tanks • To install standby generators for transmission pumps.
Implementation Delay Risks	Cause of Risks	Mitigation Measures
Delay in the implementation of the Project	• Delay in the establishment of PIU • Delay in making Loan Agreement • Delay in the preparation of Tender Documents • Delay in the approval in various procedures by HAICOP • Delay in Tender evaluations • Rupture of Tender • Delay in concurrence in various procedures by JICA • Delay in land acquisition • Delay in the approval for implementation of works by related authorities • Delay in marine works due to bad weather.	• Strong leadership and approach to related authorities by PIU. • Secure sufficient number of PIU staff • Hiring consultants • Preparation of appropriate and easily understandable tender documents. • Preparation of flexible construction plan.

CHAPTER 1

PURPOSE AND CONTENTS OF THE SURVEY

CHAPTER 1 PURPOSE AND CONTENTS OF THE SURVEY

1.1 Background

Half of the Republic of Tunisia, hereinafter referred to as “Tunisia”, belongs to semi-arid climate. Precipitation is a little less than 500 mm in average in unis. Consequently groundwater contributes to about 40 % of water usage.

Water supply system in Tunisia has been developed in accordance with continuous economic growth[1], covering 97.8 % of the entire country, i.e. 100% of urban area, 93.4% of rural area (SONEDE, 2012). In Tunisia, Ministry of Agriculture, Water Resources and Fisheries (French: Ministère de l’Agriculture, des Ressources Hydrauliques et de la Pêche, hereinafter referred to as “MOA”) establishes policies for water sector. The provision of water supply to rural areas by communal faucet method is under jurisdiction of MOA. It is the National Water Distribution Utility (French: Société Nationale d'Exploitation et de Distribution des Eaux, hereinafter referred to as “SONEDE”) that is responsible for supplying water to the urban areas and a part of rural areas by individual water supply system including water supply for domestic use and development and maintenance of conveyance and transmission system.

The Greater Sfax is the second largest city in Tunisia with a population of about 621,000[2] (Jan. 2013) located in the Sfax Governorate (about 963,000 population[2], Jan. 2013). Water supply volume is about 190,000m^3/day for SONEDE’s coverage area with a served population of about 810,000 in 2012 according to SONEDE. Because of rapid increase of population of the governorate with an average increase rate of 1.37% per annum in past 10 years, from 2003 to 2013, it is projected that serious water shortage will occur in 2018, and development of new water sources is requested. For its water supply, the Sfax Governorate relies on surface water transmitted from the northern region of Tunisia, groundwater in the central-western region, and its own groundwater. The water sources for the Sfax Governorate were shown that 42% from the North Water Transmission System, 37 % from the central western region by Jelma-Sbeitla Groundwater Transmission System, and 21 % from groundwater in Sfax Governorate. It is projected, however, that the water supplies to the Greater Sfax from other governorates will decrease because of the increase of demand in upstream governorates. In order to cope with this situation, it has been requested to develop water resources and related infrastructure only for the Greater Sfax, and SONEDE conducted “the Feasibility Study on the Mid-South Area Water Supply Scheme (hereinafter referred to as “the Feasibility Study”) in 2005. In the Feasibility Study, the regional water supply plan including the Sfax Governorate was formulated to satisfy water demand in the central and the south regions. Many projects proposed in the study, however, have not been implemented due to scarcity of budget.

In such circumstance, the Sfax Governorate, especially the Greater Sfax suffered serious water shortage

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[1] About 4% of average GDP annual growth rate in during past 15 years including 2011 when the revolution broke out with economy recession of -1.94%.

[2] http://www.ins.nat.tn/en/serie_annuelle.php?Code_indicateur=0201060

during the peak demand in the summer in 2012 due to temporary decrease of water transmitted by the North Water Transmission System. This water shortage was an opportunity to confirm the appropriateness of the regional water supply plan planned in the Feasibility Study. For solving the issue, SONEDE conducted the Strategic Study in April 2013 for enhancement of water supply capacity and improvement of water quality by 2030. In the study, a top priority was given for enhancement of water source of the Greater Sfax, and augmentation of water supply capacity by introduction of desalination of seawater was planned as a practical and immediate effective measure in the situation of shortage of water resources.

Under the background stated above, implementation of the project for seawater desalination plant in suburbs of Sfax (hereisafter referred to as "the Project") was planned based on the plan in the Strategic Study. In response to the request of Tunisian government, JICA discussed with SONEDE about Terms of Reference (TOR) for this preparatory survey for the Project, and this survey started based on the TOR.

1.2 Outline of the Survey

1.2.1 Purpose of the Survey

This survey is conducted for the formation of the project suitable for the Japanese ODA loan with Tunisian government, represented by the Ministry of Foreign Affairs, the Ministry of Development, Investment and International Cooperation, and the Ministry of Finance as borrower, and SONEDE as executing agency. The purpose of the survey is to contribute to the implementation of the project as Japanese ODA loan project by conducting feasibility study for Sfax Seawater Desalination Plant under this survey.

Accordingly, the accomplishment of the survey will be the reference for loan assessment by JICA and the scope of work planned in the survey will be the basis for the project under the Japanese ODA loan.

1.2.2 Scope of the Project

Scope of the Project is for a seawater desalination plant with a production capacity of 200,000 m^3/day. However, 100,000 m^3/day is the subject capacity for the Japanese ODA loan including intake and discharge facilities, transmission pipeline, distribution reservoir, and related pumping facilities.

1.2.3 Survey Area

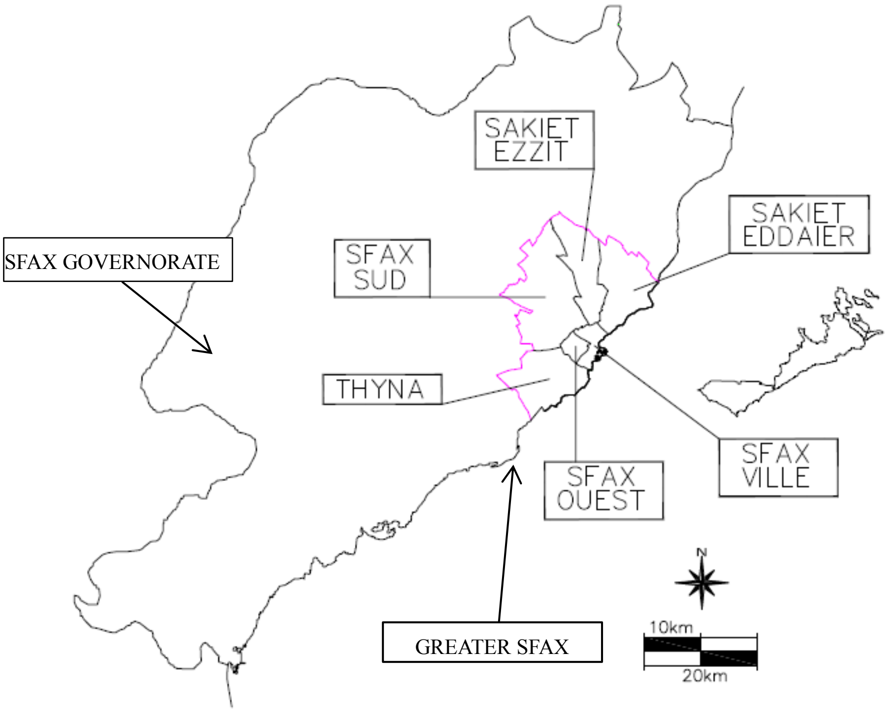
The area of the survey is the Greater Sfax and its surrounding area. Sfax is a city, located 270 km southeast of Tunis, and the capital of the Sfax Governorate. The city expansion is explained with the development as a harbour city, and of the road system to inland in multi-direction from the port. Recently, a circular road was developed and the urbanization is extending to along the road.

The Greater Sfax consists of Sfax Ville and five (5) delegations i.e. Sfax Ouest (West), Sfax Sud (South), Thyna, Sakiet Ezzit and Sakiet Eddaier. Each delegation consists of its sectors. There are 43 sectors in total in the Greater Sfax.

Table 1.2-1 Delegations and Sectors in the Greater Sfax

Delegation	Sector	Delegation	Sector
Sfax Ville	Sfax Medina	Sfax Sud	Bouzaien
	15-Novembre		El Afrane Nord
	Ain Cheikhrouhou		El Ain
	Bab B'har		El Aouabed
	Bassatine		El Khazzanet
	Cite Attaouidhi		Gremda
	Cite Khiri		Ouyoun El Mayel
	Merkez Bacha	Thyna	El Hajeb
	Merkez Gaddour		Sidi Abid
	Mohamed Ali		Tyna
	Rbat	Sakiet Ezzit	Bouacida
	Sidi Abbes		Cedra
Sfax Ouest	El Alia		Chihia
	El Hadi		Sakiet Ezzit
	Hay El Bahri		Sidi Salah
	Hay El Habib		Teniour
	Merkez Chaker	Sakiet Eddaier	Bderna
	Oued Ermal		Cite Bourguiba
	Sokra		El Khairia
			Merkez Kaaniche
			Merkez Sebii
			Sakiet Eddaier
			Seltania
			Sidi Mansour

Source: delegation; L'Institut National de la Statistique: INS, Sector: JICA Survey Team



Source: JICA Survey Team

Figure 1.2-1 Administrative Map of the Greater Sfax

1.2.4 Relevant Authorities

Authorities relevant to the survey are as follows:

- Counterpart: National Water Distribution Utility (SONEDE)
- Related Authorities：
  1) Ministry of Development, Investment and International Cooperation (MDICI, Window for the Japanese ODA loan)
  2) Ministry of Finance (Borrowing and repayment of the Japanese ODA loan)
  3) Ministry of Agriculture, Water Resources and Fisheries (Regulatory authority of SONEDE)
  4) Ministry of Foreign Affairs (International relation, Agreement with Foreign Countries)
  5) Ministry of Environment and Sustainable Development
     Environmental Protection Agency (ANPE, Appraisal of Environmental Impact Assessment)
     Coastline Protection and Planning Agency (APAL, Approval of Development in Coast)

1.2.5 JICA Survey Team

The JICA Survey Team was composed of following persons;

(1)	Mr. Takafumi Kiguchi	Team Leader / Water Supply Planning
(2)	Mr. Junichi Kamimura	Seawater Desalination Facility Designing
(3)	Mr. Tadao Funamoto	Transmission and Distribution Facilities Designing
(4)	Mr. Tetsuji Niwano	Water Resources Study
(5)	Mr. Yoshinari Fujiwara	Mechanical Facility Design 1
(6)	Mr. Ryuta Kudo	Mechanical Facility Design 2
(7)	Mr. Toru Watanabe	Electrical Facility Design 1
(8)	Mr. Akira Miura	Electrical Facility Design 2
(9)	Mr. Takashi Nakagawa	Natural Condition Survey
(10)	Mr. Daisuke Yashiro	Procurement and Cost Estimates
(11)	Mr. Yasuo Nakada	Economic and Financial Analysis
(12)	Mr. Sebastien Arnaud	Environmental and Social Consideration
(13)	Mr. Toshihiko Tamama	Institution and organization
(14)	Mr. Ryosuke Ohta	Coordination / Seawater Desalination Facility Designing Assist.

1.2.6 Schedule of the Survey

The survey was conducted in two phases as follows:

(1) Phase 1 (September to December 2013): Confirmation of Necessity and Viability of Seawater Desalination Plant

The Phase 1 survey was started from 13 September 2013, and the Field Work was conducted from 28 September to 23 November, 2013 after the preparatory work. After the fieldwork, the work were conducted Japan up to the beginning of January 2014.

(2) Phase 2 (January 2014 to August 2015): Feasibility Study

The feasibility study was conducted from January 2014 to August 2015.

The second fieldwork was conducted from the middle of January to the beginning of March 2014. After the succeeding work in Japan, the accomplishments were compiled as the Interim Report 2.

The third fieldwork was started from the middle of April 2014 and was conducted up to the middle of June, and then, the Draft Preparatory Survey Report was made in Japan from June to September 2014.

Explanation and discussion on the draft report were carried out on 29 September 2014. The Final Report, which included the revision on the draft report to reflect comments from Tunisian side, was prepared and submitted in August 2015[3].

This report was prepared based on the information obtained up to June 2015.

1.3 Scope of Work of the Survey

1.3.1 Scope of Work in Phase 1

In Phase 1, review of existing information, execution of fieldwork, and collection and analysis of information was conducted to confirm necessity and viability of the seawater desalination plant construction project. In addition, the appropriate capacity of the plant and the suitable site were recommended after reviewing the target year and the future water demand. Major survey items are as follows:

(1) Review and survey on existing information
  1) Natural Condition Survey (meteorology, topography, terrain, hydrology, hydrogeology, etc.)
  2) Social Condition Survey (Socio Economic Situation and Population, Commerce and Industry, Land Use, Infrastructure, rend of economy)
  3) Environmental Condition Survey (legislation and regulation relating to environment, public sanitation, etc.)

(2) Collection and analysis of basic information for planning of the Project
  1) Water Demand and Water Supply Volume in the Greater Sfax
  2) Available Water Volume in the Greater Sfax
  3) Water Supply Facility in the Greater Sfax
  4) Other Water Supply Projects in the Greater Sfax
  5) Candidates Sites for Seawater Desalination Plant in the Greater Sfax
  6) Existing Water Supply Facility in the Greater Sfax
  7) Existing Desalination Plants
  8) Organization Structure for Water Sector

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[3] After explanation of the draft report, revision of water balance between demand and supply, water source allocation planning were conducted to reflect SONEDE's comments, and revision of facility development plan was conducted to cope with the change of distribution flow as well. Further, review of the project cost, and financial and economic analysis were also conducted.

9) Water Tariff
10) Financial Status of SONEDE
11) Available Power Supply
12) ”Djerba Island Seawater Desalination Plant Construction Project” Tender Document

(3) Necessity of the Project and confirmation of risks
    1) Present Status and Problems of Water Sector including Domestic, Agricultural, and Industrial Uses
    2) Policy and Future Plan of Water Sector including Domestic, Agricultural, and Industrial Uses
    3) Required Capacity for Water Supply for Domestic, Agricultural, and Industrial Uses
    4) Water Resource Development Plan of SONEDE to increase Water Supply Volume
    5) Present Status and Construction Plan of Existing Distribution Facility
    6) Status of Support by Other Donors
    7) Water Supply Facility Development Plan by SONEDE (including Seawater Desalination Plant)
    8) Comparison between Seawater Desalination Plant and Alternative Water Resource and Confirmation of Risks
    9) Examination of Impact on Water Tariff by Introduction of Seawater Desalination Plant
    10) Positioning in Policy of Tunisia
    11) Examination and Recommendation of Mitigation Measures Against risks

(4) Preparation and Discussion about Interim Report 1 (IT/R1)

1.3.2 Scope of Work in Phase 2

Selection of optimum site from candidate sites identified in Phase 1 and preparation of the project plan was reported in the Interim Report 2. Upon confirmation of the contents of the Interim Report 2 with SONEDE and JICA, preliminary design and rough cost estimates were prepared, and then the Preparatory Survey Report was compiled as a feasibility study report inclusive of the project implementation plan and evaluation of the Project.

Major survey items are as follows:

(1) Planning of the Project
    1) Water Supply Plan in the Greater Sfax
    2) Required Water Production Volume by Seawater Desalination Plant
    3) Selection of Seawater Desalination Plant Construction Site
    4) Comparison of Seawater Desalination Method (RO Membrane, Multi-stage Flush Evaporation)
    5) Decision of Seawater Intake Method
    6) Decision of Discharge Method for Condensed Wastewater
    7) Site Selection for Pumping Facility
    8) Site Selection for Reservoirs
    9) System Operation Plan
    10) Calculation of required area for the Project

  11) Confirmation of legislation and procedure for land acquisition

(2) Preparation and Discussion about Interim Report 2 (IT/R2)

(3) Preliminary Design of the Project
  1) Identification of Scope of the Project
  2) Preliminary Design of Seawater Intake Facility, Seawater Desalination Plat, Concentrated Seawater Discharge Facility, Pumping Facility, Transmission Pipeline, and Reservoir
  3) Confirmation of Required Official Procedures and Legislation, Land Acquisition Procedure

(4) Assessment of and Evaluation of Major Environmental and Social Impact Item, Preparation of Mitigation Measures, and Monitoring Plan

(5) Rough Cost Estimates

(6) Preparation of Project Implementation Plan
  1) Financial Plan
  2) Execution Scheme
  3) Project Implementation Schedule
  4) Procurement Plan
  5) Organization for Project Implementation
  6) Operation and Maintenance Plan
  7) Preparation of TOR for Consultants
  8) Economic and Financial Analysis
  9) Other Considerations

(7) Project Evaluation

(8) Recommendation of Operation and Performance Indicators

(9) Recommendations

(10) Preparation of Preparatory Survey Report (Draft)

(11) Explanation and Discussion on Preparatory Survey Report (Draft)

(12) Preparation and submission of Final Report

1.4 Past Projects in Water Supply Sector under Japanese ODA Loan

Projects in water supply sector under the Japanese ODA loan in Tunisia are listed on Table 1.4-1.

In addition, the Japanese government granted the fund for the Project for Desalination of Groundwater at Ben Guerdane in Medenine Governorate, in which groundwater desalination plant with a capacity of 1,800m^3/day was constructed. Operation of the plant started in June 2013.

Table 1.4-1 Projects in Water Supply Sector under Japanese ODA Loan

Year	ODA Loan Outlines	Project Outlines	Status
1994	L/A No.: TS－P6 Project Name: Southern Area Water Supply and Sewerage Improvement Project L/A signing: 1995.03.31 Loan Amount (M yen): 7,577	● Provision of water supply and sewerage facilities in tourist resorts in south Tunisia, i.e. Djerba, Zarzis and others. ● Sites for water supply project are Djerba, Zarzis, Ben Guerdane, Medenine and Tatawin, and the site for sewerage project is the tourist spot at east area of Djerba. ● Scope of the water supply project includes; Groundwater desalination plant (15,000m^3/day x 2 plants), 15 deep wells, 5 distribution reservoirs, 169km long conveyance pipeline, 91km long distribution pipeline, and others. Completed in February 2003.	DC.
1999	L/A No.: TS－P19 Project Name: Rural Water Supply Project L/A signing: 2000.03.23 Loan Amount (M yen): 3,352	● In rural areas of 17 governorates, small-scale water supply infrastructures, consulting services and procurement of equipment materials and construction work.	DC.
2002	L/A No.: TS－P24 Project Name: Rural Water Supply Project (II) L/A signing: 2003.03.31 Loan Amount (M yen): 4,495	● Lending required fund for construction and improvement of water supply facilities, procurement of related equipment (pumps and pipes), and consulting services for about hundred poor districts based on the 10th Rural Water Supply Scheme planned by Tunisian government.	DC.
2006	L/A No.: TS－P28 Project Name: Jendouba Rural Water Supply Project L/A signing: 2006.05.23 Loan Amount (M yen): 5,412	● In rural areas of Jendouba Governorate and a part of Beja in north-west region, transmission and distribution pipelines, 1 water treatment plant, 12 distribution reservoirs, 9 pumping facilities, 1 pressure reduction facility	OG.
2011	L/A No.: TS－P36 Project Name: Local Cities Water Supply Network Improvement Project L/A signing: 2012.02.17 Loan Amount (M yen): 6,094	● Rehabilitation and extension of existing water supply facilities including civil works, procurement of ductile cast iron pipes, other materials and equipment in 19 governorates. Distribution facilities in Sfax are also subjects of the project.	OG.

Status: DC.; Disburse Completed, OG.; On-going
Source: JICA Study Team, as of December 2014

1.5 Other Donor's Programs for Water Supply Sector

SONEDE is conducting and planning the following programs with assistances of other international donors.

Table 1.5-1 Projects in Water Supply Sector Assisted by Other International Donors

Donors / Project		Project Outlines	Status
KfW Bankengruppe			
	South Tunisia Desalination Plants Construction Project	● Assistance for the project to construct desalination plants in the southern area of Tunisia. ● In the Phase 1 project (PNAQ1), the study was conducted in 2003, and, the construction of ten desalination plants will be completed in October 2015. ● For the Phase 2 project (PNAQ2), the study has started since 2011 by grant aid support. Presently the EIA report and the final report of the study are being finalized. Six desalination plants are planned to be constructed from 2015.	OG.

Donors / Project	Project Outlines	Status
Djerba Desalination Plant in Medenine	● In Djerba in Medenine governorate, a 50,000m^3/day seawater desalination plant had been planned in the study funded by EU grant aid. SONEDE has modified the plan to enable the increase of the capacity to 75,000m^3/day. ● Financial support of KfW and French Development Agency (AFD) is expected. The contract for the construction work was signed on 8th September 2014 by SONEDE as a borrower.	OG.
Zarat Desalination Plant in Gabes	● A study for 100,000m^3/day desalination plant in Zarat in Gabes governorate was started in September 2012 with the technical support from Fund for African Private Sector Assistance (FAPA）of African Development Bank (AfDB). ● As for the implementation of the project, SONEDE intends to start the project by the end of 2014 with financial support of KfW, it has not been arranged yet as of November 2014.	NF.
Kerkennah Desalination Plant in Sfax	● SONEDE have a plan to start a study for 6,000m^3/day desalination plant in Kerkennah in the Sfax Governorate in 2013. For this study, KfW's support is expected.	NF.
French Development Agency (AFD)		
Rural Water Supply Project III 2009-2016	● Agreed in 2009 about a program for rural water supply. ● Program provides drinking water supply in 49 new groups of a population of 52 536 spread over 14 governorates by: - extension of existing networks, civil works and installation of equipment. - acquisition of 80 000 meters pipeline material - implementation of energy mastering program. - implementation of the program of geographic information system ● Project cost : 21 M EUR	OG
Program securing production capacity and water supply of SONEDE: 2012-2016	● Programs to improve the capacity of SONEDE for water production and distribution. ● The implementation period of the program is from 2011 to 2016 and the programs are carrying out in 13 locations in Tunisia including connection works from Djerba desalination plant to existing distribution reservoirs in Medenine governorate. ● Project cost : 52.95M EUR	OG.
Rural water supply program : 2013 – 2017	● Agreed in July 2013 about a program for rural water supply. ● It includes the creation of sixty networks, the creation of 3 wells, 39 reservoirs, 31 pumping stations and iron removal station. ● Project cost : 23.85M EUR	OG.
World Bank Group		
Urban Water Supply Project - Additional	● For urban water supply project of SONEDE, agreed and effective on 17 November 2014. Additional financing project for the project with same name agreed in December 2005 and expected to be completed in 2012. ● The project objectives are i) to ensure the continuity of water service (twenty four (24) hours per day, seven (7) days a week) to the population in Greater Tunis and other targeted cities; and (ii) improve the financial viability of SONEDE ● Project Cost: 26.2M USD	OG
Construction of the transmission pipeline from Saida reservoir, the transmission pipeline from Kalaa Kebira reservoir, and the water treatment plant.	● For the North Water Transfer System, which supplies water to Sfax, SONEDE expect to obtain financial support for construction of the transmission pipeline from Saida reservoir, the transmission pipeline from Kalaa Kebira reservoir, and the water treatment plant. ● According to the person in charge in Tunisia, the World Bank has planned to support rehabilitation project of those transmission facilities from reservoirs. The specific contents and timing is still under consideration.	NF.

Donors / Project		Project Outlines	Status
Arab Fund for Economic and Social Development (FADES)			
	Construction of Saida reservoir and Kalaa Kebira reservoir	● Among the components of the North Water Transfer System, which supplies water to Sfax, expect to obtain financial assistance for construction of Saida reservoir and Kalaa Kebira reservoir, MOA will implement the project. FADES agreed with MOA and SONEDE in principle to provide loan for the project finance. ● Donors of Arab showed funds made their interest to fund the remaining components (transfer, treatment, reservoirs, pumping, etc.); Saudi Arabia, Kuwait, and Abu Dhabi	NF.

Status: OG.; On-going, N.F; Financial arrangement has not been finalized.
Source: JICA Study Team, as of March 2015

On-going and expected desalination projects supported by KfW Bankengruppe are as shown in Table 1.5-2 and Figure 1.5-1.

Table 1.5-2 Desalination Plant Construction Projects in Tunisia supported by KfW

No.	Location		Raw Water	Capacity (m^3/day)	Project*	Status
1	Tozeur	Tozeur	Brackish	6,000	a, PNAQ1	Completion expected in Oct. 2015
2		Nafta	Brackish	4,000	a, PNAQ1	Completion expected in Oct. 2015
3		Hezoua	Brackish	800	a, PNAQ1	Completion expected in Oct. 2015
4	Kebili	Kebili	Brackish	6,000	a, PNAQ1	Completion expected in Oct. 2015
5		Douz	Brackish	4,000	a, PNAQ1	Completion expected in Oct. 2015
6		Souk Lahad	Brackish	4,000	a, PNAQ1	Completion expected in Oct. 2015
7	Gabes	Matmata	Brackish	4,000	a, PNAQ1	Completion expected in Oct. 2015
8		Mareth	Brackish	5,000	a, PNAQ1	Completion expected in Oct. 2015
9	Medenine	Beni Khedache	Brackish	800	a, PNAQ1	Completion expected in Oct. 2015
10	Gafsa	Belkhir	Brackish	1,600	a, PNAQ1	Completion expected in Oct. 2015
11	Tozeur	Degueche	Brackish	2,000	a, PNAQ2	Construction to be started in 2015
12	Sidi Bouzid	Mazouna, etc.	Brackish	3,000	a, PNAQ2	Construction to be started in 2015
13	Medenine	Ben Guerdane	Brackish	9,000	a, PNAQ2	Construction to be started in 2015
14	Gafsa	Gafsa Est	Brackish	9,000	a, PNAQ2	Construction to be started in 2015
15		Gafsa Ouest	Brackish	6,000	a, PNAQ2	Construction to be started in 2015
16	Kebili	Bechlli, etc.	Brackish	2,000	a, PNAQ2	Construction to be started in 2015
17	Medenine	Djerba	Seawater	75,000*^{2}	b	Contracted in Sept. 2014
18	Gabes	Zarat	Seawater	100,000	c	Requesting for finance
19	Sfax	Kerkennah	Seawater	6,000	d	Under planning

Brackish: Brackish Groundwater

*:Project :

a: South Tunisia Desalination Plants Construction Project, Phase 1 (PNAQ1), Phase 2 (PNAQ2)

b: Djerba Desalination Plant in Medenine

c: Zarat Desalination Plant in Gabes

d: Kerkennah Desalination Plant in Sfax

*^{2}: Initial capacity is 50,000 m^3/day, but expandable to 75,000 m^3/day in the future.

Source: SONEDE Conseil D'Administration du 06/08/2013, confirmed and updated by SONEDE (March 2015)

List of KfW assisted Desalination

No.	Location		Capacity (m^3/day)
1	Tozeur	Tozeur	6,000
2		Nafta	4,000
3		Hezoua	800
4	Kebili	Kebili	6,000
5		Douz	4,000
6		Souk Lahad	4,000
7	Gabes	Matmata	4,000
8		Mareth	5,000
9	Medenine	Beni Khedache	800
10	Gafsa	Belkhir	1,600
11	Tozeur	Degueche	2,000
12	Sidi Bouzid	Mazouna, etc.	3,000
13	Medenine	Ben Guerdane	9,000
14	Gafsa	Gafsa Est	9,000
15		Gafsa Ouest	6,000
16	Kebili	Bechlli, etc.	2,000
17	Medenine	Djerba	75,000
18	Gabes	Zarat	100,000
19	Sfax	Kerkennah	6,000

Figure 1.5-1 On-going and Expected Desalination Projects supported by KfW Bankengruppe

CHAPTER 2

REVIEW OF EXISTING INFORMATION AND EXPLORATION

CHAPTER 2 REVIEW OF EXISTING INFORMATION AND EXPLORATION

2.1 Natural Condition

The Greater Sfax is located in the middle area of semi-arid climate of the Republic of Tunisia. It has an area of 163,610 km^2, but is characterised by mild climate with relatively high humidity because of facing the Mediterranean Sea.

2.1.1 Meteorological Information

(1) Temperature

The average annual temperature in the past 21 years (1992-2012) is 18 ^{o}C. The climate is divided into cold season from December to February and hot summer season from July to September. The climates in spring and autumn are pleasant.

Table 2.1-1 Average Temperature in Greater Sfax

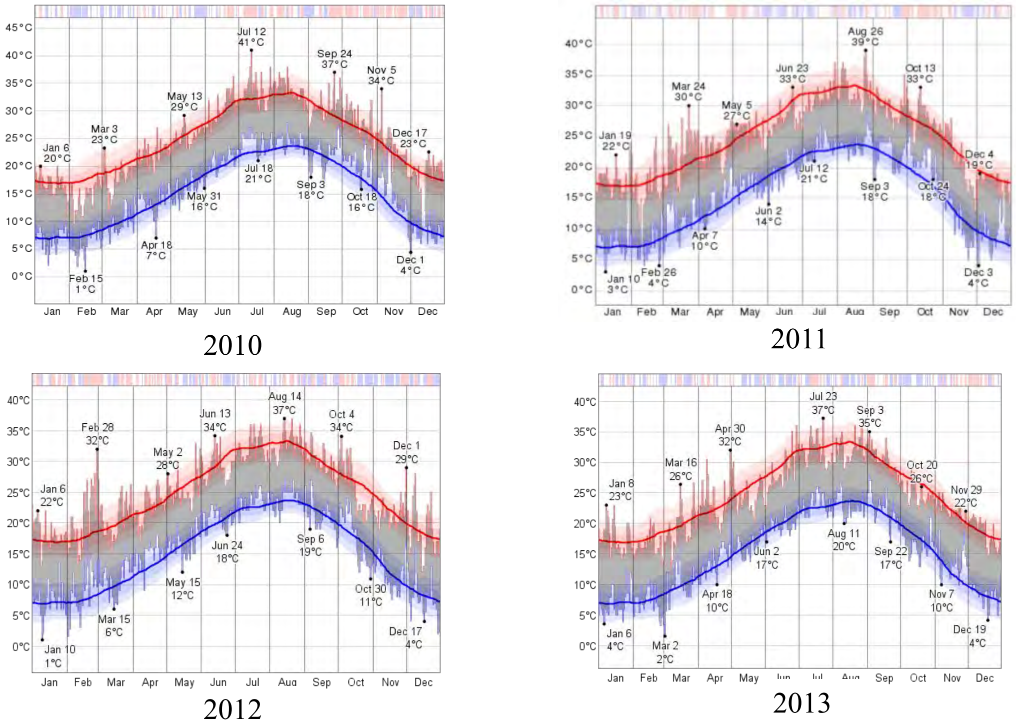
Month	1	2	3	4	5	6	7	8	9	10	11	12	Ave
High average temperature ^{o}C	16	17	18	21	24	28	31	31	29	25	20	17	23
Average temperature ^{o}C	11	12	14	16	20	23	26	27	25	21	16	12	18
Low average temperature ^{o}C	6	7	9	11	15	19	21	22	21	17	11	7	14

Source：Weatherbase

Figure 2.1-1 shows the maximum and minimum temperature ranges during 2010-2013. Monthly average lowest temperature is 6 ^{o}C in January. On 10 January 2012, the lowest temperature at 1 ^{o}C was recorded. Monthly average highest temperature is 31 ^{o}C in August. On 12 July 2010, the highest temperature at 41 ^{o}C was recorded.

(2) Humidity

Due to the influence of the Mediterranean Sea, the humidity is around 50% to 70% through the year. Figure 2.1-2 shows the humidity ranges during 2010-2013.

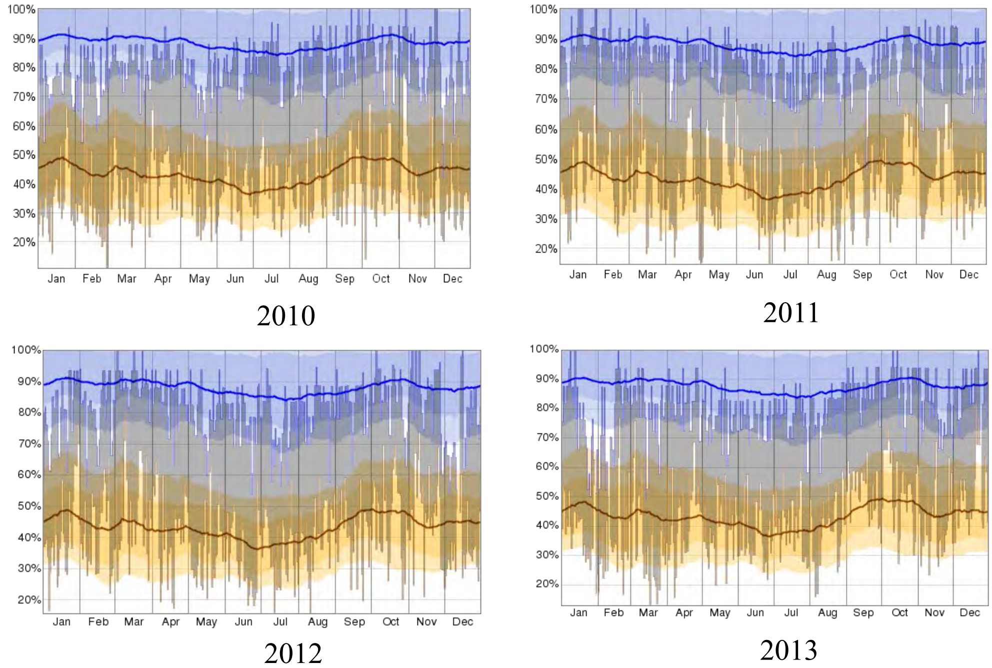


2010 2011

2012 2013

Red line: Average line of maximum temperature, Blue line: Average line of minimum temperature
Source: Weather Spark

Figure 2.1-1 Temperature Range from 2010 to 2013



2010 2011

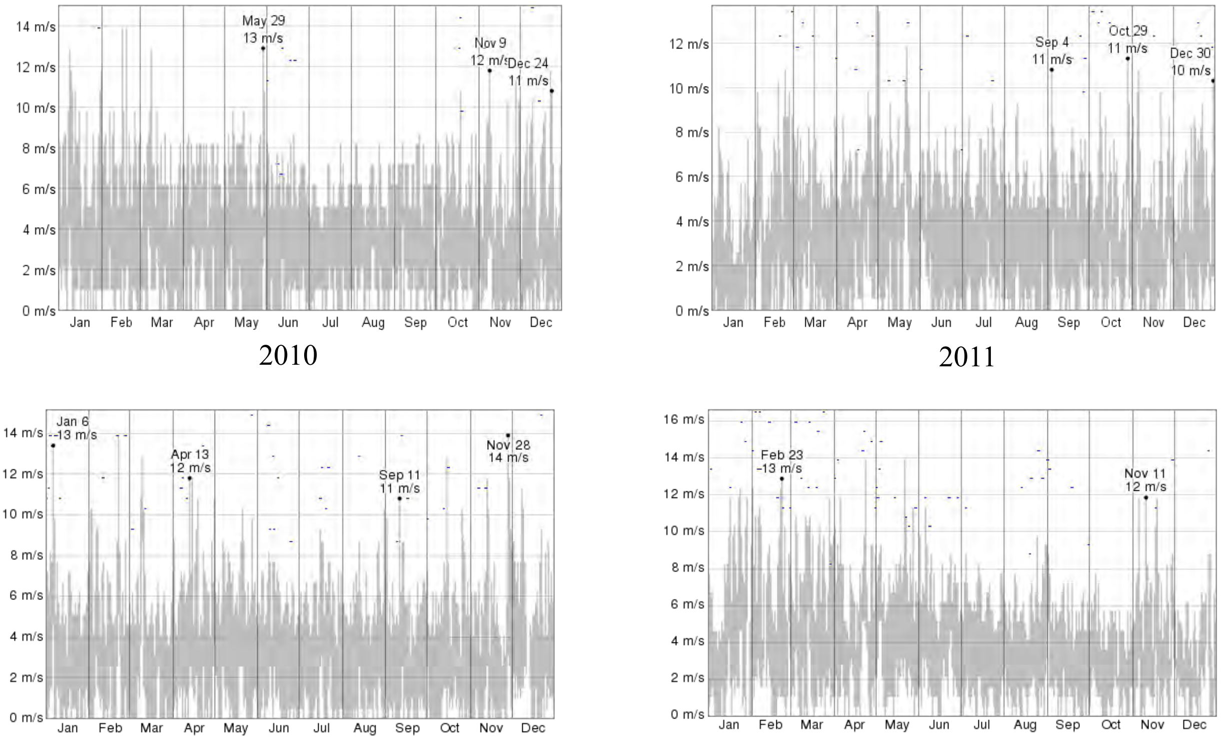
2012 2013

Blue line: Average line of maximum humidity, Brown line: Average line of minimum humidity
Source: Weather Spark

Figure 2.1-2 Humidity Range from 2010 to 2013

(3) Wind

Wind blows 300 days in a year with vary direction by season. In winter, the land breeze blows from direction ranging between North and Southwest. In summer, the sea breeze blows from direction ranging between east and southeast. Figure 2.1-3 shows changes in wind blow from 2010 to 2013.



2010

2011

2012

2013

Gray line: Changes in wind blow speed on every day, Blue point: Maximum wind speed of the day

Source: Weather Spark

Figure 2.1-3 Changes in Wind Blow from 2010 to 2013

The strongest windy month is May with an average wind speed of 5 m/s. The weakest windy month is October with an average wind speed of 3 m/s. The highest wind gust speed was recorded on 22 May 2013 at 22 m/s.

(4) Precipitation

Annual average precipitation in Greater Sfax in past 20years (1991-2010) is 228.5mm (464.5mm in Tunis). Rainfall averages about 25mm per month during the period of September to April, and then decreases from the beginning of May. There is scarce precipitation in the period from June to August.

Table 2.1-2 Average Precipitation in Greater Sfax

Month	1	2	3	4	5	6	7	8	9	10	11	12	Total	Month. Ave.
Average precipitation mm	32.3	14.1	25.7	20.6	17.4	4.6	0.3	3.1	33.0	25.0	23.7	28.6	228.5	19.0

Source：National Office of Mines

2.1.2 Topography and Geography

Greater Sfax area is the urban area spreading like a fan from the harbour. It has a little monotonous undulating terrain, gently sloping towards the sea.

2.1.3 Marine Context

(1) Tidal data

The tidal data at Sfax Port is as shown in the table below.

Table 2.1-3 Tidal Data

	Average tidal	Maximum tidal	Minimum tidal
Above sea level (m)	+1.16	+2.15	+0.00

Source：RAPPORT DU CENTRE HYDROGRAPHIQUE ET OCEANOGRAPHIQUE DE LA MARINE NATIONALE DE LA TUNISIE

Maximum tide level changes monthly in the past three years are as shown in Table 2.1-4. The highest tide was 2.0m and the lowest tide was 0.1m in the last 3 years.

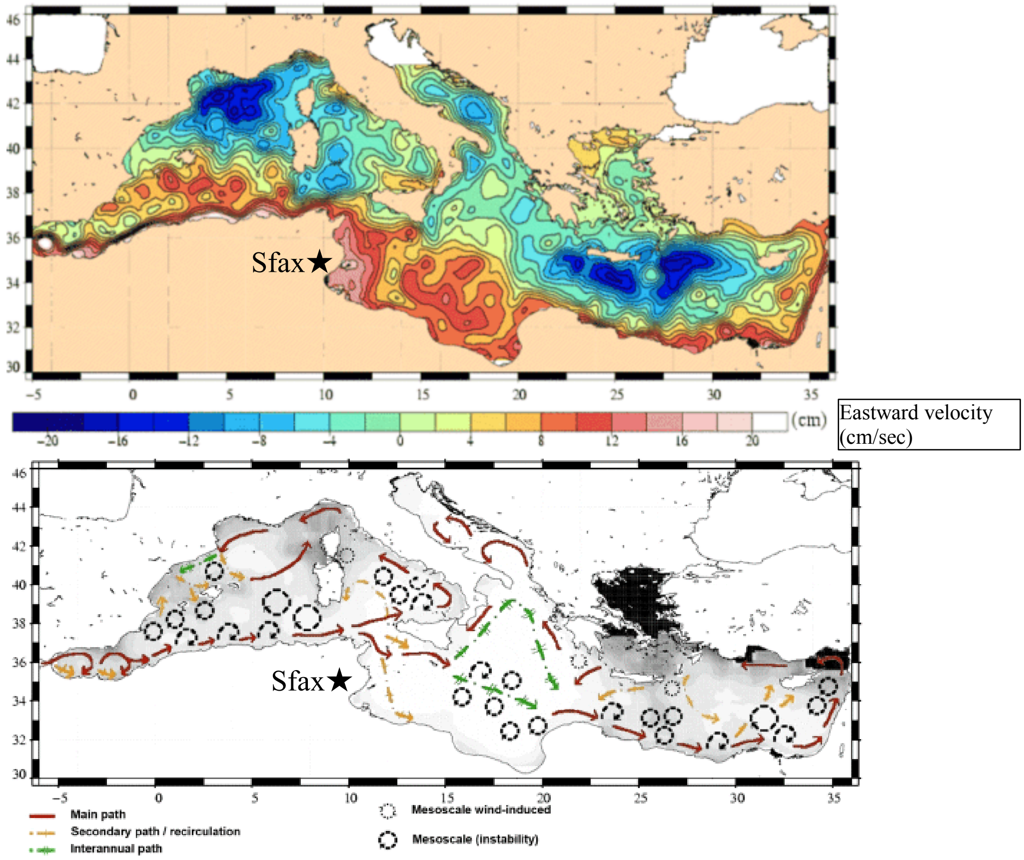
Table 2.1-4 Tidal Level in Monthly Record (2011-2013)

		1 月	2 月	3 月	4 月	5 月	6 月	7 月	8 月	9 月	10 月	11 月	12 月
2011	Day	1/21	2/19	3/20	4/18	5/17	6/15	7/31	8/29	9/28	10/27	11/25	12/25
	Max	1.8m	1.9m	1.9m	1.9m	1.8m	1.7m	1.8m	1.9m	2.0m	1.9m	1.9m	1.8m
	Min	0.2m	0.1m	0.1m	0.2m	0.2m	0.3m	0.2m	0.2m	0.2m	0.2m	0.3m	0.3m
2012	Day	1/23	2/9	3/9	4/7	5/6	6/4	7/4	8/19	9/17	10/16	11/13	12/14
	Max	1.8m	1.9m	1.9m	1.9m	1.8m	1.8m	1.7m	1.9m	1.9m	2.0m	1.9m	1.9m
	Min	0.3m	0.2m	0.1m	0.1m	0.2m	0.3m	0.3m	0.2m	0.2m	0.2m	0.3m	0.3m
2013	Day	1/12	2/10	3/28	4/26	5/25	6/24	7/23	8/21	9/19	10/5	11/3	12/3
	Max	1.8m	1.8m	1.9m	1.8m	1.8m	1.8m	1.8m	1.9m	1.9m	1.9m	1.9m	1.9m
	Min	0.3m	0.2m	0.2m	0.2m	0.2m	0.2m	0.2m	0.2m	0.2m	0.3m	0.3m	0.3m

※ 0m is relative to the 0m point of Sfax port.
Source ：Tide table for Sfax

(2) Sea Current

The sea current in the Mediterranean is generally very weak, flowing towards the east Mediterranean from the west Mediterranean, arid region of high temperature and high amount of evaporation region. In the offshore of Sfax the current flows slowly along the coast from Sousse to Gabes. The cyclic tidal current follows along the coast of the Greater Sfax corresponding to the rise and fall of the tide.



(upper: current velocity, lower: current direction)

Souce: AVISO+

Figure 2.1-4 Current Flow in East Mediterranean

(3) Bathymetric Survey

The coast of the Greater Sfax has slope gently away from the water's edge. The offshore seabed from La Cheba to Sfax through Kerkennah continues with less than 5 m in depth. The seabed with less than 10m depth spreads to 5km offshore along Gabes Bay, south of Sfax. A 60 m wide channel to the Sfax seaport has been dredged to 11m depth to offshore of about 4.5 km.

(4) Water Quality

The marine status of the Greater Sfax coast area is in calm and generally shallow. Fish and shrimp farming, handling net fishery, the shellfishery, etc. are carried out extensively in this area. On the other hand, the Greater Sfax has a large industrial area along the coast area. Wastewater containing oils, metals (Ni, Cd, Pb, Cr, Cu, Zn, Fe), radioactive material, etc. have been discharged to sea from phosphorus purification plants, olive oil production plants, metal processing plants, etc. located in Sfax coastal zone. As a result, marine pollution has occurred along the coast. In particular, hydrogen sulfide (H_2S), which is produced by the sulphate-reducing bacteria from calcium sulfate ($CaSO_4$) in seabed sediments, aggravates the marine pollution. Calcium sulfate ($CaSO_4$) is contained in the wastewater resulting from the purification process of phosphorus from phosphate rock in the phosphorus purification plant.

To cope with the situation, the TAPARURA project was implemented for the purpose of purification of the coast of the Greater Sfax. It was conducted from 2006 under the joint fund of the European Investment Bank (EIB) as the main member. Replacement of beach sand and dredging of seabed sediments were carried out in this project with positive effects. The completed purification at this time, however, was limited to the northern side of the coasts of the Greater Sfax, and is planned to be implemented to the southern area although the specific plans have not been built.

Results of water quality analysis conducted in the Survey are presented in Section 5.1.2.

2.1.4 Hydrological, Hydrogeological and Geological Features

According to DGRE of MOA, the average annual rainfall in Tunisia is 36 billion m^3/year, while the evapotranspiration amounts to 12.6 billion m^3/year or 35% of the annual rainfall. The discharge to the sea through the rivers is amounted at 18.6 billion m^3/year. Currently, the utilizable amount as water source is 4.8 billion m^3/year.

In category of the water source, the utilizable amount at dam lakes is 2.43 billion m^3/year. From rivers and reservoirs, 0.27 billion m^3/year is utilizable. Both water sources are mainly utilized for irrigation. In addition, the available amount of groundwater is 2.1 billion m^3/year, which is mainly utilized for domestic, agricultural, and industrial purposes.

Source : http://commons.wikimedia.org/wiki /File:Medjerda_river_drainage_basin-fr.svg

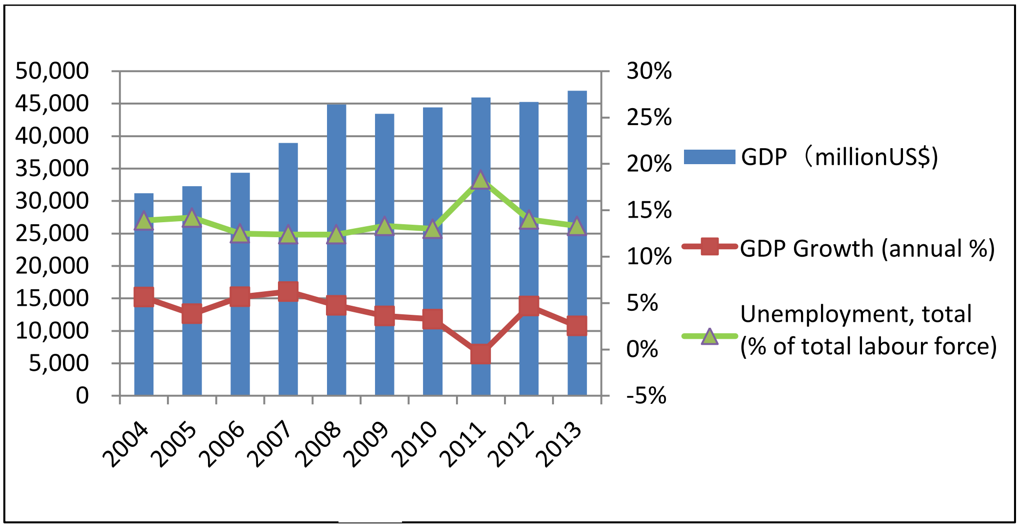
Figure 2.1-5 Major Rivers

There are no large rivers that are available as water sources near the Greater Sfax. Therefore, the surface water is not considered for the water source. In addition, extraction of groundwater in this area is regulated to control big drops in groundwater levels. As a result, the further extraction of the groundwater in the area cannot be considered for the water source. The water source in the area is to depend on the treated water transmitted from north area of the country, and the groundwater with low salinity (i.e. TDS: 1,000 mg/L to 1,800 mg/L), transmitted from Jelma-Sbeitla area. There are deep wells at each reservoir, i.e. PK10, PK11, PK13, PK10, PK14, PK15, Bou Merra, Sidi Salah EH. These wells, however, have high salinity (i.e. TDS: 3,100 mg/L to 3,200 mg/L) and high iron content. The water in these deep wells cannot be used as drinking water without treatment or dilution by clean water.

2.2 Social Condition Survey

2.2.1 Social and Economic Situation

Tunisia is positioned as a more developed country in the income classification by the World Bank. In 2013, Tunisian GDP was US$46.99 Billion and GDP growth rate was 2.5%. GNP per capita was US$4,317 although growth has slowed down. Overall unemployment rate for the second quarter of 2013 was 13.3% and the unemployment rate of young people was particularly high and has remained at high levels over a long period.



Source: http://api.worldbank.org/v2/en/country/tun?downloadformat=excel

Figure 2.2-1 GDP and Unemployment Ratio Changes

2.2.2 Population

The population of Tunisia was 10.89 million in 2013. Urban population is 66%, and 34% of the population lives in rural area. Working-age population was 43% and young working-age population is high at 33%.

The Greater Sfax, whose main area is inside the Route 11 bypass, is the second biggest city in Tunisia. It is a commercial hub where 620 thousand people out of 970 thousand of the entire Sfax region live as of July 2013. Many students, reaching almost 50,000, live in this area, but they come from other regions. During the summer holydays, the student population decreases. Many tourists stay in Tunisia during the summer holyday season, but most of them go to the resort areas such as Djerba and Sousse as tourists do not stay in Sfax.

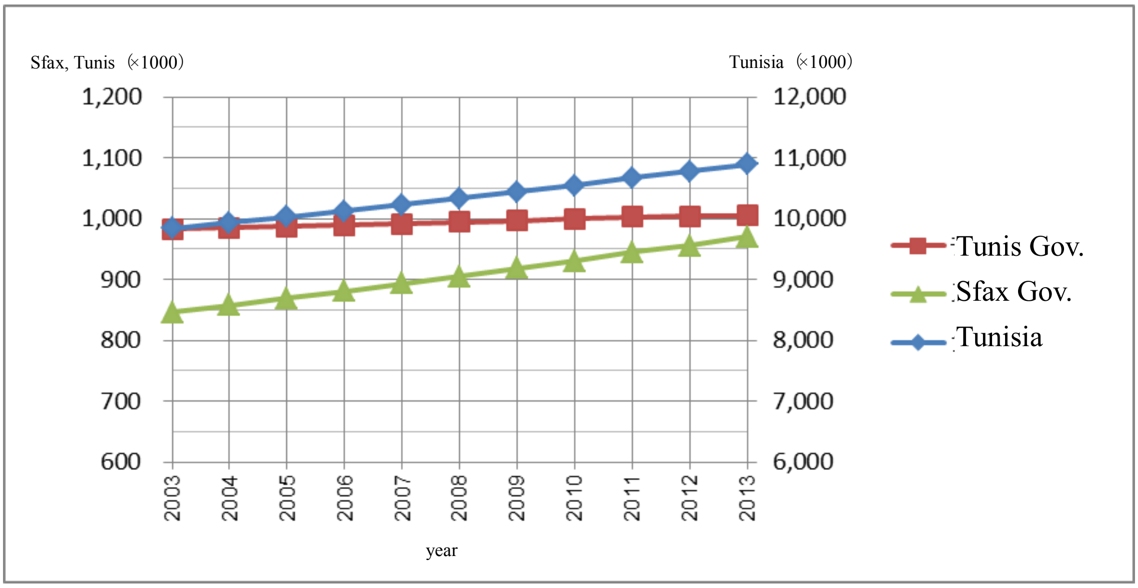
For the period between 2003 and 2013, the average population increase rate of Tunisia was 1.02%/p.a. It in the Tunis governorate was 0.21 %/p.a., while 1.37%/p.a. for the Sfax governorate exceeding that of Tunis. Table 2.2-1 and Figure 2.2-2 shows history of population increase of Tunisia, and governorates of Tunis and Sfax.

表 2.2-1　Population Change in Tunisia, and Governorates of Tunis and Sfax

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2003-2013 Increase Rate*
Total	9,839.8	9,932.4	10,029.0	10,127.9	10,225.1	10,328.7	10,439.6	10,547.0	10,673.8	10,776.4	10,886.5	1.02%
Tunis	983.2	985.3	986.7	989.0	991.3	993.9	996.4	999.7	1,002.9	1,003.7	1,004.5	0.21%
Sfax	846.5	857.1	869.4	881.0	893.0	905.0	918.5	930.1	944.5	955.5	969.8	1.37%

*: Average Annual Increase Rate in the period between 2003 and 2013

Source: http://www.ins.nat.tn/en/serie_annuelle.php?Code_indicateur=0201060

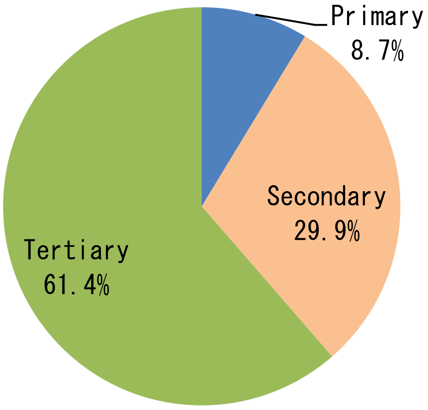


source: http://www.ins.nat.tn/en/serie_annuelle.php?Code_indicateur=0201060

Figure 2.2-2 Population Change

2.2.3 Major Industry

The percentage of the major industries of Tunisia is distributed as; Primary 8.7%, Secondary 29.9%, and Tertiary 61.4% as of 2013. The tertiary industry, which includes tourism, transportation and ICT (information and communication technology), has the large percentage. The main products of agriculture are olive and wheat. Textile is the main product of manufacturing industry and phosphate rock is the main product of mining industry. Resources such as crude oil and natural gas have been produced, but Tunisia imports oil to cover the domestic energy demand. Tourism and service industries drive Tunisian economy.



Source: http://data.worldbank.org/country/tunisia

Figure 2.2-3　GDP Structure of Industries

Sfax Governorate is the second city next to Tunis in Tunisia and various industries have been developed. There are approximately 2,300 manufacturing enterprises in the Sfax governorate and approximately 204,000 people are employed by these industries as of 2013. This population is equivalent to 37% of total employee of manufacturing enterprises in Tunisia, and it exceed more than 3 times of those of Monastir, second largest industrialized governorate. Of this member, more than 700 manufacturing enterprises employ more than 10 employees. Major activities are textiles and clothing, agro food, mechanical industries and chemical industries. There are also more than 20,000 retailers and more than 800 wholesalers, and more than 70 firms doing business with overseas. As stated above, the Sfax governorate including the Greater Sfax has the largest employee population in all industries except agriculture, fisheries and mining. But, agriculture and fishery are also thriving, accounting for 40%; olive oil, 30%; almonds, and 20%; fish catches, in domestic market. They also dominate large part of export of Tunisia, accounting for 60% of olive oil and 45% of seafood.

2.2.4 Land Use

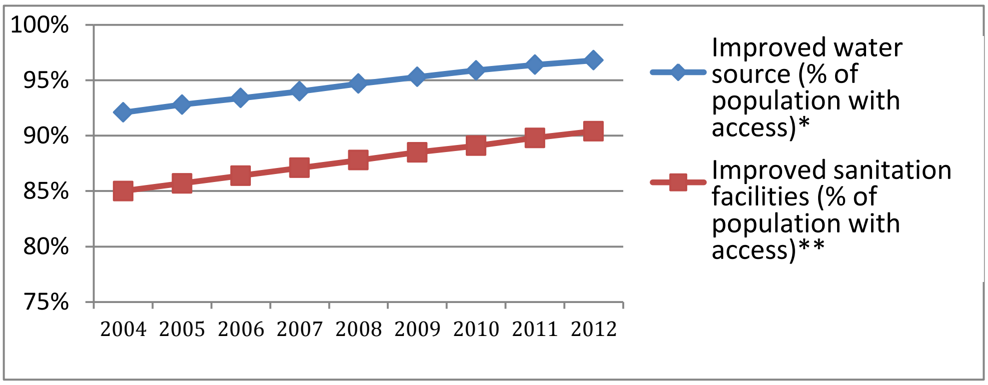
Tunisian land area is about 163,610 km^2, which consist of 155,360 km^2 inland and 8,250 km^2 of water area. Percentage of agricultural land area in the whole country is about 64.83%, arable land area is about 18.27%, permanent agricultural land is about 15.40%, and forest area is about 6.58%.

Land is divided into private property and state-owned land, and ownership is generally clear. If the acquisition of private land is required for public works, consultation is advanced between the owner of the land in accordance with the related laws and regulations, but in case consideration the importance of the public nature of the public works, public works are priority.

2.2.5 Infrastructure Development

Infrastructure development is progressing in Tunisia to keep up with both the economic and population growth. Thus, the development and realization of infrastructure projects, a long-term perspective is needed.

Access to water supply has become 100% in urban areas, 89.2 % in rural areas, and 96.4 % overall. Maintenance of sewer also is progressing, reaching up to about 90 % in 2011. Electrification access has become 99.5% in 2009 covering almost all the country. Maintaining the current service levels while meeting the demand for infrastructure such as quality water supply will be required.



*: % against national total administrative population
**: % against administrative urban population of cities served by ONAS
Source: http://api.worldbank.org/v2/en/country/tun?downloadformat=excel

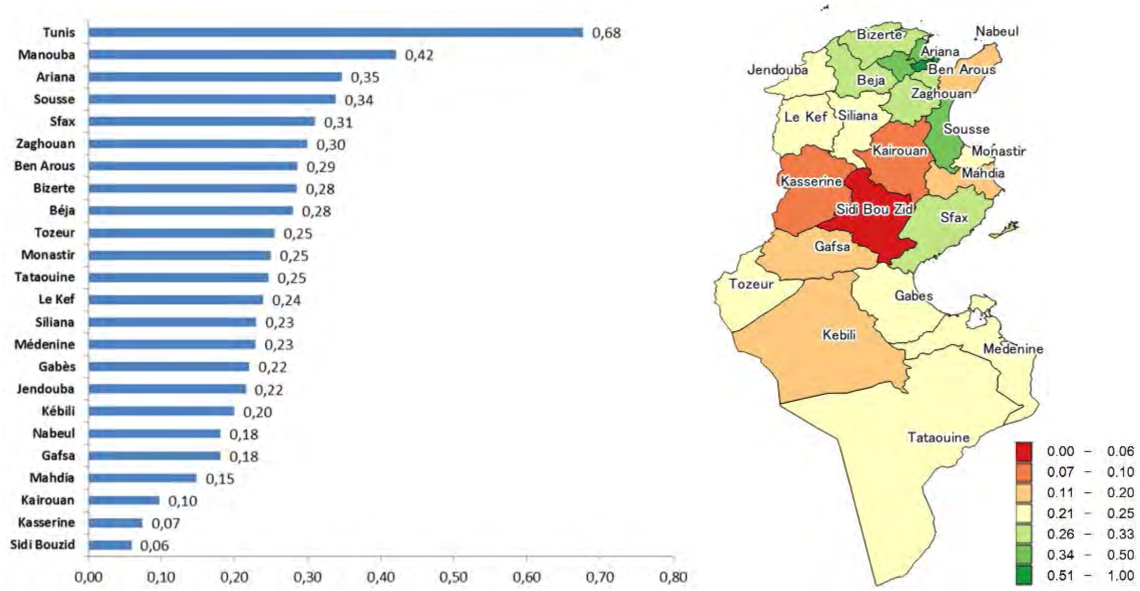
Figure 2.2-4 Accessibility of Improved Water and Sanitation Facilities

2.2.6 Trend of Economic Condition in the Future

Along with the global recession of 2008 and the impact of the Jasmine Revolution that occurred in Tunisia in December 18, 2010, GDP growth decelerated then became negative in 2011. GDP growth rate in 2012 was 3.6 % and showed sign of recovery, but the unemployment rate has remained at a high level. Job creation for young people remains a major challenge. Economic development and recovery hinge on the further expansion of the tertiary industries as well as improvements in the productivity of primary and secondary industries.

2.2.7 Public Health

The indicator of public health for each governorate according to the Ministry of Development, Investment, and International Cooperation (then Ministry of Regional Development and Planning) is shown in the figure below. The indicator for Sfax governorate is relatively high.



Source: Ministry of Regional Development and Plan (then) 2012, JICA Survey Team (map)

Figure 2.2-5 Public Health Indicator

The pollution level of shallow aquifer and seawater surrounding Sfax is thought to be high. This originates from;

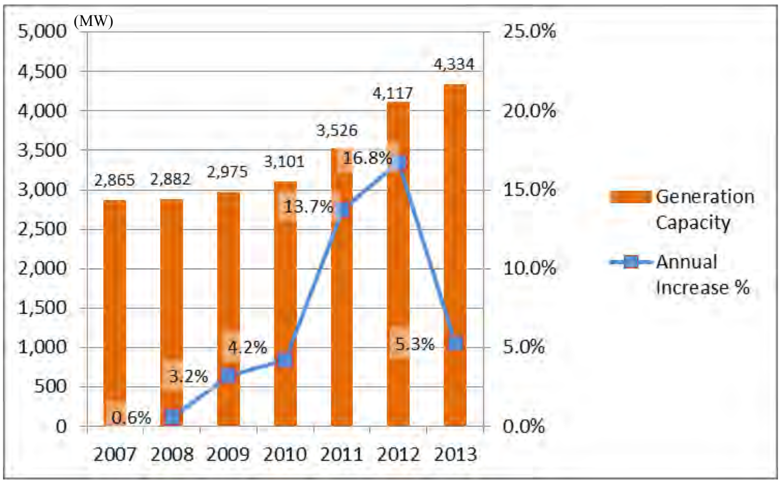
- Waste water coming from the deposit of phosphogypsum
- Waste water coming from the olive oil industry
- Waste water from the sewage treatment plant
- Waste water from garbage dumping site around the port
- Harbour (waste oil discharge)

According to hearing at the Sfax branch of SONEDE, due to the non-satisfaction in the water supply service, many households are still using rainfall and wells to complement water supply. Considering the potential pollution of these water resources, this situation stands as a public health concern.

The non-satisfaction to the water supply service could be attributed to high salinity content and water shortage, that was proven through the survey conducted to the people of Sfax (refer to sub-section 10.12.2).

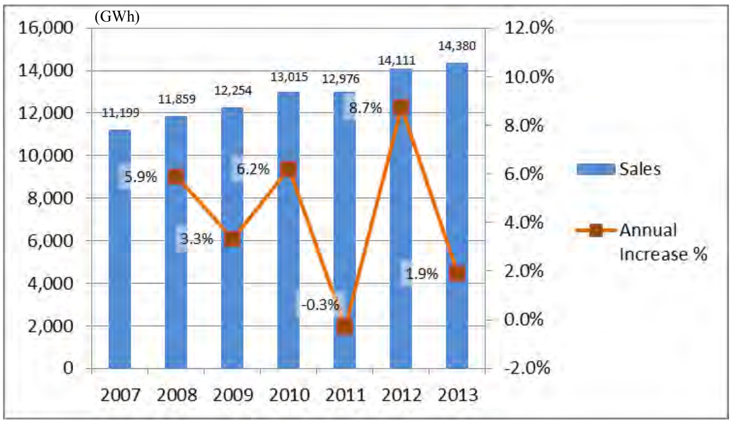
2.2.8 Situation of Power Supply

STEG is a main power supplier in Tunisia. Its status of the power generation and power sales are as shown in Figures 2.2-6 and 2.2-7.



Source: Annuaire Statistique de la Tunisie 2007-11, https://www.steg.com.tn/en/institutionnel/produire.html (2012-13)

Figure 2.2-6 STEG Power Generation Capacity



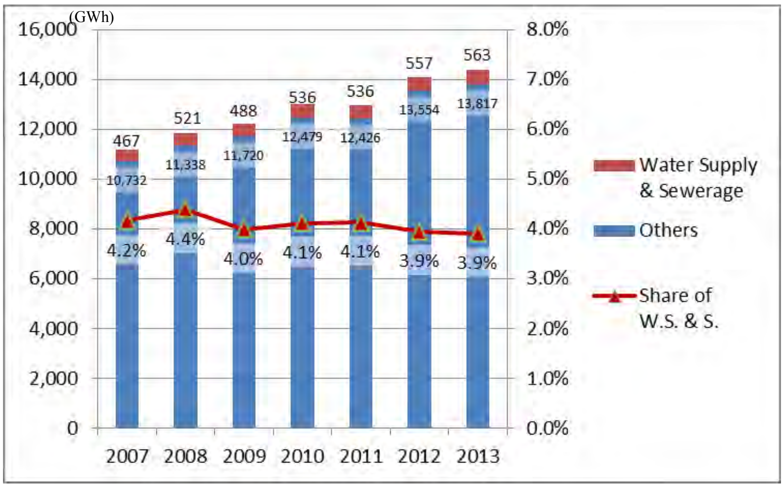
Source: Annuaire Statistique de la Tunisie 2007-11, https://www.steg.com.tn/en/institutionnel/produire.html (2012-13)

Figure 2.2-7 STEG Power Sales

The power generation of STEG has been continuously increasing since 2008 at a relatively high rate. It was 3,526 MW in 2011 with an annual increase rate of 13.7%, 4,117MW with 16.8% increase in 2012, and 4,334 MW with 5.3% increase in 2013. Total power sales has generally shown increasing tendency. It in 2011, however, showed slight decrease of 0.3% over the previous year at 12,976 GWh. It could be caused by the stagnation of industrial activities due to the Jasmine Revolution. It increased to 14,111 GWh in 2012 and 14,380 GWh in 2013.

Power Sales in 2007 was 44.6% (= (11,199 x 10^9) / (2,865 x 10^6 x 24 x 365)) of Generation Capacity. It was decreased to 37.9% (= (14,380 x 10^9) / 4,334 x 10^6 x 24 x 365)). This fact shows the improvement of balance between power supply and demand. STEG has been making effort to improve the situation.

As shown in Figure 2.2-8, the power sales for Water Supply & Sewerage Sector was 563 GWh in 2013 and it accounted for 3.9% of the total power sales. Although the power sales for the sector has increased by 28% for 6 years from 2007, its ratio for the total power sales has been stable at around 4.0% and it does not show an increasing trend. Regarding issue concerning power supply to the desalination plant is discussed in Section 11.3.



Source: Annuaire Statistique de la Tunisie 2007-11, https://www.steg.com.tn/en/institutionnel/produire.html (2012-13)

Figure 2.2-8 Share of Water Supply & Sewerage in Power Sales

CHAPTER 3

PRESENT STATUS OF WATER SUPPLY SERVICE IN TUNISIA

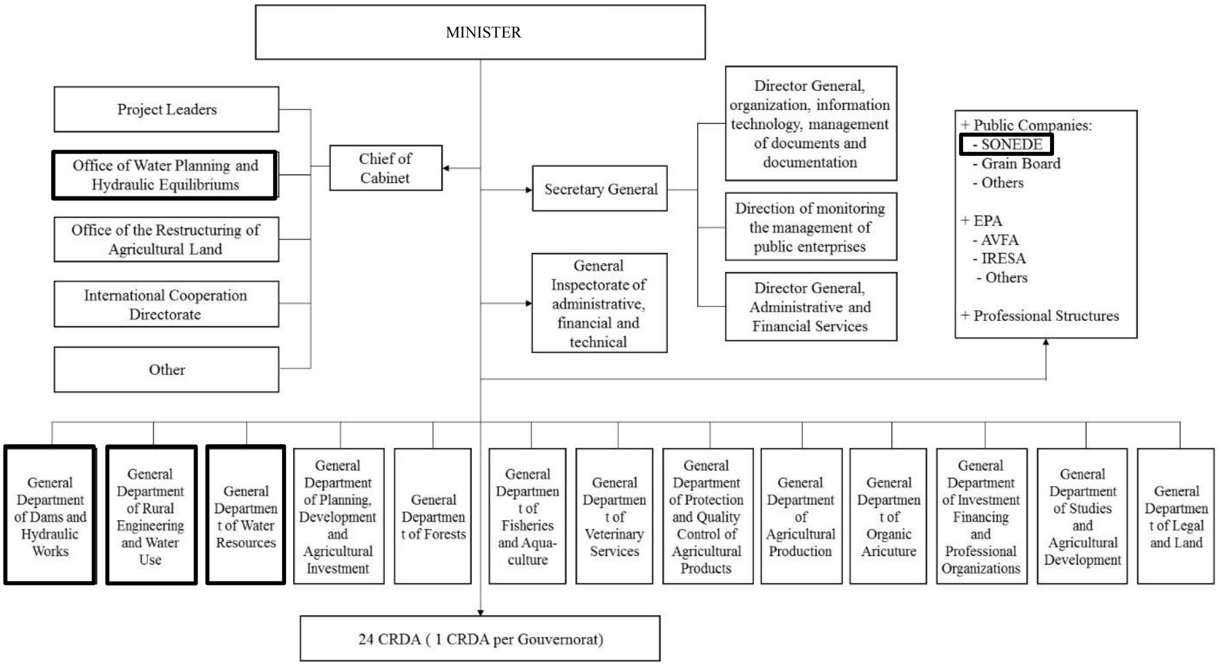
CHAPTER 3 PRESENT STATUS OF WATER SUPPLY SERVICE IN TUNISIA

3.1 Relevant Organization and Legal Framework of Water Sector

3.1.1 Outline of Relevant Organization

The MOA develops the policy framework of the water sector in Tunisia, based on the Water Act stipulated in 1975. The MOA is the governing authority of SONEDE develops policy and plans for the water sector as well as constructs, operates and maintains large-scale hydraulic structures. SONEDE, on the other hand, supplies drinking and industrial water to urban and large-scale rural communities aligned with the policy and developed plan using the hydraulic structures managed by the MOA.

The MOA responsibilities and mandates spans the field of agriculture, farming land and rural communities (see Figure 3.1-1) in addition to the water sector and the organizations of water sector within/under the control of the MOA including SONEDE, which are listed in Table 3.1-1.



Source: MOA

Figure 3.1-1 Organogram of Ministry of Agriculture, Water Resources and Fisheries

Table 3.1-1 Relevant Organizations of Water Sector within/under the Control of MOA

Name		Notes
Internal Organization of MOA	BIRH (Office of Hydraulic Inventory and Researches)	Financially autonomous pubic institution under the authority of DGRE
	BPEH (Office of Water Planning and Hydraulic Equilibriums)	Attached unit to the cabinet of the Minister of MOA
	DGRE (General Directorate of Water Resources)	Responsible for developing nationwide plan and policy on water resource; refer to 3.1.2
	DGGREE (General Directorate of Rural Engineering and Water Exploitation)	Responsible for agricultural water use and its resource in general; refer to 3.1.3
	DGBGTH (General Directorate of Dams and Large Hydraulic Works)	Responsible for large-scale water resource development by means of dams, etc.; refer to 3.1.4
Affiliated Organization of MOA	INRGREF (National institute of Researches on Rural Engineering, Water and Forests)	
	CRDA (Regional Office of Agriculture Development)	Refer to 3.1.5
	RSH (Hydraulic Drilling Cooperation)	
	SECADENORD (National Corporation for Exploitation of Northern Water Channel and Conveyors)	Financially autonomous pubic company providing water to SONEDE and CRDA
	SONEDE (National Corporation of Water Exploitation and Distribution)	Refer to 3.1.6, Executing Agency of the Project

Source: JICA Survey Team

The General Directorate of Water Resources (DGRE) is the agency in charge of policy for water resource development for the entire country. The drinking and industrial water supply service is provided by SONEDE for both urban area and large rural communities; while small-scale rural community and agricultural water falls under the General Directorate of Rural Engineering and Water Exploitation (DGGREE) in terms of policy development, planning and evaluation, with the Regional Office of Agricultural Development (CRDA) in charge of policy implementation. The Agricultural Development Group (GDA) takes charge of operation and maintenance of hydraulic works for agricultural use as an entity of users' cooperation, supported by CRDA both financially and technically.

In addition to MOA above, the Ministry of Foreign Affairs (French: Ministère des Affaires Etrangères), the Ministry of Finance (French: Ministère des Finances), the Ministry of Development, Investment and International Cooperation (MDICI, French: Ministère du Développement, de l'Investissement et de la Coopération internationale), the National Agency of Environmental Protection (ANPE, French: Agence Nationale de Protection de l'Environnemen), the Coastal Protection and Development Agency (APAL, French: Agence de Protection et d'Aménagement du Littoral), and the High Authority for Public Procurement (HAICOP, French: Haute Instance de la Commande Publique) are related organizations of Tunisian side for the Project.

The Ministry of Foreign Affairs is the responsible entity of Tunisian side for its international affairs. The Ministry of Finance is responsible for borrowing and repayment. MDICI has functions regarding economic development loans for external borrowing projects and management of the projects, and is responsible for the coordination related to the loan agreement for the Project. Both ANPE and APAL are responsible for the EIA review process prior to the bidding procedure of the Project. HAICOP is in charge of approval process of evaluating/selecting the bidders before the final concurrence of JICA. The MOA gives approval for the establishment of the Project Implementation Unit (PIU) in SONEDE and the organization restructuring of SONEDE, as the controlling entity of SONEDE.

3.1.2 General Directorate of Water Resource (DGRE)

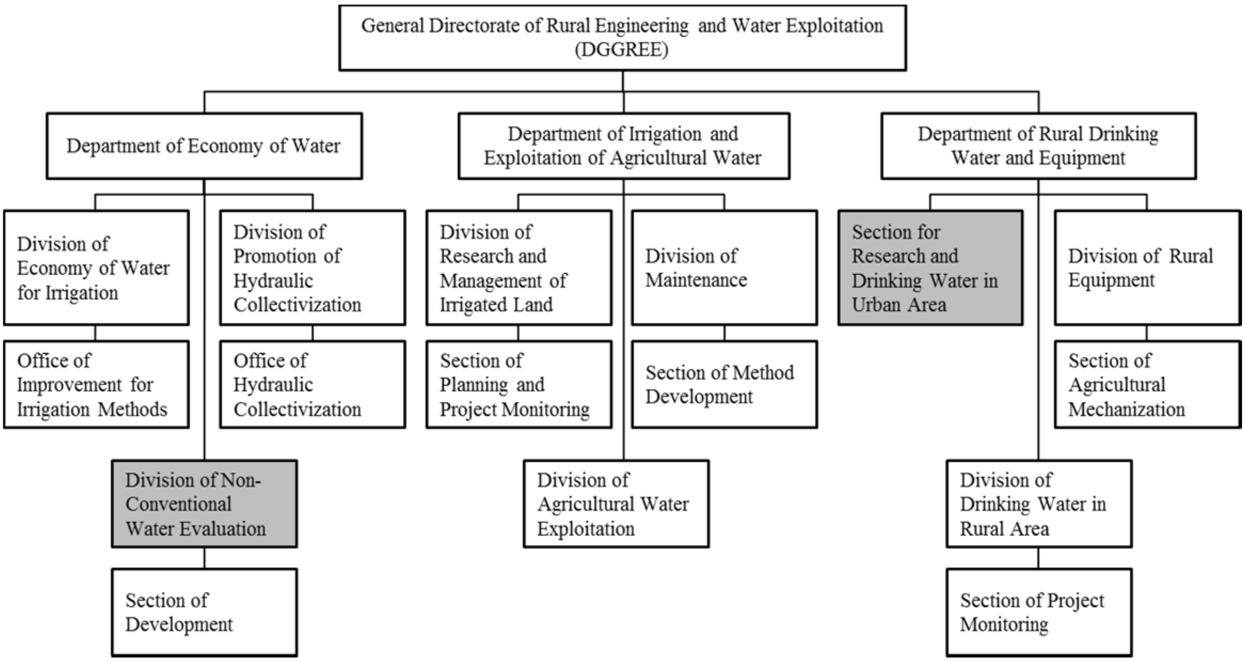
The General Directorate of Water Resource (DGRE) of the MOA is the agency in charge of developing policy and planning of water resource for the water sector nationwide. Its responsibilities are;

a) Setting up managing and measuring networks as it pertains to the various components of the country's water resources;
b) Implementing basic and applied studies on the evaluation of water resources;
c) Developing principles and methods for the management and the use of hydraulic resources to meet the demands;
d) Promoting research and experimental activities on conventional water resources in order to secure their development;
e) Preparation of master plans for the mobilization of hydraulic resources.

3.1.3 General Directorate of Rural Engineering and Water Exploitation (DGGREE)

The organogram of the General Directorate of Rural Engineering and Water Exploitation (DGGREE) of the MOA is shown on Figure 3.1-2. Its responsibilities lie on;

a) Implementing studies, developing policies and drafting plans that relate to the rural engineering field and the use of water in the agricultural sector;
b) Following up and assessing the projects of developing irrigated areas, programs for the use of irrigation water and the maintenance of hydraulic structures and equipment and designing the most appropriate technical and economic method in this field;
c) Rationalizing the use of water, evaluating the use of non-conventional water resource in agriculture, following up the institutional aspects for the promotion of water association and implementing the tools of water demand management in the agricultural sector;
d) Coordinating programs of drinking water in urban and rural environment, drawing up program for the supply of drinking water to rural zones, following up and assessing the projects relating to such program;
e) Coordinating rural infrastructure program and studying the technological and economic aspects of agriculture equipment in order to encourage the mechanization of the farming sector.



Source: JICA Survey Team

Figure 3.1-2 Organogram of DGGREE

3.1.4 General Directorate of Dams and Large Hydraulic Works (DGBGTH)

The General Directorate of Dams and Large Hydraulic Works (DGBGTH) of the MOA is in charge of research on the control of surface water and the mobilization of water resource, construction of dams and hydraulic works for the mobilization of water, as well as control, operation and maintenance of such constructed works.

3.1.5 Regional Office of Agriculture Development (CRDA)

The Regional Office of Agricultural Development (CRDA) is the financially autonomous public entity under the control of the MOA, and has its regional arms in all 24 regions. It is responsible for; a) the construction of hydraulic works except for the national structures to be provided by the MOA, and b) carrying out operation and maintenance of hydraulic works and supplying water for agricultural use.

3.1.6 National Water Distribution Utility (SONEDE)

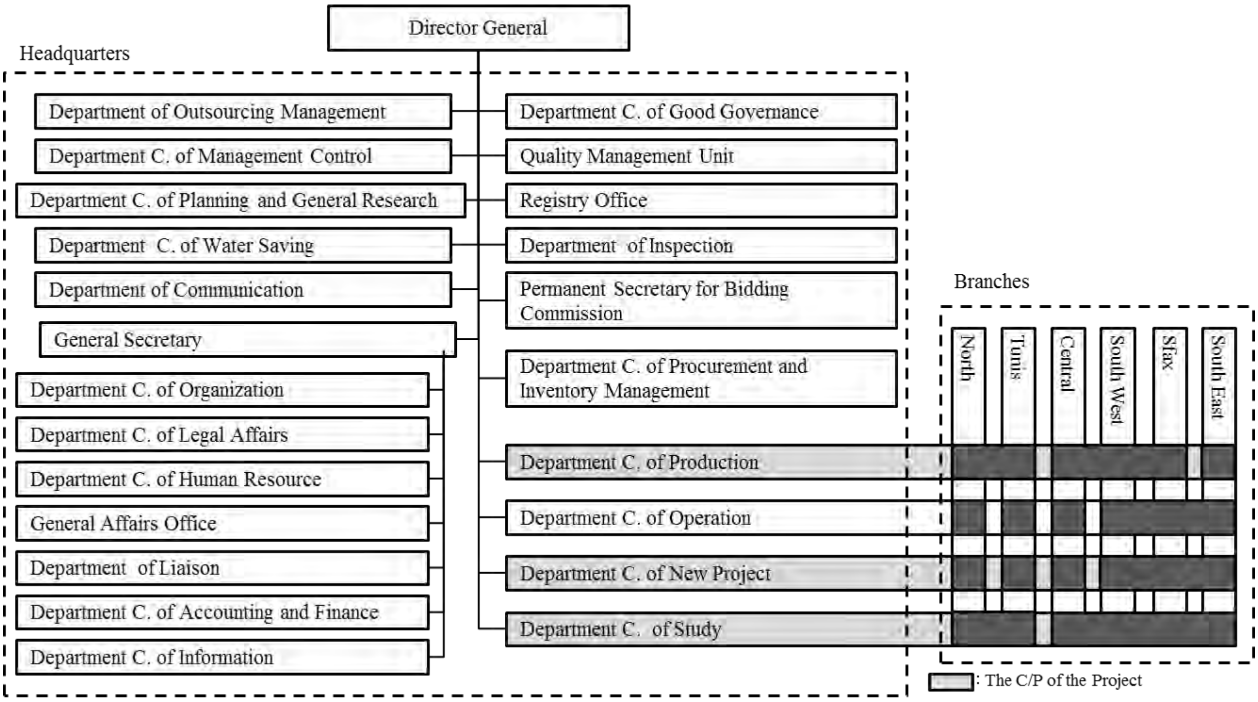
The National Water Distribution Utility (French: Société Nationale d’Exploitation et de Distribution des Eaux, SONEDE) was established in 1968 as a financially autonomous public company under the control of the MOA. It is in charge of supplying drinking water nationwide, and conducts research and planning on the intake, transfer, treatment, transmission and distribution of water, as well as uses, renews, operates and maintains constructed hydraulic works. The outline of organization and its activities as of 2013 are shown in Table 3.1-2.

Table 3.1-2 Outline of Organization and Activities of SONEDE (2013)

Item	Description	Remarks
Number connections	2,550,318 connections	Number of employees per 1,000 connections: 6,818 employees /2,550,318 connections /1000 =2.67
Served Population	9.11 million	
Annual Volume of Production	609.4 million m^3	Details of production: - Surface water: 347.2 million m^3 - Groundwater: 234.4 million m^3 - Desalinated water: 19.7 million m^3 - Deferrizated water: 6.2 million m^3
Annual Volume of Distribution	555.5 million m^3	
Annual Volume of Revenue Water	449.9 million m^3	
Length of Pipelines	49,500 km	Details: - Intake and Conveyance: 9,400 km - Transmission and Distribution:40,100 km
Personnel	Total 6,818 Permanent Employee 6,039 Temporary Employee 779	Breakdown of Permanent Employee - Technical: 4,505 - Administrative: 1,534

Source: SONEDE and JICA Survey Team

The organogram of SONEDE is shown in Figure 3.1-3. The Central Department of Production has three branches of North-Tunis, Central-Sfax-South West and South East; the Central Department of Operation and the Central Department of New Project have four branches of North, Tunis, Central, and South, respectively; and the Central Department of Study has two branches of North-Tunis, and Central- South. Further, the branches of the Central Department of Operation have 37 customer service arms, of which 10 in North Branch, nine in Tunis Branch, seven in Central Branch and 11 in South Branch.

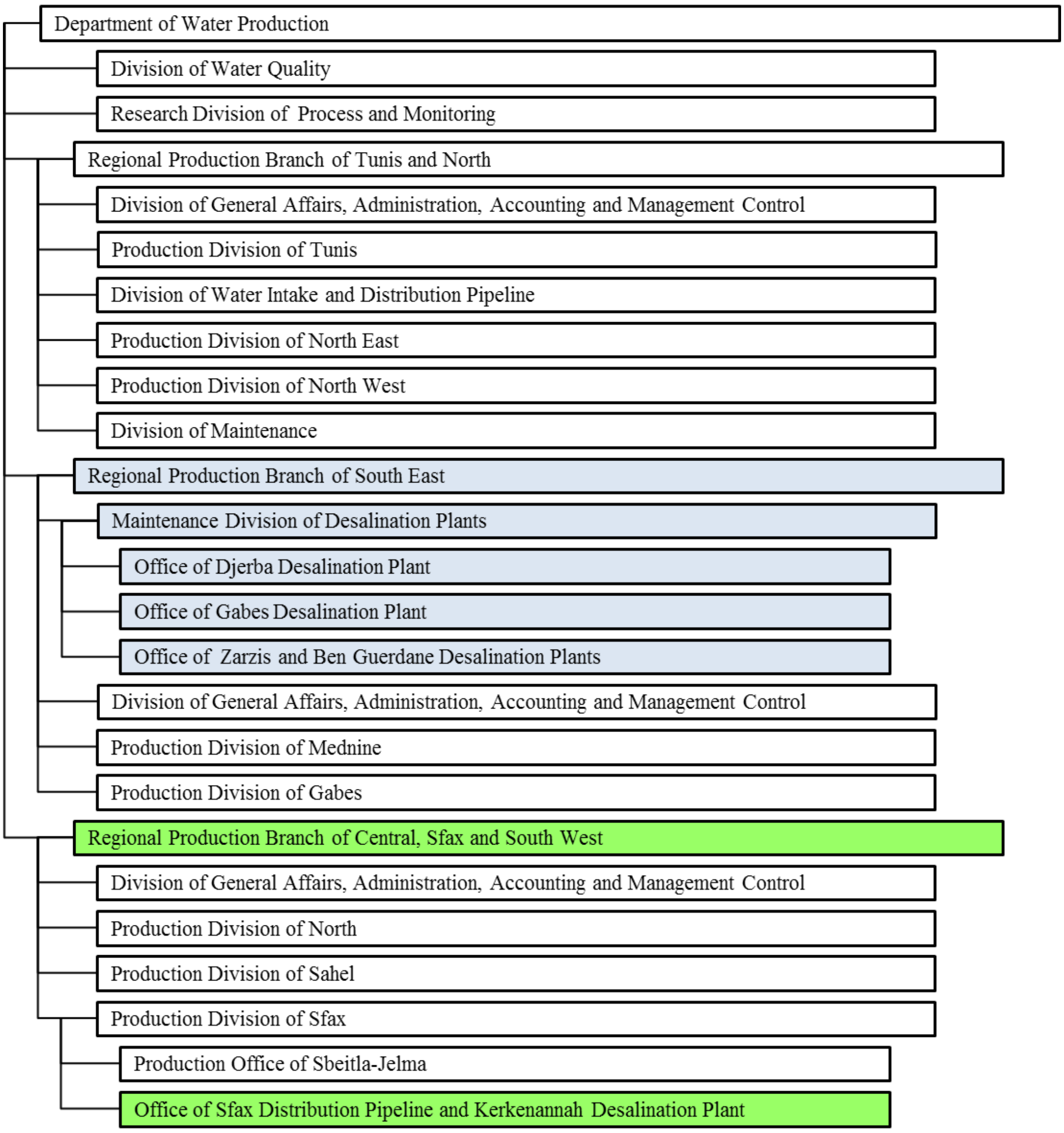


Source: SONEDE and JICA Survey Team

Figure 3.1-3 Organogram of SONEDE (as of October 2014)

The counterparts of the Project are expected to be the Central Department of Study in the planning and designing phase up to the contract of construction work, the Central Department of New Project in the construction phase after the contract of construction work, and the Central Department of Production in the operation and maintenance phase.

The Central Department of Production is in charge of the operation and maintenance of water works and its organogram is shown in Figure 3.1-4. Of the five desalination plants currently in operation i.e. Djerba, Gabes, Zarzis, Kerkennah and Ben Guerdane, the four plants except Kerkennah are under the control of its South-East Branch, and the Kerkennah is under the control of Central-Sfax-South West Branch.



Source: SONEDE and JICA Survey Team

Figure 3.1-4 Organogram of Water Production Department of SONEDE

As for the operation and maintenance of the four desalination plants being managed by the South-East Branch of the Central Department of Production as stated above, daily operation, surveillance, inspection and minor repair are conducted by the Operation Division of each plant. Technically high-level maintenance and large repair are conducted by the Maintenance Division of the branch or the Central Department of Production at headquarters in accordance with the degree.

The current staffing for the operation and maintenance of each desalination plant is shown in Table 3.1-3. The former “Operation Division of Zarzis Desalination Plant” was reorganized as the “Operation Division of Zarzis and Ben Guerdane Desalination Plants” and the latter is in charge of the operation and maintenance of Ben Guerdane Desalination Plant, which started operation in 2013. Thus, there are remarkable vacancies in the operation and maintenance staff of this reorganized division, but it will be filled in a phased manner after technological transfer from other divisions.

The operation and maintenance of the planned plant will be conducted by Central-Sfax-South West Branch. The existing desalination plant under the control of this branch is only the Kerkennah plant (capacity: 3,300 m^3/day) and the organization structure to deal with the higher maintenance and large-scale maintenance is not established yet, which is different from South East Branch. In addition, the Seawater Desalination Plant of the Project will be the second[1] plant for SONEDE as a seawater desalination plant. Although there is no remarkable difference in operation and control process between the seawater and groundwater desalination, the method of operation and maintenance should be established in accordance with the raw water quality in terms of setting up the frequency of cleaning and replacing membrane unit and the adjustment of flux. Thus, the reorganization of the two branches and the staffing of necessary personnel, as well as providing for the initial training of operation and maintenance are essential for the implementation of the Project. For the purpose of the latter, it is recommended that SONEDE should allocate the main engineers/technicians and administrative manager for the plant from the construction stage, particularly from the stage of setting up mechanical and electrical equipment, so that they can participate in the OJT (on-the-job training) including the monitoring of the setting up process.

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[1] In September 2014, the contract for construction of Djerba Sea Water Desalination Project was signed. Existing 5 desalination plants treats brackish water from wells.

Table 3.1-3 Staffing Status for O&M of Current Desalination Plants (as of November 2013)

Category		South-East Branch, Water Production Department								Central, Sfax and South-West Branch, Water Production Department	
		Maintenance Division of Desalination Plants		Office of Djerba Desalination Plant		Office of Gabes Desalination Plant		Office of Zarzis and Ben Guerdane Desalination Plants		Office of Kekennah Desalination Plant	
		Qualification	Staff	Qualification	Staff	Qualification	Staff	Qualification	Staff	Qualification	Staff
Permanent	Chief Engineer	Head of division	1	Head of office	1	Chief engineer	1				
		Chief engineer	1								
	Engineer										
	Deputy Engineer			Head, inspection	1	Head, operation	1	Head, inspection	1		4
				Head, water quality test	1			Head, water quality test	1		
				Head, Operation	4			Head, operation	3		
				Operator (mechanical)	1			Operator	1		
	Chief Technician	Section head	1	Operator (electrical)	1	Head, inspection	1			Head of Office	1
				Inspector (electrical)	1	Operator (electrical)	2				1
	Technician					Welder	1				3
	Deputy Technician	Electrical (vacancy)	1					Operator (electrical)	2		
		Mechanical (vacancy)	1					Operator (mechanical)	1		
								Operator	1		
								Inspector	1		
	Worker					Inspection	1	Welder	1		4
								Plumber (vacancy)	1		
	Others	Head of section	1	Head, operation	1	Head of office （vacancy)	1	Head of office (vacancy)	1		
		Planning and dispatcher	1	Secretary	1	Head, water quality test	1	Head, operation (vacancy)	1		
		Planning and dispatcher (vacancy)	2	Driver	1	Head, operation	4	Head, operation (vacancy)	1		
		Pumper	2	Others	3	Driver	2	Inspection (electrical、 vacancy)	1		
		Mechanical	1					Office Clerk	1		
		Electrical	1					Driver	1		
		Driver	1								
	Total		14		16		15		19		13
	Total (without vacancy)		10		16		14		14		13
Temporary				Inspection (electrical, chief technician class）	1	Worker	1	Gardiner	2		
				Inspection (electrical)	1	Plumber	1	Clearner	1		
				Worker	1	Operator	2	Guardman	2		
				Gardiner	1	Others	3				
				Others	4						
	Total		0		8		7		5		0
Sum	Vacancies included:		14		24		22		24		13
	- Operation		-		8		11		11		-
	- Inspection		-		5		4		6		-
	- Others		-		11		7		7		-
	Vacancies excluded:		10		24		21		19		13
	- Operation		-		8		11		9		-
	- Inspection		-		5		4		4		-
	- Others		-		11		6		6		-

Source: SONEDE and JICA Survey Team

3.1.7 Legal Framework of Water Sector

The Water Law (Code des Eaux), stipulated in March 1975, was a basic law on water sector in Tunisia. The outline of this law is shown in Table 3.1-4. The laws and regulations related to the environmental impact, land acquisition and construction permit relevant to the Project are described in Chapter 8 and Chapter 9.

Table 3.1-4 Outline of Water Law

Chapter	Synopsis	Remarks
1	Public water bodies	- Definition of public water bodies (Article #1) - The public water bodies are governed in principle by the MOA. (Article #4) - The establishment of Regulatory Commissions on water usage and public water bodies (Article #4, #19 and #20); these commissions have not functioned until today due to the influence of the Revolution
2	Water reservation and monitoring of public water bodies	
3	Rights on water utilization	- The right for the ownership of water should be transcribed to water utilization right. (Article #21)
4	Regulation on land use	- The land of 3m width from the periphery of public water bodies should be reserved as free-zone. (Article #40)
5	Permission and concession of water of public water bodies - General requirement - Special regulation on surface water - Special regulation on underground water - Limitation of concession	- Temporary permission (Article #52) for the installation of temporary hydraulic works within public water bodies and in free-zone land - Concession permission (Article #53) for the installation of permanent works in river bed for water intake and for the utilization of underground water
6	Water utilization - Water saving - Special regulation on drinking water - Special regulation on agricultural water	- Development of un-conventional water resource (Article #87): wastewater reuse, utilization of brine water and seawater with no potential impact by highly concentrated salt water, artificial refill of underground water, etc.
7	Countermeasures against water pollution and flooding	
8	The association of water users	
9	Penalties	

Source: JICA Survey Team

3.1.8 Drinking Water Quality Standard

The Drinking Water Quality Standard of Tunisia (NT09.14:1983), those in the WHO Guidelines (2004), the EC Directive (1998), and the Japanese Drinking Water Quality Standard (2003) are presented in Table 3.1-5. SONEDE employed TDS concentration as a general indicator for salinity in drinking water in Tunisia. Unless otherwise stated, the water quality stated as “salinity” means TDS concentration.

Table 3.1-5 Drinking Water Quality Standard in Tunisia (NT09.14:1983)

Analysis Item	unit	Tunisian Drinking Water Standard (NT09.14:1983)		WHO Guidelines (2004)	EC Directive (1998)	Japanese Sandard (2003)
		Recommendation	Standard			
Arcenic (As)	mg/l		0.05	0.01	0.01	0.01
Cadmium (Cd)	mg/l		0.005	0.003	0.005	0.01
Cyan (CN)	mg/l		0.05	0.07	0.05	0.01
Mercury (Hg)	mg/l		0.001	0.001	0.001	0.0005
Lead (Pb)	mg/l		0.05	0.01	0.01	0.01
Selenium (Se)	mg/l		0.01	0.01	0.01	0.01
Antimon（Sb)	mg/l		0.02			
Silver (Ag)	mg/l		0.02	-	-	-
Fluoline (F)	mg/l		0.8-1.7	1.5	1.5	0.8
Nitrate-Nitrogen (NO$_3^{-}$)	mg/l		45	50	50	10 (Nitrate/Nitlite)
Turbidity	NTU	5	25	5	Acceptable to consumers	2
Total Disolved Solids (TDS)	mg/l	500	2,000-2500	1,000	(Electric Conductivity 2,500μS/cm)	500
pH	-	7.0-8.0	6.5-8.5	-	6.5-9.5	5.8-8.6
Total Hardness	mg/l	10^{o}F (as CaCO$_3$)	100^{o}F (as CaCO$_3$)	-	-	300
Carcium (Ca^{++})	mg/l	75	300	-	-	
Chloride (Cl^{-})	mg/l	200	600	250	250	200
Copper （Cu)	mg/l	0.05	1	1	2	1
Iron （Fe)	mg/l	0.1	0.5-1	0.3	0.2	0.3
Magnesium (Mg^{++})	mg/l	30	150	-	-	-
Mangan（Mn)	mg/l	0.05	0.5	0.1	0.05	0.05
Sulfae ion (SO$_4^{2-}$)	mg/l	200	600	250	250	-
Zinc （Zn)	mg/l	1	5	3	0.1	1
Coliform Group	MPN/100ml		0	0	0	0
Boron (B)	mg/l		-	0.5	1	1

Note: Turbidity of Japanese standard is degree of Kaolin.

3.2 Current Situation of Water Supply and Demand in Tunisia

3.2.1 Water Resources in Tunisia

The Office of Water Planning and Hydraulic Equilibriums (BPEH, French: Bureau de la Planification et des Équilibres Hydrauliques), the MOA prepares the water distribution amount allocation plan to each region together with organizations/institutes related to water resources.

The quantity of water resource in Tunisia is presented in Table 3.2-1. Salinity is the biggest problem in the water resources in Tunisia and the TDS of more than 50% of the groundwater exceeds 1500 mg/L.

Table 3.2-1 Water Resources and Water Availability for Use in Tunisia (2013)

unit: Million m^3/year

	Water Resources	Water Availability for Use*			
		TDS <1500mg/L	1500<TDS <3000mg/L	3000mg/L <TDS	Total
Surface Water	2,700	1,200	400	100	1,700
Groundwater	2,100	300	800	500	1,600
Total	4,800	1,500	1,200	600	3,300

Remarks*：MOA plans to take measures to increase the water availability for use.

Source: MOA Documents

3.2.2 Water Demand in Tunisia

SONEDE supplies water for drinking, industries and tourism as follows:

Table 3.2-2 Water Demand in Tunisia (2013)

unit: Million m^3/year

Administration	MOA	SONEDE			Total
Usage	Irrigation	Drinking	Industries	Tourism	
Water Demand	2,160	380	130	30	2,700

Source: MOA Documents, SONEDE Documents

3.2.3 Water Balance in Tunisia

As shown in Table 3.2-3 and Table 3.2-4, among the available water resources of below 3000mg/L TDS, 100% of the surface water and almost of all of the groundwater have been utilized and only water of more than 3000mg/L are available. The utilization of the remaining water is limited to be utilized due to the salinity. For example, in accordance with the water norm for agricultural use, TDS is permissible up to 2000mg/L, but actually, the remaining water clearing this criterion is very limited. For olive cultivation the permissible TDS is about 3000mg/L; however, in the long run the salinity will be accumulated in the ground and exceed the permissible value.

Table 3.2-3 Water Demand and Resources in Tunisia (2013)

unit: million m^3/year

Usage	Demand	Surface Water			Groundwater		
		TDS <1500mg/L	1500<TDS <3000mg/L	3000mg/L <TDS	TDS <1500mg/L	1500<TDS <3000mg/L	3000mg/L <TDS
Irrigation	2,160	970	370	0	250	570	0
Drinking	380	160	0	0	40	110	70
Industries	130	60	20	0	10	40	0
Tourism	30	10	10	0	0	10	0
Total	2,700	1,200	400	0	300	730	70
Utilized rate		100%	100%	0%	100%	91%	14%

Source: MOA Documents, SONEDE Documents

Table 3.2-4 Water Balance between Demand and Resources in Tunisia (2013)

unit: million m^3/year

	Demand			Water Available to Use			Utilized rate		
Usage	Surface Water	Ground water	Total	Surface Water	Ground water	Total	Surface Water	Ground water	Total
Irrigation	1,340	820	2,160						
Drinking	160	220	380						
Industries	80	50	130						
Tourism	20	10	30						
Total	1,600	1,100	2,700	1,700	1,600	3,300	94%	69%	82%

Source: Ministry Agriculture Documents, SONEDE Documents

3.3 Future Plan of Water Sector

The Tunisian Government released the 12th Five Year Plan (2010 – 2014), before the revolution in 2011. This national plan, which includes water service rate of 100% in urban area and an installation of seawater desalination plants for the drinking water quality improvement, was cancelled because of the revolution. SONEDE, however, works based on the national plan.

This project is to construct a seawater desalination plant contributing the improvement of drinking water quality with sustaining 100 % service rate in the urban area. Therefore, this project meets the policy of the water sector in Tunisia. Presently, Tunisian Government is preparing to implement its new social economic development plan from 2016 to 2020, which aims 7% annual increase of GDP. As a reference, the 12th Five Year Plan is introduced below.

[Reference: 12th Five-Year Plan for Economic & Social Development in Tunisia 2010 – 2014]

Tunisia has set its national target to take necessary action for construction and reform towards comprehensive and balanced development to catch up with developed countries, and consequently to win the confidence of the international community.

In the 12th Five Year Plan, from 2010 to 2014, Tunisia aims to establish a new growth model by consolidation of social welfare and economic progress in the process of catching up with developed countries, and sets following policies.

1) To introduce new contents of growth through innovation
2) To increase the per capita income and reduce poverty to the lowest level
3) To increase job and reduce unemployment for graduates of higher education
4) To adapt education and training system to the requirements of the actual economy
5) To consolidate social gains
6) To integrate all regions and strengthen their competitiveness
7) To introduce environmental economy to improve the quality of life

In accordance with the National 12th Five Year Plan, the MOA sets their policies, (1) Food Security, (2) Strength the economic competitiveness, (3) Export promotion, and (4) National resources mobilization. The following water sector policies align with the National Resources Mobilization policy, as follows:

- Water resources in Tunisia are scarce and are unevenly located. In addition to uneven rains and the inequality in distribution of water resources through the country, high salinity and possible contamination of water resources are issues to be dealt with.
- Master plans for exploitation of water resources and the strategies for water resources mobilization, development and preservation shall be prepared. Issue of effective use of water resources shall be tackled in the medium and long terms in all sectors taking water saving as a nucleus. In addition, the existing public irrigation area shall be rehabilitated, and the management of irrigation and potable water networks shall be enhanced.
- The water infrastructure in Tunisia has been developed as 29 large dams, 226 small dams, 827 mountain lakes, about 95,000 shallow wells and more than 5,000 deep wells in use. Those facilities mobilize more than 88% of the exploitable water resources.
- Concerning potable water, the projects under execution by SONEDE and Rural Engineering Department will supply potable water to the rural areas and the supply rate will be 98% by 2014. In the coming period, improvement of supply rate shall be achieved by implementation of project in the north-western region (Kef, Beja, Bizerte and Jendouba).
- As to urban areas, keeping 100% supply rate, SONEDE will increase water production and improve water quality in the areas suffering from the deterioration through the implementation of water desalination stations or transporting good quality water from other regions.
- The agricultural sector is one of the most water consuming sectors at 78% and followed by household consumption at 16% and industrial and touristic sectors at 6%.
- The mobilization rate shall be increased up to 95% around the year 2016 and mobilization of untraditional waters shall be promoted to ensure potable water supply.
- The program to rehabilitate public irrigation areas and water network system and introduce modern technologies for water saving shall be extended from current area of 120,000ha to 200,000ha in 2016.

3.4 Future Plan for Water for Agriculture Sector

(1) Current Situation on Agriculture Sector in Tunisia

It is forecasted that in case the whole dam construction projects be completed up to the end of 2015, 95% of the potential resources of 4.8 billion m^3/year are to be utilized. On the other hand, the agricultural sector, which consumes approximately 80% of the available water, is required to sift some of their consumption to other sectors in accordance with the national policy and take necessary action for construction and reform towards comprehensive and balanced social and economic development.

Recently completed and on-going dam construction projects are as shown in Table 3.4-1.

Table 3.4-1 Recently Completed and On-going Dam Construction Projects

Dam	Region	Capacity (million m^3)	Completion year	Status	Project Name	Fund
Zarga	Jendouba	22.0	2012	completed	a	FADES
El Kbir	Jendouba	64.0	2012	completed	b	FADES
El Maoula	Jendouba	26.3	2012	completed	b	FADES
Zaiatine	Bizerte	33.0	2012	completed	c	FADES
Gamgoum	Bizerte	18.3	2012	completed	c	FADES
El Harka	Bizerte	30.3	2012	completed	c	FADES
El Maleh	Bizerte	41.0	2015	on-going	c	FADES
Ettin	Bizerte	34.0	2015	on-going	c	FADES
Serat	El kef	21.0	2015	completed	d	Abu Dhabi & FADES
El Kbir Gafsa	Gafsa	24.0	2016	on-going	e	FADES
Eddouimiss	Bizerte	45.6	2018	on-going	c	FADES
Melleg El Aloui	El kef	195.0	2020	on-going	f	FADES

Project Name:

a. Projet du barrage de Zarga et d'irrigation des plaines de Tabarka et de Makna
b. Projet des barrages Kebir et Moula
c. Projet de construction de six barrages au nord pour l'eau potable
d. Projet du barrage Sarrat et d'irrigation des plaines de Ouled Boughanem et Mahjouba
e. Projet Barrage Oued El Kebir
f. Projet Barrage Mallègue Supérieur

Source: DGBGTH, Ministry of Agriculture, Water Resources and Fisheries, 02 June, 2015

(2) SONEDE's Program to Take Water from Agricultural Dam

SONEDE has reached an agreement with the MOA to divert annually agricultural water of 6 million m^3 in 2012. However, it is not an agreement to use the water throughout the year but during the agricultural off-season only. SONEDE, for the water supply in Sousse, has already started to take some of agricultural water and sifted it for drinking water.

To supply water for irrigation in Sahel, Barrage Nabhana had been constructed in Kairouan Governorate, which located in the west of Sahel. This barrage had been planned only for irrigation purpose and the water from this barrage is preserved by the MOA and its agricultural association.

SONEDE discussed with the ministry and the association, and in 2005, an agreement was reached to divert a part of irrigation water to the potable water for 15 days in the seasonal peak period. After the initial agreement, SONEDE encountered more serious problem of water shortage in summer season than expected. Then they discussed again and agreed to extend the period of the special arrangement to a total of four (4) months, two months in summer season and one or two months in agricultural off-season.

(3) Policy and Future Plan for Agricultural Water

The MOA has compiled water management policies and future plans into their water management strategy. The followings approaches are to be taken to use the limited water resources more effectively.

- Comprehensive water mobilization system shall be organized involving dam construction projects and networks between big dams and water conveyance to the regions where there is a water shortage.
- Water conservative technologies shall be introduced rigorously in modernization of water collective networks, water utilization and water saving equipment.
- Recycling of water for irrigation use
- In association with all water management sectors institutional and regulatory frameworks shall be organized.
- Increase water value policies such as shifting to higher valuated cropping systems and more effective irrigation networks shall be adopted.

3.5 Future Plan for Water for Industrial Sector

Generally, medium and small size industrial firms in Tunisia get their water from SONEDE and relatively large scale firms dig their own wells and extract groundwater.

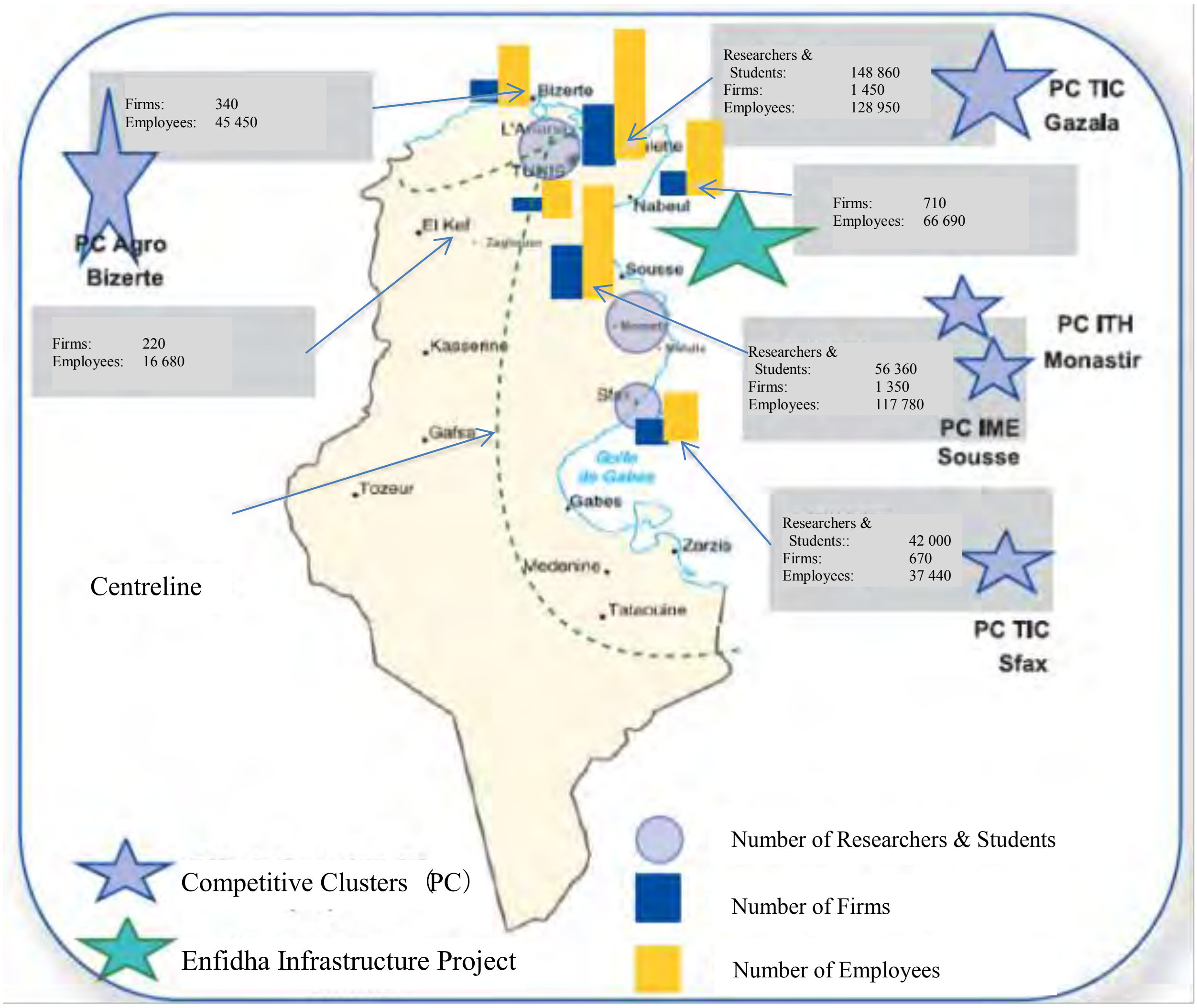
In 2008, the Ministry of Industry, Energy and Small and Middle Enterprises (then, French: Ministere de l'industrie, del'energie et des petites et moyennes entreprises) proclaimed the national policies for the medium and small size industry centring on three important industries, i.e. Industries Textile and Apparel (Industries textile et habillement /ITH), Farm Product-Food Industry (Industries agroalimentaries), and Mechanical and Electric Industries (Industries mecaniques et electroniques /IME). In addition, there is now a focus on Technology for Information and Communication (Technologies de l’information et de la communication /TIC) for Tunisian’s future development. The industries competitive clusters (Pôle de compétitivité /PC) are shown in Figure 3.5-1.

Monastir in Sahel area is categorized as PC for ITH, and Souse in Sahel area is classified as PC for IME and up to 2009. It was supposed to accommodate 56,360 researchers and students, 1,350 firms and 117,780 employees. Regarding Sfax, it is categorized as PC for TIC and up to 2009, it was supposed to accommodate 42,000 researchers and students, 670 firms and 37,440 employees. TIC does not require the industrial water.

While large-scale firms have drilled own wells to fill their demands for water; over-extraction has led to regulation and it is now very difficult to get authorized permission to drill new wells in Sfax. Firms have started constructing their own seawater desalination plant as a second choice.

As to the reuse of the treated wastewater there are still problematic issues to be clarified up to the actually extension in terms of water quality and cost performance.

For Tunisia, it is inevitable to face to the reality of water shortage. This fact may shift the focus from examining for new water resources to monitoring the increasing water demand. The MOA had already conducted many studies financed by international funds such as AFD, KfW, AfDB, etc. However, those studies recommended short-term solutions.



Source: National Horizon 2016, Ministry of Industry, Energy and SMEs, 2008

Figure 3.5-1 Main Industrial Area in Tunisia

Table 11.5-3 Power Supply Risks and Mitigation Measures

Power Supply Risks	Cause of Risks	Mitigation Measures
Power failure	• Lack of emergency generators • Accidents	• To intensify generating facilities (below: measures at the plant) • Two-line power receiving system • To receive power from high voltage line • To secure large capacity of production water tanks • To install standby generators for the transmission pumps.

11.5.4 Project Delay Risks and Mitigation Measures

There will be various causes for delay risk. Most probable case is the delays in processing various procedures shown in Table 10.7-1 and Figure 10.7-1. Furthermore, delays in getting approval from related authorities for the implementation of works, such as permission of road authorities for works in road premises can cause delay of the works. The project shall be implemented under the control of the PIU which will be established in SONEDE together with cooperation with related authorities. The PIU is expected to have strong leadership and approaches with related authorities for implementing the project without delay.

The risks and mitigation measures are summarized in Table 11.5-4.

Table 11.5-4 Project Delay Risks and Mitigation Measures

Risks of Delay of Implementation	Cause of Risks	Mitigation Measures
Delay in implementation of the Project	• Delay in establishment of PIU • Delay in making Loan Agreement • Delay in preparing Tender Documents • Delay in the approval of various procedures by HAICOP • Delay in Tender evaluations • Rupture of Tender • Delay in the concurrence in various procedures by JICA • Delay in land acquisition • Delay in the approval of implementation of works by related authorities • Delay in marine works due to bad weather.	• Strong leadership and approach to related authorities by PIU. • Secure sufficient number of PIU staff • Hire consultants • Preparation of appropriate and easily understandable tender documents. • Preparation of flexible construction plan.

CHAPTER 4

WATER SUPPLY PLAN FOR GREATER SFAX

CHAPTER 4 WATER SUPPLY PLAN FOR GREATER SFAX

Water consumed in the Greater Sfax is mainly transmitted from the North Water Transmission System and the Jelma-Sbeitla groundwater transmission system. The Greater Sfax does not have its own local water sources. In addition, since the Greater Sfax is located in the lowermost portion of the North Water Transmission System, water supply is dependent on water consumption in seven governorates upstream of the North Water Transmission System. This situation makes it necessary to evaluate water demand and supply starting with the North Water Transmission System, then the Sfax Governorate, and finally with the Greater Sfax. This chapter presents the water supply plan for the Greater Sfax using this order. Outline of the locations of those governorates is shown in the Figure 4.1-1.

Source: SONEDE

Figure 4.1-1 Location of Seven Governorates in North Water Transmission System and Greater Sfax

In this Chapter, present status of water supply for domestic use, agricultural use and industrial use in the Sfax Governorate was discussed, and the balance of water supply and demand in the Greater Sfax was examined. Regarding water demand projection, water supply and demand in seven governorates relating to the North Water Transmission system and Jelma-Sbeitla was examined at first. Then, those in the Sfax Governorate and the Greater Sfax were further studied. Based on the results of examination, required capacity of the desalination plant was considered.

4.1 Current Status and Future Plan of Water Sector

4.1.1 Current Status of Water Sector

SONEDE is in charge of water supply in urban areas and large rural centres in the Sfax Governorate, while DGGREE of the MOA is in charge of medium and small water supply systems. The population and the population served data in the Sfax Governorate from 2006 to 2012 are shown in Table 4.1-1.

Table 4.1-1 Administrative and Served Populations in Sfax Governorate

unit: 1,000m^3/year

Item	Year	2006	2007	2008	2009	2010	2011	2012
	Total Population	887.9	900.0	911.3	923.8	936.7	938.7	963.1
Urban	Population	570.0	578.9	586.5	595.6	605.0	613.8	624.2
	SONEDE Covered Pop.	570.0	578.9	586.5	595.6	605.0	613.8	624.2
	Covered Rate	100%	100%	100%	100%	100%	100%	100%
Rural	Population	317.9	321.1	324.8	328.2	331.7	334.9	338.9
	SONEDE Covered Pop.	179.2	183.8	188.6	192.3	194.4	197.6	199.9
	DGGR Covered Pop.	131.6	134.4	134.6	118.0	119.4	119.1	120.6
	Covered Rate	97.8%	99.1%	99.5%	94.5%	94.6%	94.6%	94.6%
Covered Rate in Sfax Governorate		99.2%	99.7%	99.8%	98.1%	98.1%	98.1%	98.1%

Source: SONEDE Annual Report

The annual water supplies (consumption) in the Sfax Governorate from SONEDE are shown in Table 4.1-2.

Table 4.1-2 Annual Water Supply in Sfax Governorate (Consumption)

unit: 1,000m^3/year

Item	Year	2006	2007	2008	2009	2010	2011	2012
House Hold Water	Connection Supply	23,037	24,064	26,164	26,388	28,093	29,138	31,440
	Communal Tap	1,364	1,560	2,116	1,965	3,072	2.396	2,862
	Total	24,401	25,624	28,280	28,353	31,165	31,534	34,302
Public Office & Commercial		3,186	3,278	3,257	3,307	3,428	3.464	3,648
Industrial		2,784	2,817	2,921	2,786	2,963	2,826	3,441
Tourism		191	199	209	205	189	173	182
Others		229	246	188	136	138	177	97
Total		30,791	32,164	34,855	34,787	37,883	38,174	41,670

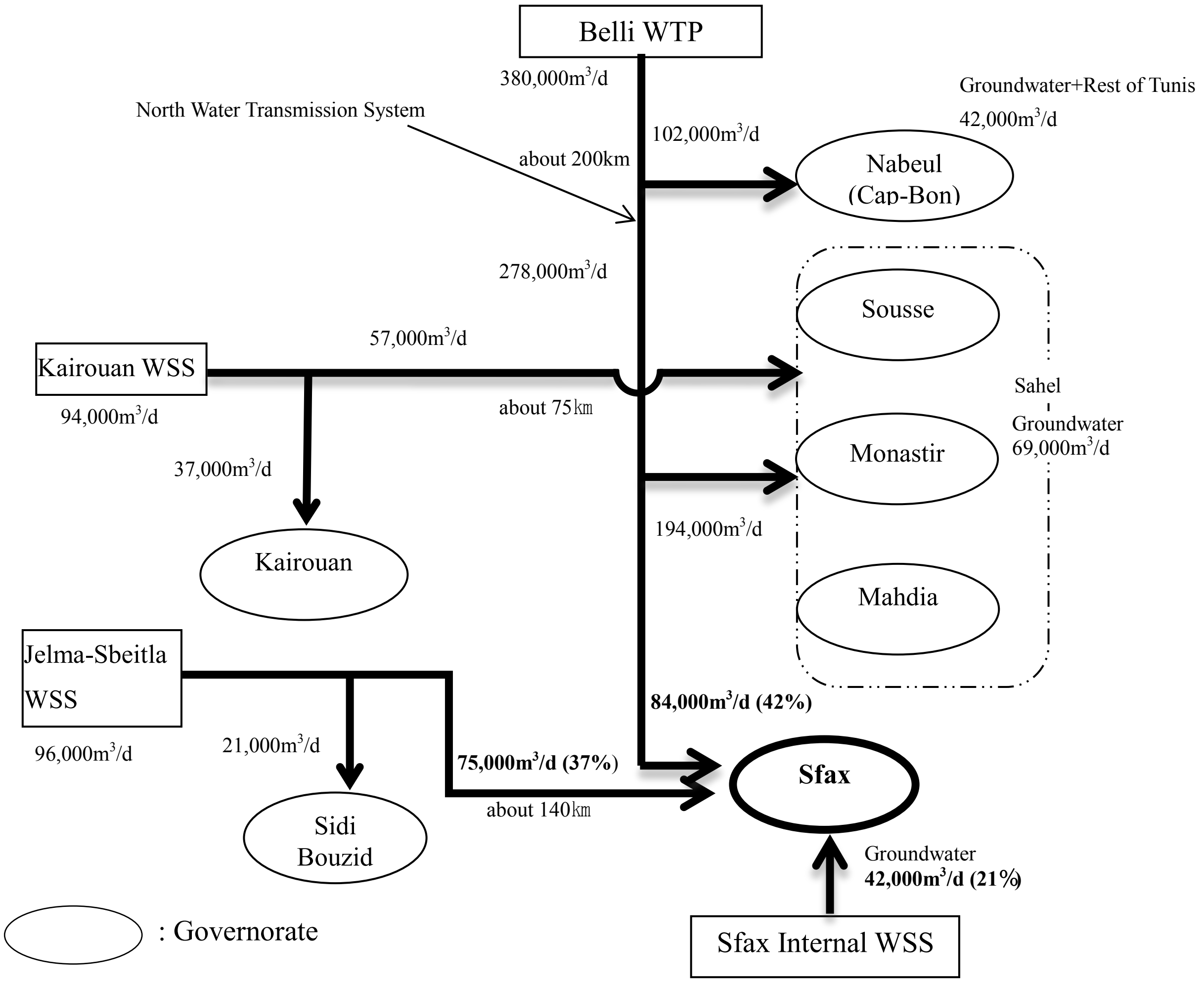
Source: SONEDE Annual Report

The usage-wise rates of SONEDE water supply in 2012 are as follows; Household; 82.3%, Administration and Commercial; 8.8%, Industrial; 8.3%, Tourism; 0.4%, Others; 0.2%. Regarding the water supply for industries, the figures are only for SONEDE's subscribers and relatively large-scale consumers such as factories which have their own private wells and to obtain required water supply. With the growth of population and industrial expansion, the water demand is also increasing. SONEDE's responsibility is to ensure continuous water supply services to their growing customer bases.

4.1.2 Water Resources for Water Supply in Sfax

(1) Outline of Water Resources

Water resources for the water supply in the Sfax Governorate are from the North Water Transmission System, the Jelma-Sbeitla Groundwater Transmission System from Sidi Bouzid Governorate and Sfax's own groundwater supply. Figure 4.1-2 shows a schematic diagram of the water resources for the water supply in the Sfax Governorate. Total available water supply volume at peak period in 2013 was 201,000 m^3/day and ratios by each water source are 42%, 37%, and 21% respectively.



Source: JICA Survey Team
Note: Water flow rate is estimated at the peak in 2013.

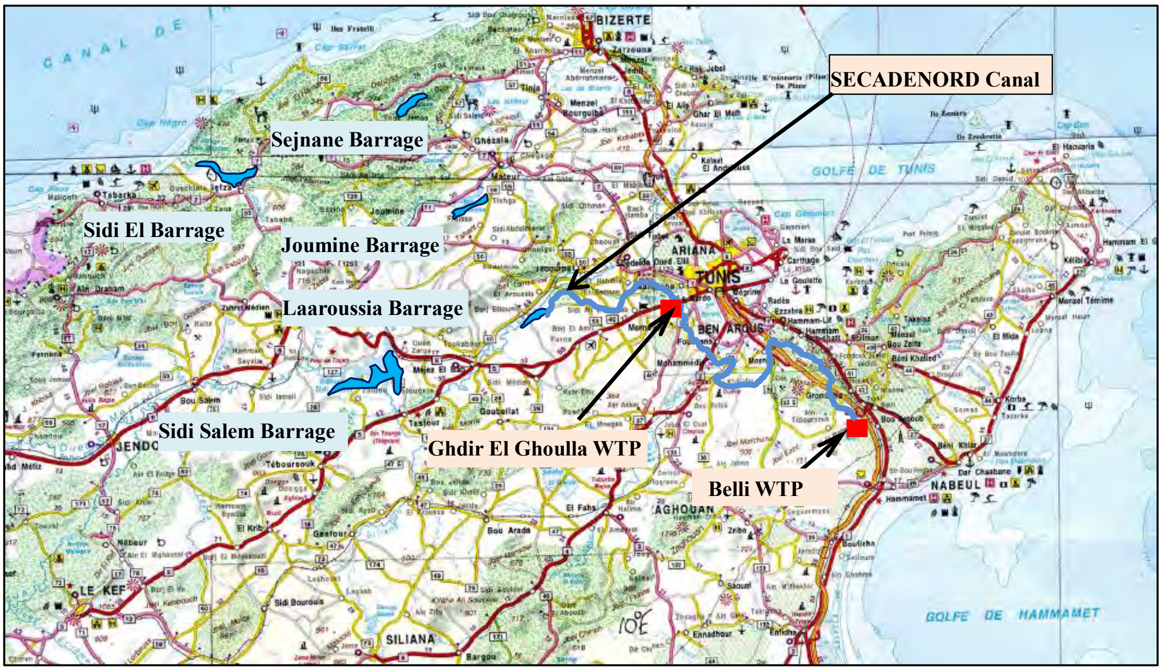
Figure 4.1-2 Schematic Diagram of the Water Resources for Sfax Governorate

(2) North Water Transmission System

a) Water Sources for North Water Transmission System

The water supply system in the Sfax Governorate is one of the components of the wide area water supply system which supplies surface water from the northern Tunisia to the areas which require water. The North Water Transmission System supplies water to governorates of Nabeul, Sousse, Monastir, Mahdia and Sfax. The system also obtains the water from Kairouan where groundwater resources are located. This Kairouan system, however, is not connected with the North Water Transmission System.

The North Water Transmission System is a wide area water supply system with the water from the Belli Water Treatment Plant. Dams in the Majerda River Basin and other rivers supply water to the Belli Plant through the canal and conduits managed by SECADENORD (North Canal and Conduit Development Corporation, French: Société d'Exploitation du Canal et des Adductions des Eaux du Nord). Figure 4.1-3 shows locations of the canals and dams and SONEDE's water intakes for the Gedir El Golla Water Treatment Plant (WTP) and the Belli WTP.



Source: JICA Survey Team

Figure 4.1-3 SECADENORD Canal and SONEDE Water Treatment Plants for North Water Transmission System

SECADENORD, a public establishment possessing legal personality and financial autonomy, under the authority of the MOA, operates, manages, services and maintains the canal and pipelines used to transport water from the dams of Sidi Salem and others. SECADENORD, without obtaining any subsidiary from the ministry, sells water to SONEDE and CRDA, and gains profit from water sales.

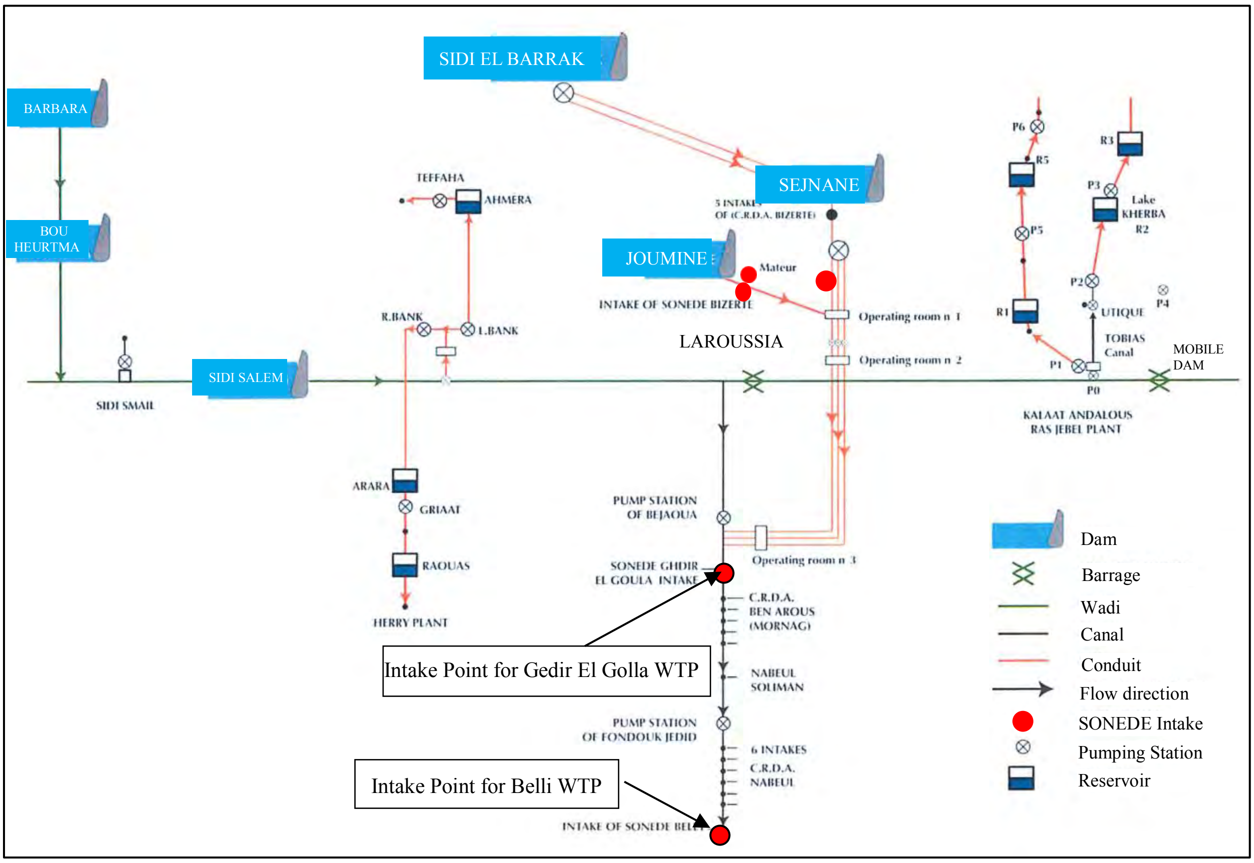
SONEDE made a contract with SECADENORD to purchase water. Current contract is effective for three years, from 01/04/2015 to 31/03/2018. The contents of the contract are as follows:

(i) Raw Water Intake Site (see Figure 4.1-4)

- Sejnane intake through Sejnane-Joumine pipeline for Matour WTP at the 34.750 km point

(March to June)[1]

- Joumine intake through the Joumine-Medjerdah pipeline for Matour WTP at the 4.430 km point (July to February)
- Two intakes of Gedir El Golla WTP through the canal at the 35.430 km point
- Belli WTP intake through the canal at the 120.165 km point



Source: SONEDE

Figure 4.1-4 Schematic Diagram of SECADENORD Canals and SONEDE Water Intakes

(ii) Water Flow to be Supplied

- From 01/04/2015 to 31/03/2016

  Min. Annual Volume = 250 million m^3, Max Annual Volume = 320 million m^3
- From 01/04/2016 to 31/03/2017

  Min. Annual Volume = 256 million m^3, Max Annual Volume = 325 million m^3
- From 01/04/2017 to 31/03/2018

  Min. Annual Volume = 262 million m^3, Max Annual Volume = 330 million m^3

(iii) Water Quality

- Maximum salinity shall be less than 1500mg/L
- Maximum turbidity shall be less than 2000NTU

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[1] The pipelines transmit water from Dams of Sidi El Barak, Sejnane, and Joumine to a suburb of Tunis and discharge it to the middle point of the canal. The Matour WTP supplies water to Matour located at western suburb of Tunis.

(iv) Price

- The price for 1 m^3 of water excluding the value-added tax is TND 0.04911 at water intake sites for Matour WTP and Gedir El Golla WTP
- The price for 1 m^3 of water excluding the value-added tax is TND 0.05161 at water intake site for Belli WTP

(v) Amount of Framework Deal

- The minimum amount of the deal corresponding to the first year is fixed at TND14,820,800 including value-added tax, and the maximum amount at TND18,912,686.

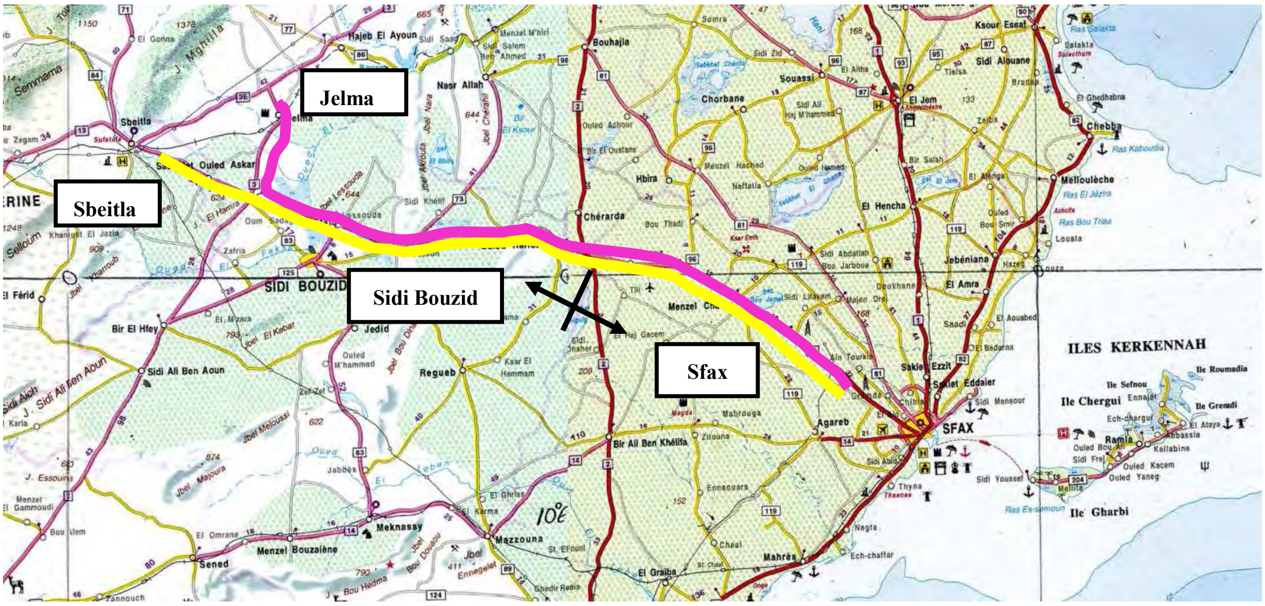
b) Water Treatment Plants for North Water Transmission System

In the North Water Transmission System, raw water is treated at the Gedir El Golla WTP and the Belli WTP, and the treated water is delivered to the service area.

The water treated at the Gedir El Golla WTP is delivered to the water supply system in Tunis and the Nabeul Governorate. The water treated at the Belli WTP is delivered to the water supply system in Nabeul and the southern areas through the North Water Transmission System. (Refer to Figure 4.2-2)

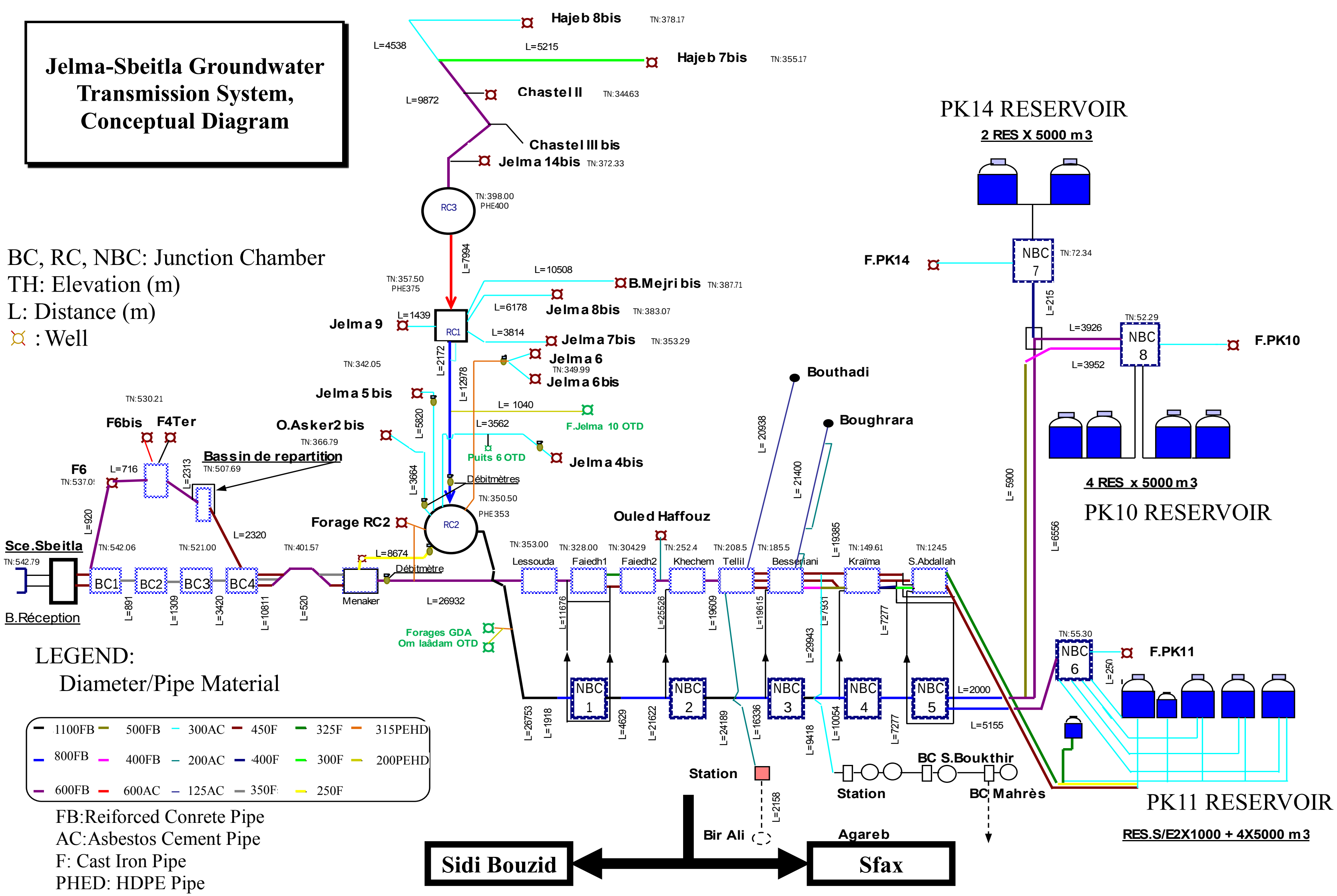
(3) Jelma-Sbeitla Groundwater Transmission System

The Sbeitla water resources area in the Kasserine Governorate and the Jelma water resources area in the Sidi Bouzid Governorate are located in the mountainous area spread from the western area of the Sfax Governorate to the state borderline. Both water resources produce groundwater of good quality. The water extracted from these two water resources is transferred to the Greater Sfax by water conveyance pipelines of about 140kms in length. Before arriving at the Greater Sfax, a part of the water is diverted to the rural areas. SONEDE operates and maintains the all water supply system such as the water intake facilities of those water resources, water conveyance pipelines, and facilities for water distribution.



Source: JICA Survey Team

Figure 4.1-5 Location Map of Jelma-Sbeitla Groundwater Transmission System



Source: SONEDE

Figure 4.1-6 Schematic Diagram of Jelma-Sbeitla Groundwater Transmission System

During the peak seasonal demand period in 2012, the Greater Sfax was beset with serious water shortage, which was considered a serious social problem. SONEDE received an exceptional government approval for the construction of new wells as one of measures to meet the peak seasonal demand. The approval came in the face of stringent regulations which banned any new construction of wells. In 2013 in Sidi Bouzid, three new wells were constructed and operations commenced soon after.

Table 4.1-3 New Wells in Sidi Bouzid Governorate

Name	Year	Designed Capacity (L/s)	Actual Operation (L/s)	Remarks
Garaat Hadid 2	2013	20	15	Operating Rate 75%
Garaat Hadid 3	2013	20	25	Operating Rate: 125%
Ouled Asker 2	2013	40	40	Operating Rate: 100%

Source: SONEDE

Operating Rate = Actual Operation / Designed Capacity. Overdraft at the operating rate more than 100%

Sidi Bouzid water supply system totally depends on its own groundwater. To control the increase of water demand in Sidi Bouzid, all new groundwater development within six areas in the governorate have been regulated since 1985. The pipeline route of the transmission includes the controlled area (Declaration et N 85-251 on 07/02/1985 Sidi Bouzid Governorate). Since the system started to deal increased water demand in Sidi Bouzid, operating status has been on overdraft.

Actual values of extractions from Jelma water resources in 2010 and Sbeitla water resource in 2009 are shown in Table 4.1-4.

Table 4.1-4 Actual Value of Extractions from Jelma and Sbeitla Water Resources

unit: million m^3/year

Jelma water resources in 2010	SONEDE	Industry	Irrigation	Total	Regulated Value	Extraction Rate
	22.0	-	9.0	31.0	27.8	111%
Sbeitla water resource in 2009	SONEDE	Industry	Irrigation	Total	Regulated Value	Extraction Rate
	9.15	0.13	6.82	16.1	13.5	119%

Source: SONEDE

(4) Sfax Groundwater Supply System

In addition to the main water resources for the Greater Sfax, i.e. the North Water Transmission System and the Jelma-Sbeitla Groundwater Transmission System, SONEDE extracts groundwater from 14 water resources in the Sfax Governorate during the peak seasonal demand period. The water resources where SONEDE maintains and operates wells in 2012 are shown in Table 4.1-5.

Table 4.1-5 Water Resources of Wells of SONEDE in Sfax Governorate (2012)

No	Name	Code	Location	Commenced Year	Water Level (m)	Extraction (L/s)	TDS (mg/L)	Depth (m)	Remarks
1	Ramla 1	5611	Kerkennah	1951	+24.1	6.25	3,500	702	Operating
2	Ramla 2	16693	Kerkennah	1979	+24.1	16.88	3,900	363	Operating
3	Wells in PK 11	18805	Sfax South	1978	-21.1	49.21	3,030	570	Operating
4	Wells in PK 10	19059	Sfax South	1982	-20.35	48.2	3,160	497	Operating

No	Name	Code	Location	Commenced Year	Water Level (m)	Extraction (L/s)	TDS (mg/L)	Depth (m)	Remarks
5	Wells in PK 14	19706	Sfax South	1990	-42.6	52.16	3,200	482	Operating
6	Sidi Salah	20729	Sakiet Zit	2000	-48	46.52	3,100	471	Operating
7	Aouabed	20740	Sfax South	2000	-33.75	51.74	3,100	500	Operating
8	Sidi Boukthir	21367	Agareb	2004	-104.8	23	4,000	700	Operating
9	Hancha	21365	Hancha	2003	-32.54	0	3,580	512	Not Operating
10	Bir Sidi Abdallah	21366	Sfax South	2003	-57.6	47.38	3,060	580	Operating
11	Ramla 4	21340	Kerkennah	2004	+19.00	25	3,620	370	Operating
12	Ouled Youssef	21518	Jebeniana	2006	-42.6	17	3,600	360	Operating
13	Ramla 5	21800	Kerkennah	2009	18.00	8.8	3,700	360	Operating
14	Bir Chabba	20397	Hancha	1998	-40.75	22	4,000	505	Operating

Source: CRDA Sfax 2012 Annual Report

The national water quality code in Tunisia, NT09.14:1983, permits salinity or TDS up to 2500 mg/L; however, TDS of the groundwater in the Governorate of Sfax is approximately 3500 mg/L which is higher than the regulated value. Accordingly, SONEDE mixes the water of Sfax with water from other sources in reservoirs prior to water distribution. SONEDE tries to keep the mixed TDS concentration less than the target quality, i.e. 2000 mg/L.

Faced with the water shortage in 2012, SONEDE constructed additional wells upon getting the government's special permits. The situation of the new well programs is as follows:

Table 4.1-6 New Well Programs in Sfax Governorate

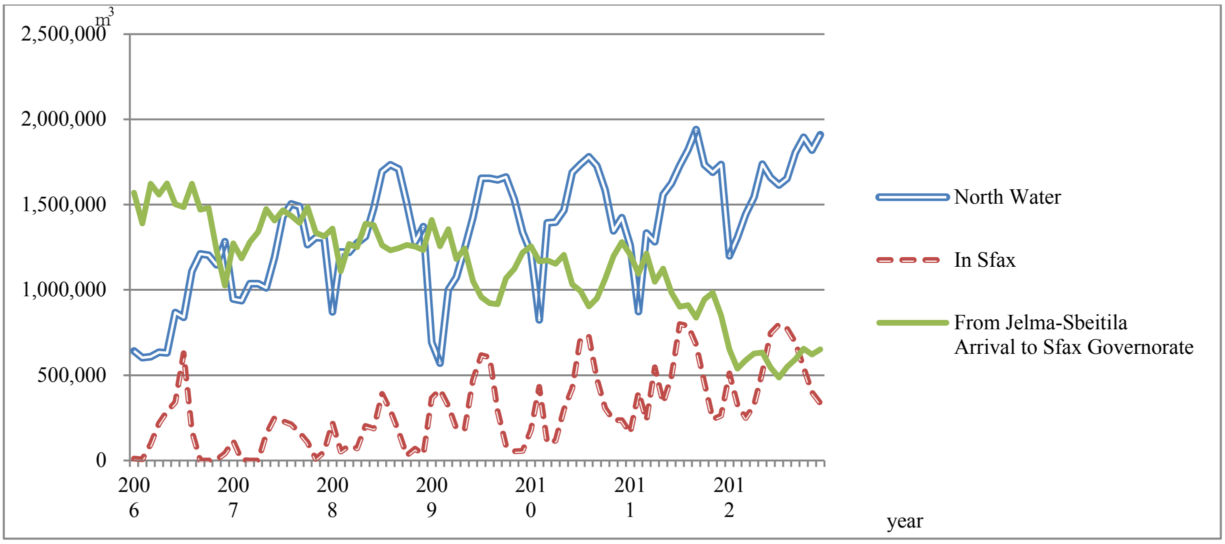
Name/Location	Year	Design Capacity (L/s)	Operation Capacity (L/s)	Operating Rate*
Mahrouga	2013	30	30	100%
PK 15	2013	40	50	125%
Agareb	2013	30	15	50%
Oued Batha	Under Construction	30	30	100%
Saint Louis	2013	20	20	100%
Bir Chooba	2013	20	20	100%
Hencha	2013	20	20	100%
Markez Kammoun	Scheduled in 2014	-	20	

Source: SONEDE

*: Operating Rate = Operation Capacity / Design Capacity. Overdraft at the operating rate more than 100%

(5) Issues on Water Resources in Sfax Governorate

Lacking its own water resources, the Sfax Governorate inevitably relies on water resources from outside of its jurisdiction, such as from the North Water Transmission System and the Jelma-Sbeitla Groundwater Transmission System.

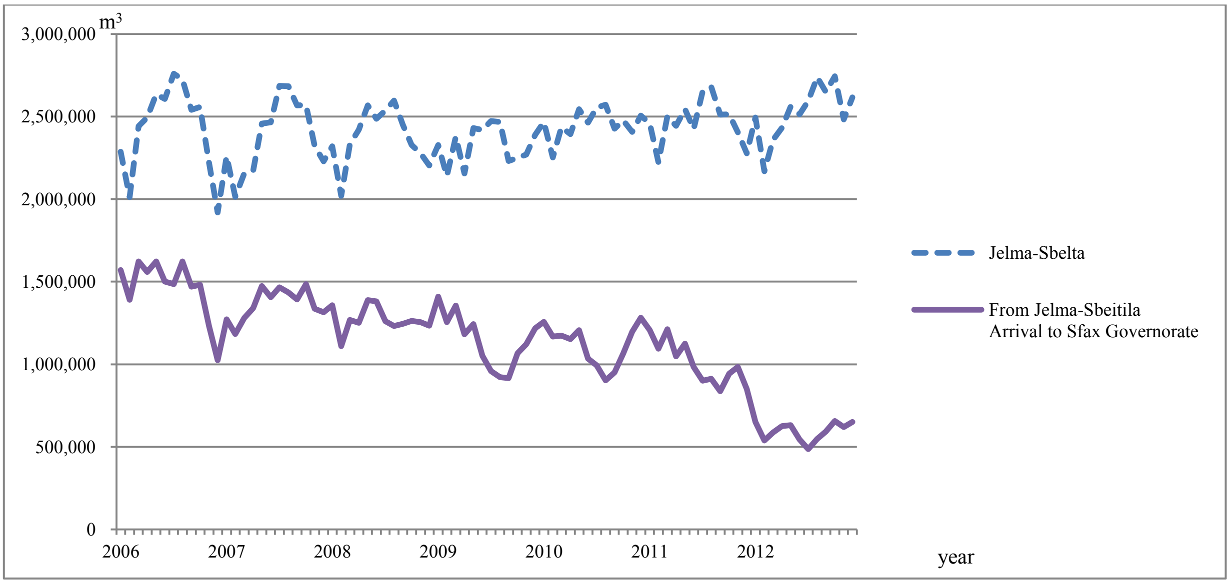


Source: SONEDE

Figure 4.1-7 Monthly Water from Three Water Resources to Sfax Governorate (2006~2012)

To continue having water from the North Water Transmission System, SONEDE renews its contract with SECADENORD every three years. For SONEDE, the security of its water resources greatly depends on how SECADENORD manages the water balance among water demands of SONEDE and other sectors.

Regarding the water from the Jelma-Sbeitla Groundwater Transmission System to the Sfax Governorate, water flow has been on a steady decline.



Source: SONEDE

Figure 4.1-8 Monthly Water from Jelma-Sbeitla Groundwater Transmission System to Sfax Governorate (2006~2012)

SONEDE has to determine how to delineate the limited water resources by taking into consideration the balance between the water demand in the groundwater origin area and the demand in the area where water is transmitted. Getting the agreement of all stakeholders is not easy, especially when it comes to filling in the gap between water demand and supply availability by increasing the extraction of the groundwater in the Sfax Governorate. The extraction of groundwater must still adhere to limitations set in terms of both time period and extraction volume.

4.1.3 Current Status and Future Plan of Water Sector for Agriculture and Industry

(1) Current Status of Water Sector for Agriculture

Annual rainfall in the Sfax Governorate is approximately 230mm. The "Wadi" has water only during times of heavy rain or simply an intermittent stream could be found. Therefore, the quantity of surface water for irrigation is very limited such that agriculture is dependent on groundwater. After installation of many wells, especially shallow wells, decline of groundwater levels had become a big issue in the Sfax Governorate. Currently well construction is restricted and permission from the MOA is required.

The Water Resources Department of CRDA Sfax Office is responsible for managing irrigation wells through the Water Conservation Section, the Agricultural Infrastructure Section, and the Irrigation Section.

Current status of the irrigation wells that CRDA Sfax Office operates and maintains is as follows.

1) Shallow Wells

Depth: 0 to 50m

Registered Number: 13,788

Salinity Concentration: TDS 2000to 6000mg/L (52% of them exceed 4000mg/L)

Current Status: The annual production capacity is estimated at 39.8 million m^3/year according to the MOA's survey result in 2003. Extraction of existing wells has already reached 53 million m^3, meaning that extraction is well over the limit of 136%. A new well installation work is restricted and periodically inspected by the Water Conservation Section, especially for the densely installed areas.

2) Mid-layer Wells

Depth: 70 to 200m

Registered Number: 125

Salinity Concentration: TDS 3000 to 4000 mg/L

Current Status: The aquifer was confirmed in recent studies and its capacity is approximately 11.3 million m^3/year. Mainly private farmers have constructed wells and CRDA is confirming the actual situation.

3) Deep Wells

Depth: 250 to 400m

Registered Number: Equipped Wells 28, Artesian Wells 9

Salinity Concentration: TDS 3000 to 4000 mg/L

Current Status: The entire production capacity in the Sfax Governorate is assumed to be

25.5 million m^3/year. SONEDE extract water from this aquifer. Relatively big firms also extract water using their own wells in the industrious area in Skihira.

Due to scarcity of rainfalls in the Sfax Governorate, agriculture is dependent on groundwater; however, shallow aquifers have been fully developed. Water from deep aquifers have been extracted by SONEDE and industrious users up to the regulated limit. There is also the need to clarify and acknowledge the issue of salinity. This requires not only water transmission from outside to Sfax, but also recommends the reuse treated wastewater for the agricultural sector within Sfax. The latter is an ambitious program that must also be clarified further.

(2) Current Status of Water Sector for Industry

In the Sfax Governorate, industrial water is supplied by SONEDE and private entities which have installed their own wells under authority permission.

1) Industry Water Supplied by SONEDE

Annual consumption of industrial water supply by SONEDE in the Sfax Governorate is as follows:

Table 4.1-7 Water for Industry supplied by SONEDE in Sfax Governorate

Year	2006	2007	2008	2009	2010	2011	2012
Annual Consumption in Sfax (1,000m^3/year)	2,784	2,817	2,921	1,942	2,113	1,999	2,471
Comparison with previous year	-	1.01	1.04	0.66	1.09	0.95	1.24

Source: SONEDE Annual Report

2) Industry Water Extracted by Private Entities

Annual consumption volumes of water by private industrial entities in the Sfax Governorate are as follows.

Table 4.1-8 Water for Industry extracted by Private Firms in Sfax Governorate

Year	2010	2011	2012
Annual Consumption in Sfax (1,000m^3/year)	12,690	11,760	8,460
Comparison with previous year	-	0.93	0.72

Source: CRDA Annual Report (2012)

The list of the registered wells in the Sfax Governorate that private industrial entities operate and maintain in 2012 is as follows.

Table 4.1-9 Registered Industrial Wells in Sfax Governorate (in 2012)

No	Name	Code	Location	Commenced Year	Water Level (m)	Extraction (L/s)	Salinity (mg/L)	Depth (m)	Remarks
1	NPK Well 4	19472	Sfax City	1987	+27.38	49	3,100	592	Not Operating
2	SFTB Well	19658	Menzel Chaker	1988	-120	9.5	2,900	332	Operating (12L/s)
3	British Gas	21743	Mahares	2007-2008	+1.04	18	3,500	539	Operating (18L/s)
4	SIAPE 15		Sfax South	2012	+12.8	39.72	3,390	560	Operating (37L/s)

No	Name	Code	Location	Commenced Year	Water Level (m)	Extraction (L/s)	Salinity (mg/L)	Depth (m)	Remarks
5	TRAPSA 7	19765	Skhira	1997	-6.79	40	8,000	240	Operating (8L/s)
6	SIAPE II 7	20671	Skhira	1999	-27.49	50	10,300	315	Operating (50L/s)
7	SEPT	21104	Skhira	2002	-10.53	5	9,260	263	Operating (16L/s)
8	SIAPE II 4	21105	Skhira	2003	-27.73	40	8,000	264	Operating (50L/s)
9	SIAPE 14	21342	Sfax South	2004	+15.60	55	3,460	555	Operating (35.3L/s)
10	TRAPSA 6	21521	Skhira	2004	-11.19	25	8,300	242	Operating (9L/s)
11	SIAPE II 1	21798	Skhira	2008	-24.65	40	8,100	260	Operating (57.66L/s)
12	TPAP Poulina	21702	Agareb	2008	-59	25	3,800	326	Operating (25L/s)
13	SIAPE II 5	21797	Skhira	2008	-22.35	40	9,600	270	Operating (57.77L/s)
14	SIAPE II 3	21794	Skhira	2008	-26.04	50	9.6	274	Operating (41.66L/s)
15	SIAPE II 7	20277	Skhira	1997	-16.2	68.5	11,500	327	Not Operating

Source: CRDA Annual Report (2012)

3) Issues on Water Supply for Industrial Use in Sfax Governorate

In the Sfax governorate, many private entities extract groundwater under expressed authority or permission. The extracted water volume is larger than the volume that SONEDE can supply. However, the total extraction of water for households, agriculture and industry has already exceeded the permissible volume. The limitation on water extraction has been prevents Sfax's industries from growing.

Accordingly, one of Tunisian national companies, Groupe Cheimique, located at Skhira has constructed a desalination plant to supply their own water requirements. The capacity of the plant is 12,000m^3/day and its operations commenced in 2013.

Groundwater consumption for industrial use decreased because of the influence of the revolution. It, however, is expected to increase in accordance with recovery of the industrial activities. Therefore, it is not practical to convert those water resources to domestic use, because an alternative water source will be necessary for said conversion. Such groundwater has high TDS concentration. Especially, those wells located near sea seem being suffered by sea water intrusion due to excessive pumping. Therefore, it is not appropriate to convert groundwater sources being used for industrial use to domestic use.

4.2 Development Plans of SONEDE

Current plans and studies for the water supply system in the Greater Sfax are shown in Table 4.2-1.

Table 4.2-1 Existing Plan and Studies for the Water Supply System in Greater Sfax

Plan or Study	year	Outline	Relationship to the Project
1) Plan of Distribution Networks and Distribution in Greater Sfax	March 2003	Development Plan of Distribution System of Greater Sfax Water Supply System	Distribution Plan
2) Feasibility Study on the Mid-South Area Water Supply Scheme	March 2005	Plan of Several Seawater Desalination Plants in Mid-South Area and Water Transmission Plan for Produced Water	Outlines of Seawater Desalination Plants
3) Study on Water Supply Network of Tourba-Agareb-Mahres-Skhira	January 2011	Water Distribution System Development Plan in the Area South of Greater Sfax	Demand-Supply Water Balance
4) Strategic Study	April 2013	Development Plan of Water Supply System in Greater Sfax urgent developed to cope with the draught in the summer 2012.	Outline of Sfax Seawater Desalination Plant, Water Demand

Source: SONEDE

Outlines of each plan and study are as follows:

(1) Plan of Distribution Networks and Distribution in Greater Sfax

Plan of Distribution Networks and Distribution in the Greater Sfax ("Etude du Plan Directeur des Réseaux de Répartition et de Distribution du Grand Sfax"), was conducted by SONEDE and its contracted engineering consortium of two Tunisian Consultants, SCET-TUNISI and BRL Engineering.

The main objective of the master plan was to propose the optimal plan for the service area of the Greater Sfax, i.e. Sfax, North Sfax and South Sfax. The study was conducted from 2001, and had four stages as follows:

i) Mission A: To collect information on existing facilities and their evaluations
ii) Mission B: To collect basic information on social-urban development and study future water demand
iii) Mission C: To examine alternatives for phased water distribution network augmentation plan
iv) Mission D: To select the optimal alternative and conduct detailed design for the programs of Phase 1

The capacities of the facilities were determined based on the target year of 2032. In addition, the detailed design of Phase 1 project was implemented for the facilities constructed until 2011. The following is the facilities constructed in Phase 1 and by 2032.

Facilities constructed in Phase 1:

- New construction of Sidi Issa High Altitude Zone Reservoir
- Augmentation of Sidi Salah Low Altitude Zone Reservoir
- Augmentation of existing main distribution pipes
- Augmentation of Bou Merra Reservoir

Facilities constructed until 2032:

- Augmentation of Sidi Salah Low Altitude Zone Reservoir
- Augmentation of the transfer pipe from Mahrouga Pressure Regulation Chamber to Sidi Salah Low Altitude Zone Reservoir
- Transmission Pipe up to PK11 Reservoir

- Augmentation of Bou Merra Reservoir

Although the project has been delayed due to financial issues, it is still being implemented following to the plan. In fact a part of the plan, Sidi Salah Low Reservoir and the distribution network has been constructed by Local Cities Water Supply Network Improvement Project under the JICA ODA loan project.

(2) Feasibility Study on the Mid-South Area Water Supply Scheme

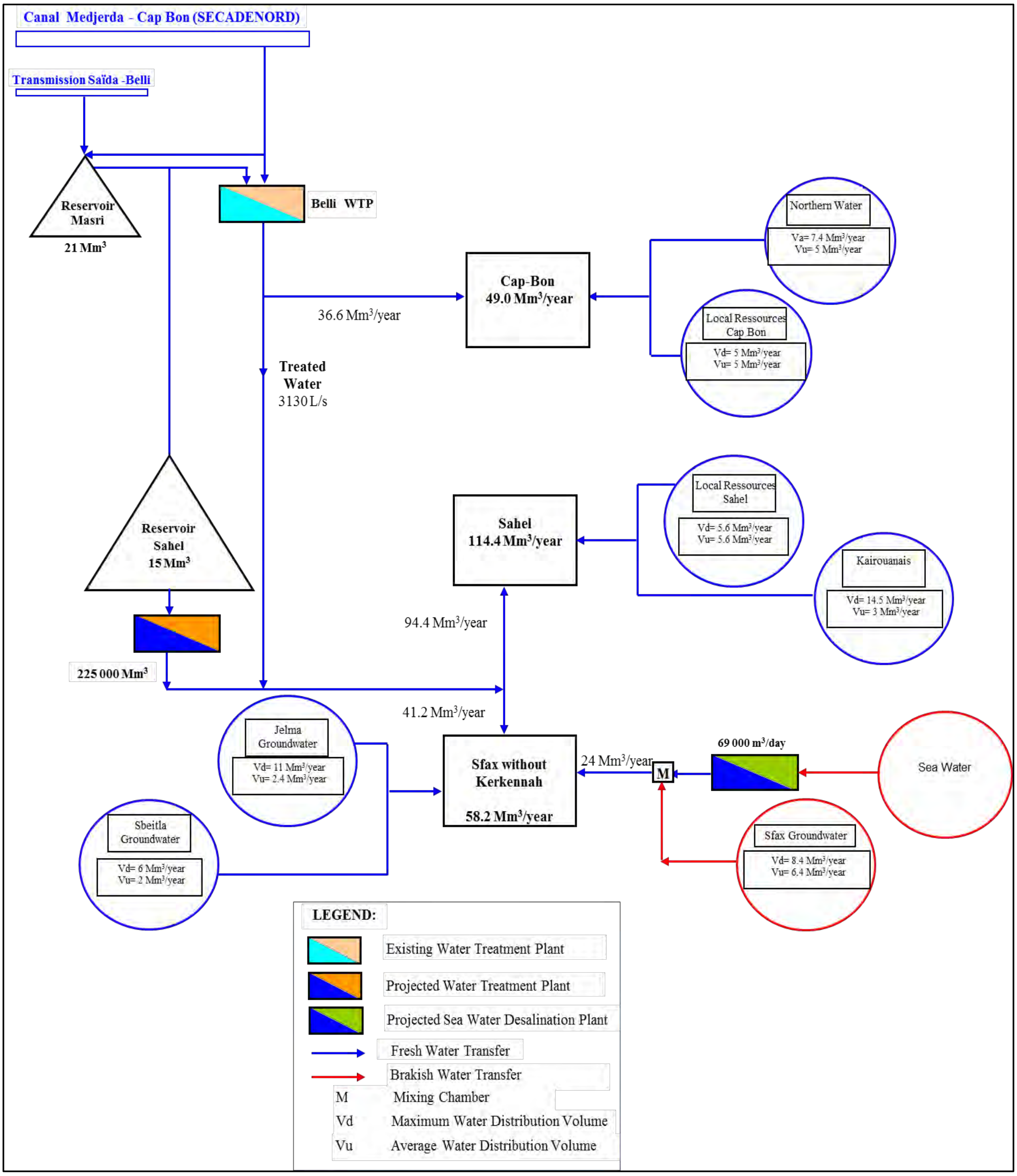
The Feasibility Study on the Mid-South Area Water Supply Scheme ("L'étude de faisabilité du projet d'alimentation en eau potable jusqu'à l'horizon 2030 du Cap-Bon, Sahel, Sfax, Gabès, Médenine et Tataouine) was conducted, utilizing Japanese fund to the World Bank, SONEDE contracted the study with an engineering consortium consisting of a French Consultant, SOGREAH and two Tunisian Consultants, STUDI and IDEACONSULT.

The main objective of the feasibility study was to propose the optimal plan for the supply area of Cap-Bon (Nabeul Governorate), Sahel (Sousse, Monastir and Mahdia), Sfax, Gabes, Medenine and Tataouine, and it was conducted from 2003with three stages as follows:

i) Mission 1: To meet the increasing water demand especially in Sahel region at the seasonal peak demand period up to 2025 a reservoir for potable water was examined. The capacity of the reservoir was 8 million m^3 for 15 days peak demand.
ii) Mission 2: An investigation about the balance between future water demand and water resources was conducted and based on the result eight options were proposed and in terms of water production method two solutions where offered. In the context of discussion, the Engineering Consulting Committee proposed to extend the target year from 2025 to 2030.
iii) Mission 3: Based on the result of technological, environmental and economic-financial assessment, the optimal plan for water supply system in the study area, 2nd Option-Solution 2, was selected

The general contents of the most optimal plan for water supply system in the study area, 2nd Option-Solution 2, are as follows (see Figure 4.2-1 as an extract of conceptual schematic relating to the Greater Sfax):

i) Water for Cap-Bon and Sahel will be transmitted from North Water Transmission System and in Sfax Governorate a new seawater desalination plant will be introduced.
ii) In Gabes to fill the gap between water demand and its existing water resources, a new brine water desalination plant and a seawater desalination plant will be installed.
iii) In Medenine and Tataouine in addition to the existing brine water desalination plants new brine water desalination plant will be installed in Djerba Island.



Source: SONEDE

Figure 4.2-1 Optimal Plan, 2nd Option-Solution 2（F/S Report Mission 2: SOLUTION 2V2）

The Draft Final Report of the Study was discussed in the Engineering Consulting Committee and the Committee permitted the finalization of the report with these comments. In accordance with the permission granted by the Engineering Consulting Committee, the implementation of the plan was authorized together with the proposed schemes.

The Engineering Consulting Committee had been organized with the following members.

- SONEDE General Director
- General Directorate, DGRE, Ministry of Agriculture and Environment (then)
- General Directorate, DGBGTH, Ministry of Agriculture and Environment (then)
- DGRE, Ministry of Agriculture and Environment (then)
- DGGREE, Ministry of Agriculture and Environment (then)
- SECADENORD
- Ministry of Scientific Research and Promotion of Competences (then)
- Ministry of Investment and International Cooperation (then)
- Ministry of Industry, Energy and Small and Middle Enterprises (then)

Based on the study results, the schemes for the Sfax Governorate planned as national projects are as follows:

- In the Sfax Governorate, the annual water demand in 2030 was assumed to be 58.2 million m^3. To meet this demand the water from the North Water Transmission System for Wide Area was planned as 29.8 million m^3, the water from Jelma-Sbeitla Groundwater Transmission System as 4.4 million m^3, the water from Sfax Groundwater Supply System as 6.4 million m^3, and the water from newly constructed seawater desalination plant as 17.6 million m^3.
- The raw water reservoir in Sahel was planned to be 15 million m^3 to meet the seasonal peak demand in 2030 (This was determined in the Mission 2 discussion).
- The capacity of the new seawater desalination plant is planned to be 69,000m^3/day.
- Based on the study result, SONEDE further took into consideration the changing of circumstances from the time of the study, i.e. 2005, to the present, and called for flexibility in the implementation of the programs.

As stated above, the capacity of the Sfax Seawater desalination Plant was planned as 69,000m^3/day in this study. However, it was considered to be revised because of water shortage issue occurred in 2012. Consequently, the Strategic Study shown in item (4) below was established.

(3) Study on Water Supply Network of Tourba-Agareb-Mahres-Skhira

Study on Water Supply Network of Tourba-Agareb-Mahres-Skhira ("Etude du réseau d'adduction Tourba - Agareb - Mahrès – Skhira") was conducted by SONEDE and its contracted Tunisian consultant, BICHE.

The main objective of the study was to propose urgent measures for increasing water demand in the southern area of the Sfax Governorate, Tourba - Agareb - Mahrès – Skhira, including how to transmit the water from the Jelma-Sbeitla Groundwater Transmission System. However, with the issue on water scarcity as experienced in 2012, the organization of planned programs to deal with and properly manage actual emergency situation needs further discussions.

(4) Strategic Study

As stated in above item "(2) Feasibility Study on the Mid-South Area Water Supply Scheme", development of a Seawater Desalination Plant in the Sfax Governorate was confirmed as the national project. Its urgent implementation became necessary because of water shortage in southern Tunisia including the Sfax Governorate at the seasonal peak demand period in 2012. In order to implement the project, SONEDE formulated the Strategic Study ("ETUDE STRATEGIQUE") and laid out plans and programs that should be implemented up to 2030.

In the study, future water demand was evaluated based on not collected basic planning data such as population, industry, tourism but statistic assessments of past actual water consumption.

The study area covers governorates being supplied of water from the North Water Transmission System; namely, Cap-Bon (Nabeul Governorate), Sahel (Sousse, Monastir and Mahdia), Kairouan, Sfax, and Sidi Bouzid; the origin of Jelma-Sbeitla Groundwater Transmission System. Water supply facilities to be constructed were examined to meet the water demand in the study area.

In addition to the desalination plant in Sfax, water transfer schemes consisting of two water reservoirs; Saida reservoir in the west area of Tunis and the other reservoir in Sahel (Kalaa Kebira) with its treatment plant were also planned. The outline of this scheme is to transmit water from Saida reservoir to Kalaa Kebira reservoir, and from Kalaa Kebira treatment plant, water of 4 m^3/second or 345,600 m^3/day will be supplied to the Sahel area and the Sfax Governorate through the North Water Transmission System during the summer water demand peak season.

Major component of planned facilities are as follows (see Figure 4.2-2):

- Saida reservoir: about 45 million m^3
- Transmission pipeline from Majerda river to Saida Reservoir: Pump Stations 3, Pipeline 13km, Reservoir 5000m^3
- Canal from Saida Reservoir to Belli Treatment Plant: 60km, Pump Stations 2
- Sahel (Kalaa Kebira) Reservoir: 28 million m^3
- Sahel (Kalaa Kebira) Treatment Plant: 4 m^3/sec.
- Sfax Seawater Desalination Plant: 200,000 m^3/day

Table 4.2-2 shows treatment plant and desalination plant planned in the Strategic Study.

Table 4.2-2 Treatment Plant and Desalination Plant planned in the Strategic Study

Name	Operation year	Capacity	Water supply to Greater Sfax (maximum)
Saida Reservoir, and Kalaa Kebira Reservoir and Treatment Plant	2019	4,000L/sec. (345,600m^3/day)	-
Seawater Desalination Plant in Greater Sfax	2018	1,157 L/sec. (100,000m^3/day)	1,157 L/sec. (100,000m^3/day)
	2028	2,325 L/sec. (200,000m^3/day)	2,325 L/sec. (200,000m^3/day)

Based on the results of this study, the Tunisian Government requested the Japanese Government to extend the Japanese ODA loan for the project of seawater desalination plant of 200,000m^3/day in Sfax to be constructed by 2018.

出典：ETUDE STRATEGIQUE, SONEDE

Figure 4.2-2 Location of Planned Facilities in the Strategic Study

4.3 Appropriateness of Seawater as Water Source

In the Strategic Study, a plan for seawater desalination facility was added. In this section, the appropriateness of seawater as water source is reviewed.

Existing water sources are surface and groundwater, but these have already been used up according to a study by the MOA. Groundwater is strictly regulated in terms of increasing extraction flow and the new construction of wells to conserve the water resources. The details of groundwater extraction are presented in Table 4.3-1.

Table 4.3-1 Extraction Volume of Groundwater in Sfax and Jelma-Sbeitla

(unit: million m^3/year)

Location	Year	Domestic use	Industrial use	Agricultural use	Total	Limit of extraction	Margin of extraction
Sfax Governorate	2010	5.6	12.7	7.6	25.9	25.5	▲0.4
	2011	6.3	11.8	8.7	26.8	25.5	▲1.3
	2012	8.8	8.5	6.6	23.9	25.5	1.6
Jelma water sources	2010	22.0	-	9.0	31.0	27.8	▲3.2
Sbeitla water sources	2009	9.2	0.1	6.8	16.1	13.5	▲2.6

Note: The extraction for industrial use was decreased largely in 2011 and 2012 due to the revolution.
Source: JICA Survey Team

As shown in Table 4.3-1, the groundwater extraction exceeded the limit or is close to the limit. It is obvious that an increase of groundwater extraction is not possible. Besides groundwater, the new water resources mentioned below could be considered for an increase in water supply.

1) Utilization of water for agricultural use
2) Utilization of treated water from wastewater treatment plant
3) Utilization of excess water for agricultural use obtained by utilization of treated water at wastewater treatment plant to the agriculture
4) Increase of Effective water by reduction of Leakage

Said four types of the approaches, however, are not practical from the reasons mentioned as follows:

1) Utilization of water for agricultural use
In 2012, MOA gave the permission to SONEDE for utilizing water for agricultural use at 600 million m^3/year. This availability, however, is limited to agricultural off-season. Therefore, the water cannot be utilized for the entire year. In addition, the farmers protest this permission, and claim strongly for a decrease of providing water to the MOA. Therefore, it is not a practical idea to increase the water transfer volume from the agricultural use to SONEDE.

2) Utilization of treated water from wastewater treatment plant
Treated effluent from wastewater treatment plant utilised for orchards due to water shortage is believed dirty or contaminated. In addition, it is also thought that the land irrigated by the treated effluent is be dirty or contaminated. Considering such situation, utilization of the treated water as raw water of

SONEDE’s water supply system is not possible.

3) Utilization of excess water for agricultural use obtained by using treated water from wastewater treatment plant to agricultural use

Actually, the treated effluent from wastewater treatment plant has been utilized for agriculture as substitute. The treated effluent, however, has limited use because of high salinity concentration and high operation cost for transmission of the water by pumps. With this condition, a utilization ratio of the treated water at Sfax South Wastewater Treatment Plant decreased from 36% in 2007 to 14% in 2011. Therefore, it will be difficult to expect an increased utilization ratio of the treated effluent for agricultural use.

Therefore, it is not practical idea to shift the water presently used for agriculture to SONEDE’s water resource.

4) Increase of Effective Water by Reduction of Leakage

According to the SONEDE’s record, the ratio of Non-Revenue Water of the water supply system in the Greater Sfax already reached 16% in 2013 (see Table 4.6-1). Taking account of cost effectiveness and required period for obtaining satisfactory result, it is not practical as a measure for increase of effective water for urgent needs.

Consideration all the arguments, the most practical approach to augment water source in the Greater Sfax is to utilize and desalinate for increasing water supply.

4.4 Water Demand and Supply in North Water Transmission System

4.4.1 Water Demand in North Water Transmission System

SONEDE formulated the "Feasibility Study on the Mid-South Area Water Supply Scheme" in 2005 in which the target year was 2030. As the countermeasure against severe water shortage which occurred in 2012, the "Strategic Study" was formulated in 2013. The Strategic Study, however, was not prepared with spending a couple years because the Feasibility Study was formulated, and the formulated plan was requested to be implemented urgently. The future water demand was estimated by a statistical analysis on the past water supply data in seven governorates such as Cap-Bon (Nabeul Governorate), Sahel (Sousse, Monastir and Mahdia), Kairouan, Sfax, and Sidi Bouzid, on the following detailed assumptions:

1) Based on the consumption data in the seven governorates for 10 years, from 2001 to 2010, average water demand growth rates of each governorate were calculated based on actual consumption data from 2001 to 2010.
2) Average water demand growth rates of each governorate from 2011 to 2020 were calculated by increasing the average water demand growth rates from 2001 to 2010. The increased rate of the average water demand varies from 0.3% to 1.1% and SONEDE determined each figure as per assumed weight of each area.
3) Water demand growth rates from 2021 to 2030 was assumed to decline somehow, for this reason,

the average increase rates from 2021 to 2030 decrease by 0.5% from the ones from 2011 to 2020.

4) Daily peak factor for each governorate was determined based on the actual data in 2010 and for Sfax it is 1.4.
5) Performance factor was assumed for each governorate and for Sfax it will gradually improve from 76% to 80% from 2010 to 2030.
6) Based on the above-mentioned assumptions the calculated water demands for 2010 are different from actual water demands in 2010. The difference comes from the accuracies of the assumptions and that in reality, the peak flows do not occur simultaneously. Thus the results for all governorates except for three governorates in Sahel were adjusted using multiplier 0.89. The adjustment takes into consideration the socio-economic importance of Sahel from SONEDE's viewpoint.

In this survey, water demand was reviewed based on the method applied in the Strategic Study with revision by following adjustment parameters. Then, appropriateness of results was examined by consideration of calculated per capita consumption.

1) Increase rate in demand

SONEDE assumed the average water demand growth for each governorate from 2011 to 2020 by increasing the average growth rate for each governorate from 2001 to 2010. For example, in case the average rate from 2001 to 2010 is 3.0% per year during the 10 years and the growth rate exceeds 3.5% five times, then the annual increase rate from 2011 to 2020 is assumed to be 3.5%. After that from 2021 to 2030 the annual growth rate goes back to 3.0%. This planning justification, in the first decade taking upper value and in the second decade taking the average value, is not based on a rationale reason. Therefore, clarifying future demand should be forecasted based on the previous actual consumption, the assumption is that the annual growth rate of water demand for each governorate is equal to the calculated average rate, so this rate should be constant.

2) Regional factor

In the Strategic Study, to fill the gap between the actual measured figure and the estimate, the adjustment factor 0.89 was applied. SONEDE applied this adjustment rate to four governorates except three governorates in the Sahel region. This arrangement is based on the importance of Sahel's tourism peak during the summer season. Meanwhile the regional gravities have already been taken care of in the past water consumption data. Therefore in the calculation for the study report a common factor 0.944[2] for the entire area is adopted.

3) Peak factor

The peak demand generally does not occur at the same time. According to this assumption, the peak factor is applied to the entire Governorate with the uniform value of 0.95.

4) Target Year

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[2] The calculated result in 2010 is 8,251 L/s, the actual production in 2010 is 7,893 L/s; therefore, the adjustment rate is 7,893/8,251 = 0.944.

SONEDE set 2030 as the target year of the plan in the Strategic Survey. In this survey, the target year was changed to 2035 because said year of 2030 is 15 years after present time, and it seems to be too short for planning final facilities in the future.

Comparison of SONEDE's projection method in the Strategic Study and revisions in this survey are summarized in Table 4.4-1.

Table 4.4-1 Comparison of SONEDE's Projection Method in the Strategic Study and Revisions

Item	Projection Method in Strategic Study	Revisions in this Survey
1. Average increase rate of water consumption by governorate	Calculated based on 10 years records from 2001 to 2010 by governorates	No revision
2. Increase Rate for the period between 2011and 2020.	Increase of the recorded rates by 0.3% to 1.1%, considering regional importance.	Apply the average rates calculated for the period between 2001 and 2010.
3. Increase Rate for the period between 2021and 2030.	Decrease of increase rate from those applied for 2011 to 2020 by 0.5% considering decrease of population increase.	Same as above. Target year was extended to 2035.
4. Peak Factor	Applied based on the actual record of each governorate. In Sfax Governorate, it is 1.4.	No revision
5. Revenue Water rate	Assumed based on the actual record by governorate considering improvement in future. It is assumed to be improved from 76% in 2010 to 80% in 2030in Sfax Governorate.	No revision[3]。
6. Adjustment Factor	To adjust the calculated volume, the regional adjustment factor of 0.89 derived from actual record and assumed volume in 2010 was applied to 4 governorates except 3 governorates in Sahel area.	Regional adjustment factor of 0.944 is applied to all governorates. Further, Peak adjustment factor of 0.95 was introduced considering peak consumption would not occur in all regions at same time. It is not applied for calculation of distribution volume within sole governorate.

Projection method applied in this Survey is as follows:

1) Calculate average annual increase rate of water consumption by governorate base on the record from 2001 to 2010 (Table 4.4-2)
2) Calculate average water consumption by governorate based on the assumed average annual increase rate (Table 4.4-2)
3) Calculate ratio of own water resource by governorate based on the water consumption of own water source (Table 4.4-3)

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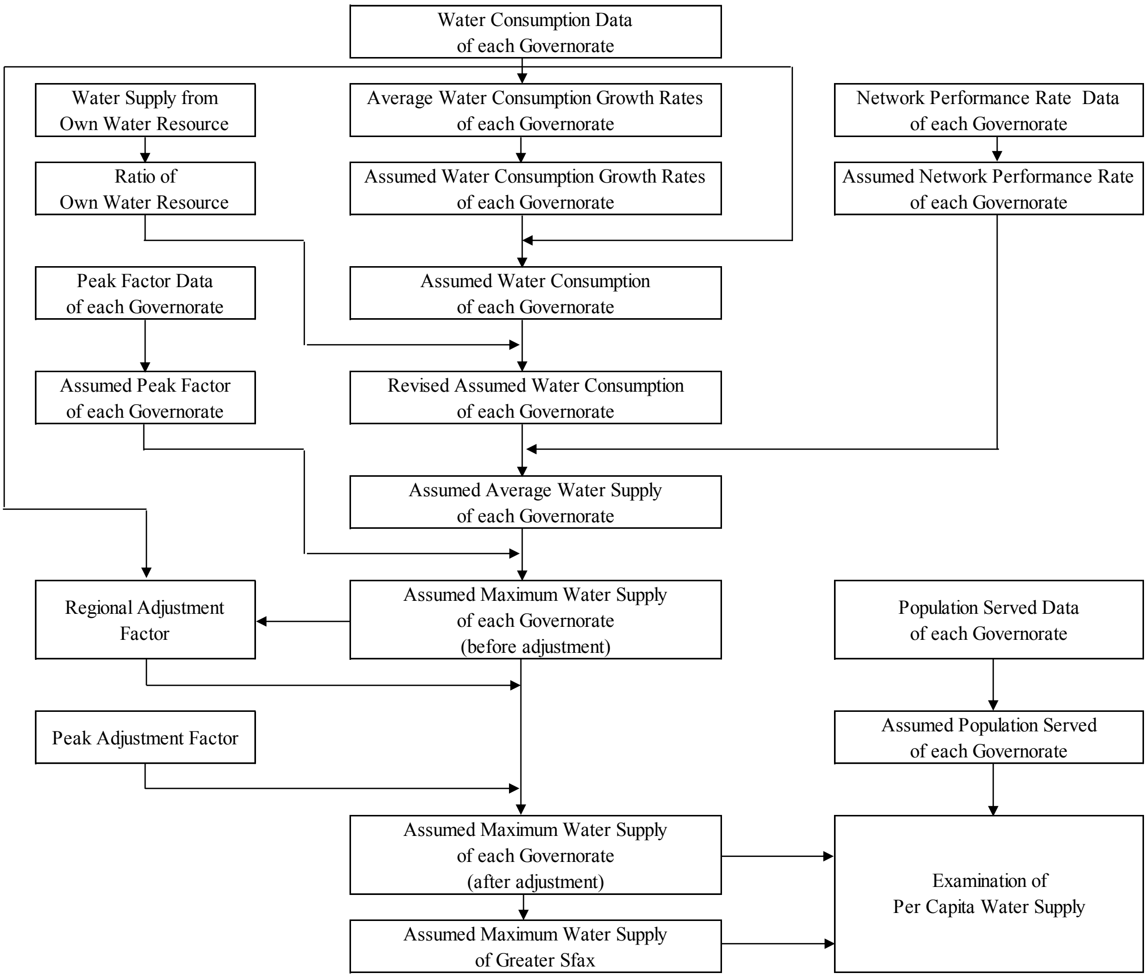
[3] According to SONEDE's Operation Department Sfax Branch Office, the network performance rate in the Greater Sfax was 87.6% at the highest in 2012, and 79.4% at the lowest in 2005 during the period from 2002 to 2013. That of the Sfax Governorate was assumed to be lower than that of the Greater Sfax.

4) Calculate adjusted water consumption by governorate based on the average water consumption by governorate and the ratio of own water resource by governorate (Table 4.4-4)
5) Calculate network performance rate by each governorate based on the record from 2001to 2010 (Table 4.4-5)
6) Calculate average water consumption by government based on the adjusted water consumption by governorate and the network performance rate by each governorate (Table 4.4-6)
7) Calculate peak factor by governorate based on the record (Table 4.4-7)
8) Calculate regional adjustment factor based on the water consumption record in 2010 and the calculated water consumption for 2010 (Table 4.4-7)
9) Calculate maximum water demand by governorate based on the regional adjustment factor and the peak factor by governorate (Table 4.4-8)
10) Project population served by governorate based on the records (Table 4.4-9)
11) Calculate and examine per capita water consumption based on the maximum water demand and projected population served

The flow diagram of projection of the survey stated above is as shown in Figure 4.4-1 below:

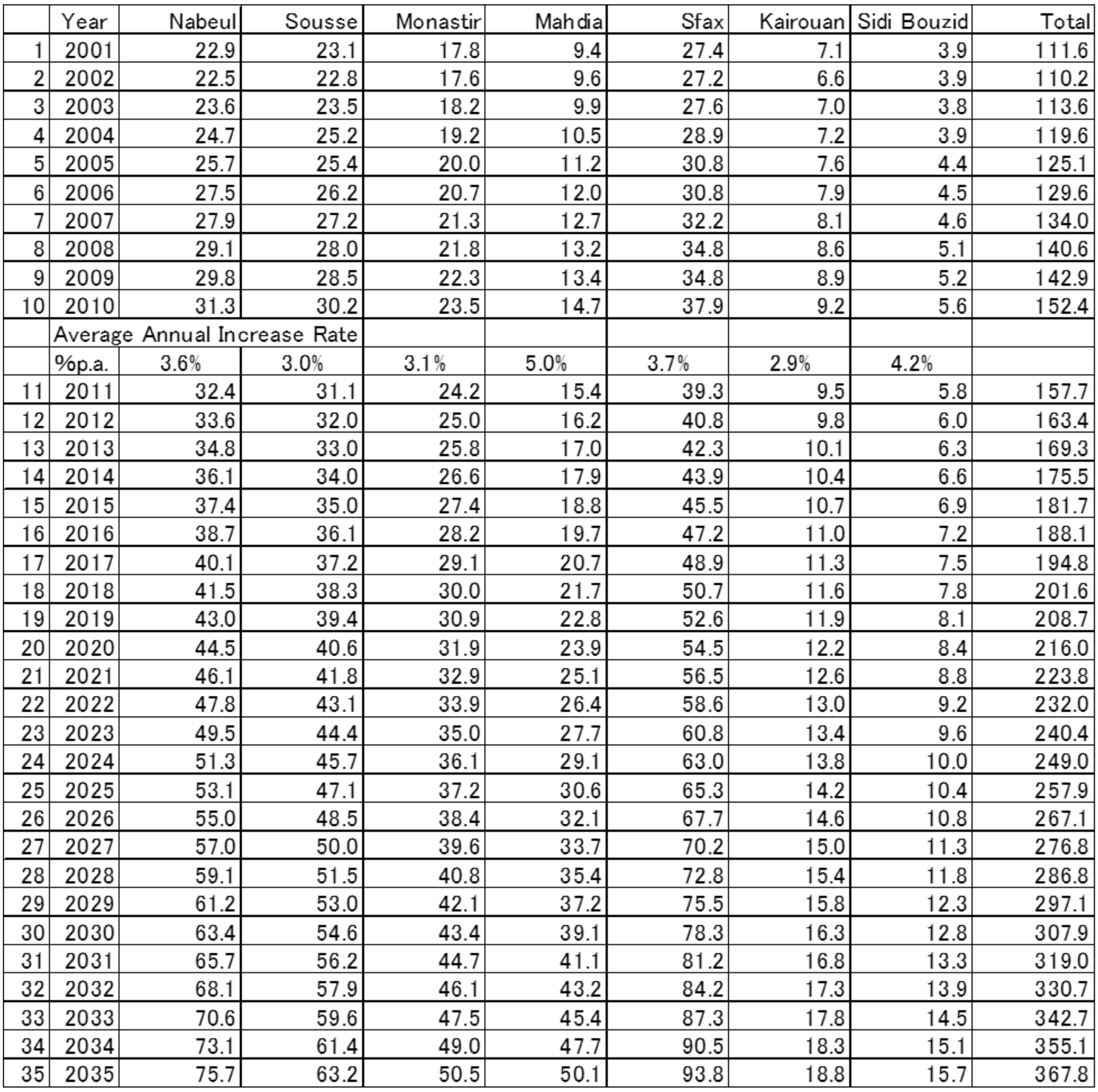


Source：JICA Survey Team

Figure 4.4-1 Flow Diagram of Water Demand Projection of the Survey

Table 4.4-2 Water Consumption by Governorate

Unit: million m^3/year



	Year	Nabeul	Sousse	Monastir	Mahdia	Sfax	Kairouan	Sidi Bouzid	Total
1	2001	22.9	23.1	17.8	9.4	27.4	7.1	3.9	111.6
2	2002	22.5	22.8	17.6	9.6	27.2	6.6	3.9	110.2
3	2003	23.6	23.5	18.2	9.9	27.6	7.0	3.8	113.6
4	2004	24.7	25.2	19.2	10.5	28.9	7.2	3.9	119.6
5	2005	25.7	25.4	20.0	11.2	30.8	7.6	4.4	125.1
6	2006	27.5	26.2	20.7	12.0	30.8	7.9	4.5	129.6
7	2007	27.9	27.2	21.3	12.7	32.2	8.1	4.6	134.0
8	2008	29.1	28.0	21.8	13.2	34.8	8.6	5.1	140.6
9	2009	29.8	28.5	22.3	13.4	34.8	8.9	5.2	142.9
10	2010	31.3	30.2	23.5	14.7	37.9	9.2	5.6	152.4
	Average Annual Increase Rate								
	%p.a.	3.6%	3.0%	3.1%	5.0%	3.7%	2.9%	4.2%	
11	2011	32.4	31.1	24.2	15.4	39.3	9.5	5.8	157.7
12	2012	33.6	32.0	25.0	16.2	40.8	9.8	6.0	163.4
13	2013	34.8	33.0	25.8	17.0	42.3	10.1	6.3	169.3
14	2014	36.1	34.0	26.6	17.9	43.9	10.4	6.6	175.5
15	2015	37.4	35.0	27.4	18.8	45.5	10.7	6.9	181.7
16	2016	38.7	36.1	28.2	19.7	47.2	11.0	7.2	188.1
17	2017	40.1	37.2	29.1	20.7	48.9	11.3	7.5	194.8
18	2018	41.5	38.3	30.0	21.7	50.7	11.6	7.8	201.6
19	2019	43.0	39.4	30.9	22.8	52.6	11.9	8.1	208.7
20	2020	44.5	40.6	31.9	23.9	54.5	12.2	8.4	216.0
21	2021	46.1	41.8	32.9	25.1	56.5	12.6	8.8	223.8
22	2022	47.8	43.1	33.9	26.4	58.6	13.0	9.2	232.0
23	2023	49.5	44.4	35.0	27.7	60.8	13.4	9.6	240.4
24	2024	51.3	45.7	36.1	29.1	63.0	13.8	10.0	249.0
25	2025	53.1	47.1	37.2	30.6	65.3	14.2	10.4	257.9
26	2026	55.0	48.5	38.4	32.1	67.7	14.6	10.8	267.1
27	2027	57.0	50.0	39.6	33.7	70.2	15.0	11.3	276.8
28	2028	59.1	51.5	40.8	35.4	72.8	15.4	11.8	286.8
29	2029	61.2	53.0	42.1	37.2	75.5	15.8	12.3	297.1
30	2030	63.4	54.6	43.4	39.1	78.3	16.3	12.8	307.9
31	2031	65.7	56.2	44.7	41.1	81.2	16.8	13.3	319.0
32	2032	68.1	57.9	46.1	43.2	84.2	17.3	13.9	330.7
33	2033	70.6	59.6	47.5	45.4	87.3	17.8	14.5	342.7
34	2034	73.1	61.4	49.0	47.7	90.5	18.3	15.1	355.1
35	2035	75.7	63.2	50.5	50.1	93.8	18.8	15.7	367.8

Source : 2001-2010 : Actual record ETUDE STRATEGIQUE, SONEDE, 2013
2011-2035 : Projection by JICA Survey Team

Table 4.4-3 Rate of Water Consumption from Own Water Sources*

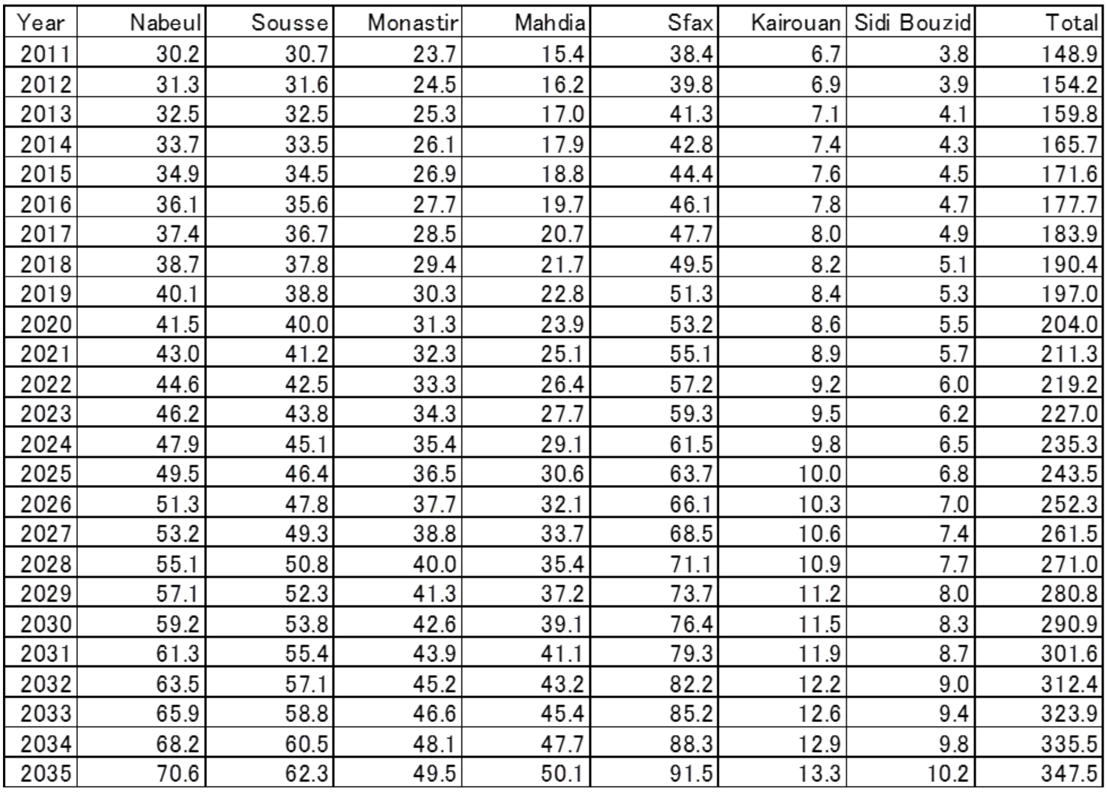
Unit: million m^3/year

	Nabeul	Sousse	Monastir	Mahdia	Sfax	Kairouan	Sidi Bouzid	Total
Consumption	2.1	0.4	0.4	-	0.9	2.7	2.0	8.5
Rate	6.7%	1.4%	1.9%	0.0%	2.4%	29.3%	34.9%	5.6%

*: small scale water supply system without any relation with the North water transmission system.
Source: ETUDE STRATEGIQUE, SONEDE, 2013

Table 4.4-4 Adjusted Water Consumption by Governorate

Unit: million m^3/year



Year	Nabeul	Sousse	Monastir	Mahdia	Sfax	Kairouan	Sidi Bouzid	Total
2011	30.2	30.7	23.7	15.4	38.4	6.7	3.8	148.9
2012	31.3	31.6	24.5	16.2	39.8	6.9	3.9	154.2
2013	32.5	32.5	25.3	17.0	41.3	7.1	4.1	159.8
2014	33.7	33.5	26.1	17.9	42.8	7.4	4.3	165.7
2015	34.9	34.5	26.9	18.8	44.4	7.6	4.5	171.6
2016	36.1	35.6	27.7	19.7	46.1	7.8	4.7	177.7
2017	37.4	36.7	28.5	20.7	47.7	8.0	4.9	183.9
2018	38.7	37.8	29.4	21.7	49.5	8.2	5.1	190.4
2019	40.1	38.8	30.3	22.8	51.3	8.4	5.3	197.0
2020	41.5	40.0	31.3	23.9	53.2	8.6	5.5	204.0
2021	43.0	41.2	32.3	25.1	55.1	8.9	5.7	211.3
2022	44.6	42.5	33.3	26.4	57.2	9.2	6.0	219.2
2023	46.2	43.8	34.3	27.7	59.3	9.5	6.2	227.0
2024	47.9	45.1	35.4	29.1	61.5	9.8	6.5	235.3
2025	49.5	46.4	36.5	30.6	63.7	10.0	6.8	243.5
2026	51.3	47.8	37.7	32.1	66.1	10.3	7.0	252.3
2027	53.2	49.3	38.8	33.7	68.5	10.6	7.4	261.5
2028	55.1	50.8	40.0	35.4	71.1	10.9	7.7	271.0
2029	57.1	52.3	41.3	37.2	73.7	11.2	8.0	280.8
2030	59.2	53.8	42.6	39.1	76.4	11.5	8.3	290.9
2031	61.3	55.4	43.9	41.1	79.3	11.9	8.7	301.6
2032	63.5	57.1	45.2	43.2	82.2	12.2	9.0	312.4
2033	65.9	58.8	46.6	45.4	85.2	12.6	9.4	323.9
2034	68.2	60.5	48.1	47.7	88.3	12.9	9.8	335.5
2035	70.6	62.3	49.5	50.1	91.5	13.3	10.2	347.5

Source: JICA Survey Team

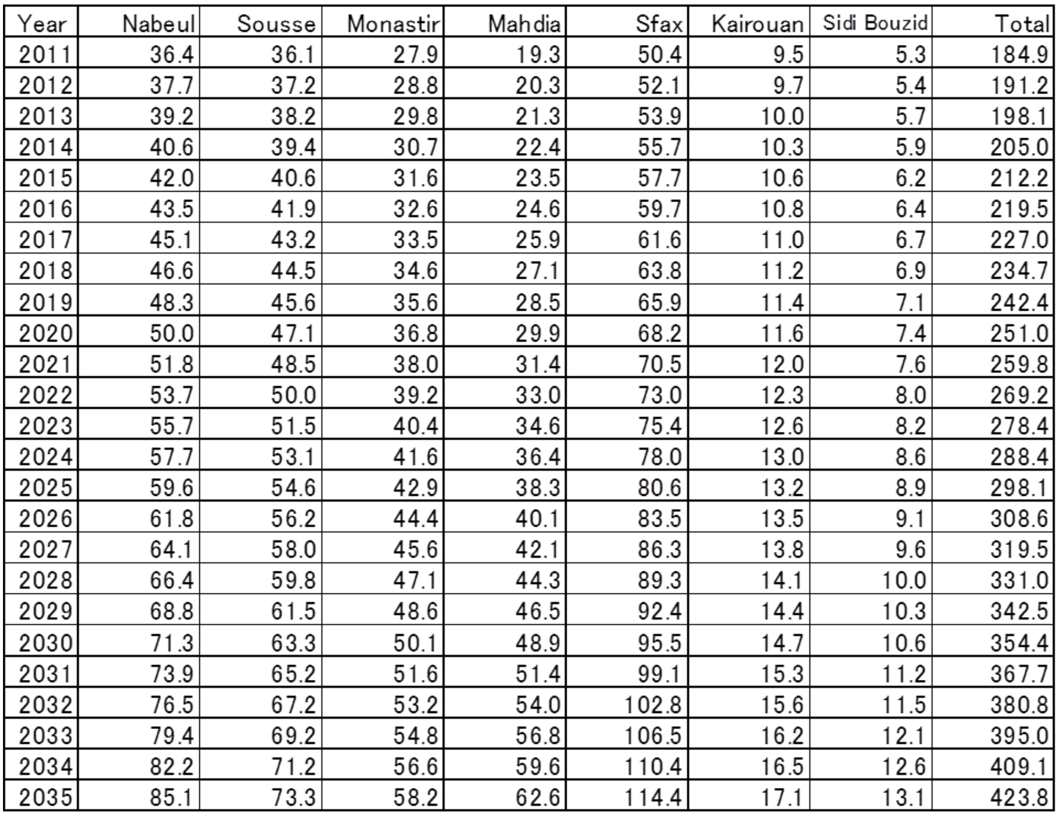
Table 4.4-5 Network Performance Rate by Governorate

Year	Nabeul	Sousse	Monastir	Mahdia	Sfax	Kairouan	Sidi Bouzid
2010 | 2030	0.83	0.85	0.85	0.8	0.76 | 0.80	0.70 | 0.78	0.71 | 0.78

Source: ETUDE STRATEGIQUE, SONEDE, 2013

Table 4.4-6 Average Water Demand by Governorate

Unit: million m^3/year



Year	Nabeul	Sousse	Monastir	Mahdia	Sfax	Kairouan	Sidi Bouzid	Total
2011	36.4	36.1	27.9	19.3	50.4	9.5	5.3	184.9
2012	37.7	37.2	28.8	20.3	52.1	9.7	5.4	191.2
2013	39.2	38.2	29.8	21.3	53.9	10.0	5.7	198.1
2014	40.6	39.4	30.7	22.4	55.7	10.3	5.9	205.0
2015	42.0	40.6	31.6	23.5	57.7	10.6	6.2	212.2
2016	43.5	41.9	32.6	24.6	59.7	10.8	6.4	219.5
2017	45.1	43.2	33.5	25.9	61.6	11.0	6.7	227.0
2018	46.6	44.5	34.6	27.1	63.8	11.2	6.9	234.7
2019	48.3	45.6	35.6	28.5	65.9	11.4	7.1	242.4
2020	50.0	47.1	36.8	29.9	68.2	11.6	7.4	251.0
2021	51.8	48.5	38.0	31.4	70.5	12.0	7.6	259.8
2022	53.7	50.0	39.2	33.0	73.0	12.3	8.0	269.2
2023	55.7	51.5	40.4	34.6	75.4	12.6	8.2	278.4
2024	57.7	53.1	41.6	36.4	78.0	13.0	8.6	288.4
2025	59.6	54.6	42.9	38.3	80.6	13.2	8.9	298.1
2026	61.8	56.2	44.4	40.1	83.5	13.5	9.1	308.6
2027	64.1	58.0	45.6	42.1	86.3	13.8	9.6	319.5
2028	66.4	59.8	47.1	44.3	89.3	14.1	10.0	331.0
2029	68.8	61.5	48.6	46.5	92.4	14.4	10.3	342.5
2030	71.3	63.3	50.1	48.9	95.5	14.7	10.6	354.4
2031	73.9	65.2	51.6	51.4	99.1	15.3	11.2	367.7
2032	76.5	67.2	53.2	54.0	102.8	15.6	11.5	380.8
2033	79.4	69.2	54.8	56.8	106.5	16.2	12.1	395.0
2034	82.2	71.2	56.6	59.6	110.4	16.5	12.6	409.1
2035	85.1	73.3	58.2	62.6	114.4	17.1	13.1	423.8

Source: JICA Survey Team

Table 4.4-7 Adjustment Factors by Governorate

Adjustment Factor	Nabeul	Sousse	Monastir	Mahdia	Sfax	Kairouan	Sidi Bouzid
1.Peak factor (Daily Max./Daily Ave.)	1.500	1.400	1.500	1.500	1.400	1.500	1.500
2. Regional Adjustment Factor	0.944	0.944	0.944	0.944	0.944	0.944	0.944
3. Peak Adjustment Factor	0.950	0.950	0.950	0.950	0.950	0.950	0.950
Integrated Adjustment factor 1x2x3	1.3452	1.2555	1.3452	1.3452	1.2555	1.3452	1.3452

Source: JICA Survey Team

Table 4.4-8 Maximum Water Demand by Governorate

Unit: million m^3/year

Year	Nabeul	Sousse	Monastir	Mahdia	Sfax	Kairouan	Sidi Bouzid	Total
2011	49.0	45.3	37.5	26.0	63.3	12.8	7.1	241.0
2012	50.7	46.7	38.7	27.3	65.4	13.0	7.3	249.1
2013	52.7	48.0	40.1	28.7	67.7	13.5	7.7	258.4
2014	54.6	49.5	41.3	30.1	69.9	13.9	7.9	267.2
2015	56.5	51.0	42.5	31.6	72.4	14.3	8.3	276.6
2016	58.5	52.6	43.9	33.1	75.0	14.5	8.6	286.2
2017	60.7	54.2	45.1	34.8	77.3	14.8	9.0	295.9
2018	62.7	55.9	46.5	36.5	80.1	15.1	9.3	306.1
2019	65.0	57.3	47.9	38.3	82.7	15.3	9.6	316.1
2020	67.3	59.1	49.5	40.2	85.6	15.6	10.0	327.3
2021	69.7	60.9	51.1	42.2	88.5	16.1	10.2	338.7
2022	72.2	62.8	52.7	44.4	91.7	16.5	10.8	351.1
2023	74.9	64.7	54.3	46.5	94.7	16.9	11.0	363.0
2024	77.6	66.7	56.0	49.0	97.9	17.5	11.6	376.3
2025	80.2	68.6	57.7	51.5	101.2	17.8	12.0	389.0
2026	83.1	70.6	59.7	53.9	104.8	18.2	12.2	402.5
2027	86.2	72.8	61.3	56.6	108.4	18.6	12.9	416.8
2028	89.3	75.1	63.4	59.6	112.1	19.0	13.5	432.0
2029	92.5	77.2	65.4	62.6	116.0	19.4	13.9	447.0
2030	95.9	79.5	67.4	65.8	119.9	19.8	14.3	462.6
2031	99.4	81.9	69.4	69.1	124.4	20.6	15.1	479.9
2032	102.9	84.4	71.6	72.6	129.1	21.0	15.5	497.1
2033	106.8	86.9	73.7	76.4	133.7	21.8	16.3	515.6
2034	110.6	89.4	76.1	80.2	138.6	22.2	16.9	534.0
2035	114.5	92.0	78.3	84.2	143.6	23.0	17.6	553.2

Unit: m^3/day

Year	Nabeul	Sousse	Monastir	Mahdia	Sfax	Kairouan	Sidi Bouzid	Total
2011	134,247	124,110	102,740	71,233	173,425	35,068	19,452	660,274
2012	138,904	127,945	106,027	74,795	179,178	35,616	20,000	682,466
2013	144,384	131,507	109,863	78,630	185,479	36,986	21,096	707,945
2014	149,589	135,616	113,151	82,466	191,507	38,082	21,644	732,055
2015	154,795	139,726	116,438	86,575	198,356	39,178	22,740	757,808
2016	160,274	144,110	120,274	90,685	205,479	39,726	23,562	784,110
2017	166,301	148,493	123,562	95,342	211,781	40,548	24,658	810,685
2018	171,781	153,151	127,397	100,000	219,452	41,370	25,479	838,630
2019	178,082	156,986	131,233	104,932	226,575	41,918	26,301	866,027
2020	184,384	161,918	135,616	110,137	234,521	42,740	27,397	896,712
2021	190,959	166,849	140,000	115,616	242,466	44,110	27,945	927,945
2022	197,808	172,055	144,384	121,644	251,233	45,205	29,589	961,918
2023	205,205	177,260	148,767	127,397	259,452	46,301	30,137	994,521
2024	212,603	182,740	153,425	134,247	268,219	47,945	31,781	1,030,959
2025	219,726	187,945	158,082	141,096	277,260	48,767	32,877	1,065,753
2026	227,671	193,425	163,562	147,671	287,123	49,863	33,425	1,102,740
2027	236,164	199,452	167,945	155,068	296,986	50,959	35,342	1,141,918
2028	244,658	205,753	173,699	163,288	307,123	52,055	36,986	1,183,562
2029	253,425	211,507	179,178	171,507	317,808	53,151	38,082	1,224,658
2030	262,740	217,808	184,658	180,274	328,493	54,247	39,178	1,267,397
2031	272,329	224,384	190,137	189,315	340,822	56,438	41,370	1,314,795
2032	281,918	231,233	196,164	198,904	353,699	57,534	42,466	1,361,918
2033	292,603	238,082	201,918	209,315	366,301	59,726	44,658	1,412,603
2034	303,014	244,932	208,493	219,726	379,726	60,822	46,301	1,463,014
2035	313,699	252,055	214,521	230,685	393,425	63,014	48,219	1,515,616

Table 4.4-9 Administrative and Served Populations by Governorate

Unit: 1000

Administrative Population

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Nabeul	709.7	719.2	728.5	738.4	747.4	757.6	768.5	779.4	788.1	798.0	807.9	817.8	827.7	837.5	847.4	857.3	867.2	877.1	887.0	896.9	906.8	916.7	926.5	936.4	946.3	956.2	966.1	976.0	985.9	995.8	1005.7
Sousse	562.4	573.6	584.5	596.3	605.3	616.2	633.8	648.7	656.7	668.7	680.7	692.7	704.7	716.7	728.8	740.8	752.8	764.8	776.8	788.8	800.8	812.8	824.9	836.9	848.9	860.9	872.9	884.9	896.9	909.0	921.0
Monastir	470.5	479.8	490.0	499.8	509.6	520.2	533.2	539.3	550.8	560.9	571.0	581.1	591.2	601.3	611.4	621.5	631.6	641.7	651.9	662.0	672.1	682.2	692.3	702.4	712.5	722.6	732.7	742.8	752.9	763.0	773.1
Mahdia	383.1	385.5	388.4	391.4	394.1	398.7	399.0	395.0	401.8	404.0	406.2	408.4	410.6	412.8	415.0	417.1	419.3	421.5	423.7	425.9	428.1	430.3	432.5	434.7	436.9	439.1	441.3	443.5	445.7	447.9	450.1
Sfax	875.1	887.9	898.8	910.9	923.8	937.9	948.7	963.1	974.5	987.0	999.5	1012.0	1024.5	1037.0	1049.5	1062.0	1074.5	1087.0	1099.5	1112.1	1124.6	1137.1	1149.6	1162.1	1174.6	1187.1	1199.6	1212.1	1224.6	1237.1	1249.6
Kairouan	549.3	551.1	552.8	554.9	558.9	563.3	564.9	569.4	571.2	574.1	577.0	580.0	582.9	585.8	588.7	591.6	594.6	597.5	600.4	603.3	606.2	609.2	612.1	615.0	617.9	620.8	623.8	626.7	629.6	632.5	635.4
Sidi Bouzid	399.8	402.3	404.5	407.3	410.9	414.4	416.3	418.4	421.7	424.5	427.3	430.1	432.9	435.6	438.4	441.2	444.0	446.8	449.5	452.3	455.1	457.9	460.7	463.4	466.2	469.0	471.8	474.6	477.3	480.1	482.9
Total	3949.9	3999.4	4047.5	4099.0	4150.0	4208.3	4264.4	4313.3	4364.8	4417.2	4469.6	4522.1	4574.5	4626.7	4679.2	4731.5	4784.0	4836.4	4888.8	4941.3	4993.7	5046.2	5098.6	5150.9	5203.3	5255.7	5308.2	5360.6	5412.9	5465.4	5517.8

Served Population

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Nabeul	614.8	624.3	633.0	642.0	650.1	660.6	670.6	680.5	688.9	698.2	707.5	716.8	726.2	735.5	744.8	754.1	763.4	772.7	782.0	791.3	800.7	810.0	819.3	828.6	837.9	847.2	856.5	865.8	875.2	884.5	893.8
Sousse	534.5	545.3	556.6	568.0	576.7	587.5	606.2	623.8	630.1	642.3	654.6	666.9	679.2	691.4	703.7	716.0	728.2	740.5	752.8	765.1	777.3	789.6	801.9	814.2	826.4	838.7	851.0	863.3	875.5	887.8	900.1
Monastir	470.5	479.8	490.0	499.8	509.6	520.2	533.2	539.3	550.8	560.9	571.0	581.1	591.2	601.3	611.4	621.5	631.6	641.7	651.9	662.0	672.1	682.2	692.3	702.4	712.5	722.6	732.7	742.8	752.9	763.0	773.1
Mahdia	306.0	311.5	322.3	334.8	337.5	341.5	341.8	338.4	352.7	357.9	363.2	368.4	373.6	378.8	384.1	389.3	394.5	399.7	404.9	410.2	415.4	420.6	425.8	431.0	436.3	441.5	446.7	451.9	457.2	462.4	467.6
Sfax	735.9	749.2	761.3	774.8	787.9	800.4	811.4	824.1	837.3	850.0	862.6	875.2	887.8	900.4	913.0	925.6	938.2	950.8	963.4	976.0	988.6	1001.2	1013.8	1026.4	1039.0	1051.6	1064.2	1076.8	1089.4	1102.1	1114.7
Kairouan	319.7	321.8	324.5	333.8	341.4	345.5	347.1	351.3	358.0	363.0	368.0	373.0	378.0	382.9	387.9	392.9	397.9	402.9	407.8	412.8	417.8	422.8	427.8	432.7	437.7	442.7	447.7	452.7	457.6	462.6	467.6
Sidi Bouzid	183.8	189.2	190.8	192.3	194.1	196.3	197.3	198.3	201.4	203.3	205.2	207.1	209.0	210.9	212.8	214.7	216.6	218.5	220.4	222.3	224.3	226.2	228.1	230.0	231.9	233.8	235.7	237.6	239.5	241.4	243.3
Total	3165.2	3221.1	3278.5	3345.5	3397.3	3452.0	3507.6	3555.7	3619.2	3675.6	3732.1	3788.5	3845.0	3901.2	3957.7	4014.1	4070.4	4126.8	4183.2	4239.7	4296.2	4352.6	4409.0	4465.3	4521.7	4578.1	4634.5	4690.9	4747.3	4803.8	4860.2
Service Ratio in Sfax Governorate									85.9%	86.1%	86.3%	86.5%	86.7%	86.8%	87.0%	87.2%	87.3%	87.5%	87.6%	87.8%	87.9%	88.0%	88.2%	88.3%	88.5%	88.6%	88.7%	88.8%	89.0%	89.1%	89.2%
Service Ratio in 7 Governorates									82.9%	83.2%	83.5%	83.8%	84.1%	84.3%	84.6%	84.8%	85.1%	85.3%	85.6%	85.8%	86.0%	86.3%	86.5%	86.7%	86.9%	87.1%	87.3%	87.5%	87.7%	87.9%	88.1%

Note: Populations from 2013 to 2035 were projected by linear approximation method.

Source: 2005-2012; RAPPORT DES STATISTIQUES, SONEDE, 2013-2035; JICA Survey Team

4.4.2 Water Supply Plan in North Water Transmission System

In the Strategic Study, the scenario for the water supply to meet the demand until 2030 was studied. Treatment plants planned in the Strategic Study are as shown in Table 4.2-2. In the Survey, the JICA Survey Team confirmed SONEDE about implementation of those plants. As a result of discussion, SONEDE indicated the 1 year delayed schedule of the project for Saida reservoir and Kalaa Kebira reservoir & water treatment plant as shown in Table 4.4-10. SONEDE also intends to expedite the Project for Sfax Seawater Desalination Plant as soon as possible.

In this survey, the schedule presented by SONEDE is applied for the project for Saida reservoir and Kalaa Kebira reservoir & water treatment plant. Sfax Seawater Desalination Plant, however, is scheduled considering the required period of necessary procedures for JICA ODA loan for the project. After examination of the said schedule, which is discussed in Chapter 10 in detail, commissioning of the plat is expected in 2022. The period for Phase 1 is considered as the period when the capacity of first phase facility, 100,000 m^3/day, which is a half of final capacity, can meet the demand. After that, Phase 2 will be started.

Scope of work for JICA ODA loan is considered to be the Phase 1 facilities of the seawater desalination plant and its related facilities.

Table 4.4-10 Water Treatment Plant and Seawater Treatment Plant formulated in the Strategic Study

Name	Year	Production capacity	Supply to Greater Sfax
Saida reservoir & Kalaa Kebira reservoir / water treatment plant	2020	1,500 L/s (129,600 m^3/d)	-*
	2024	3,000 L/s (259,200 m^3/d)	-*
	2029	4,000 L/s (345,600 m^3/d)	-*
Sfax sea water desalination plant	2020	1,157 L/s (100,000 m^3/d)	1,157 L/s (100,000 m^3/d)
	2026	2,325 L/s (200,000 m^3/d)	2,325 L/s (200,000 m^3/d)

*: As a part of water of the North Water Transmission System, supplied water is mixed with the water supplied from existing water sources.

Source: SONEDE, 2014

Even though new water resources stated above are developed, upstream areas of the North water transmission system will be suffered after 2031 due to water shortage caused by increase of water demand. Because of this reason, additional water source with a capacity of 250,000 m^3/day will be required as shown in Figure 4.4-3. This new water source is required to be developed at the place close to large water demand area like the Souse Governorate to avoid transmission of big volume of water.

4.4.3 Review on Demand and Supply Plan in the Strategic Study

Water demand and supply were reviewed under the conditions stipulated in Sections 4.4.1 and 4.4.2. The results are presented in Tables 4.4-11 to 4.4-13, and Figures 4.4-2 and 4.4-3. In addition, calculation table showing demand and supply analysis in seven governorates is presented in Table 4.4-14.

Table 4.4-11 Water Demand in Seven Governorates in North Water Transmission System

	2015	2020	2025	2030	2035
Population	4,469,600	4,731,500	4,993,700	5,255,700	5,517,800
Population Served	3,732,100	4,014,100	4,296,200	4,578,100	4,860,200
Per Capita Consumption (L/person/day)	103	114	127	143	161
Non Domestic Rate (%)	22	22	22	22	22
Average Non-Revenue Water (%)	23.7	23.0	22.4	21.8	22.0
Daily Average Demand (m^3/day)	581,400	687,700	816,700	971,000	1,161,100
Peak Factor (Daily Max/Daily Average)	1.303	1.291	1.305	1.305	1.305
Daily Maximum Demand (m^3/day)	757,800	887,500	1,065,700	1,267,400	1,515,600

*: Daily Max/Daily Average of 7 governorates x adjusting coefficient (0.944)
Source: JICA Survey Team

Table 4.4-12 Water Balance in Seven Governorates in North Water Transmission System (existing facilities only)

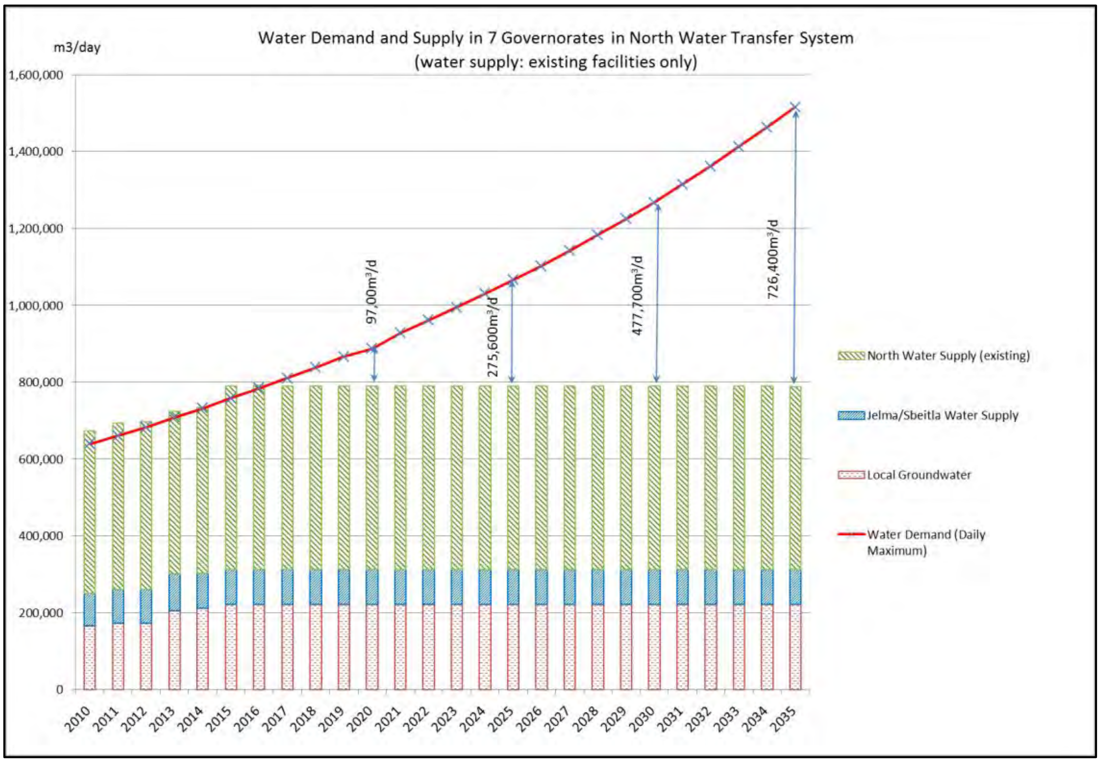
(m^3/day)		2015	2020	2022	2025	2030	2035
Available Water	North Water Transmission	476,800	477,600	477,500	477,200	476,800	476,300
	Jelma-Sbeitla GW Transmission	91,600	91,600	91,600	91,600	91,600	91,600
	Local Groundwater	221,400	221,400	221,400	221,400	221,400	221,400
	Total	789,800	790,600	790,400	790,100	789,700	789,300
Daily Maximum Water Demand		757,800	887,500	961,800	1,065,700	1,267,400	1,515,600
Balance		31,900	▲97,000	▲171,400	▲275,600	▲477,700	▲726,400

Source: JICA Survey Team (Note: Due to rounding, (available volume-demand) is not equal to Balance.)

Table 4.4-13 Water Balance in Seven Governorates in North Water Transmission System (existing facilities + new facilities)

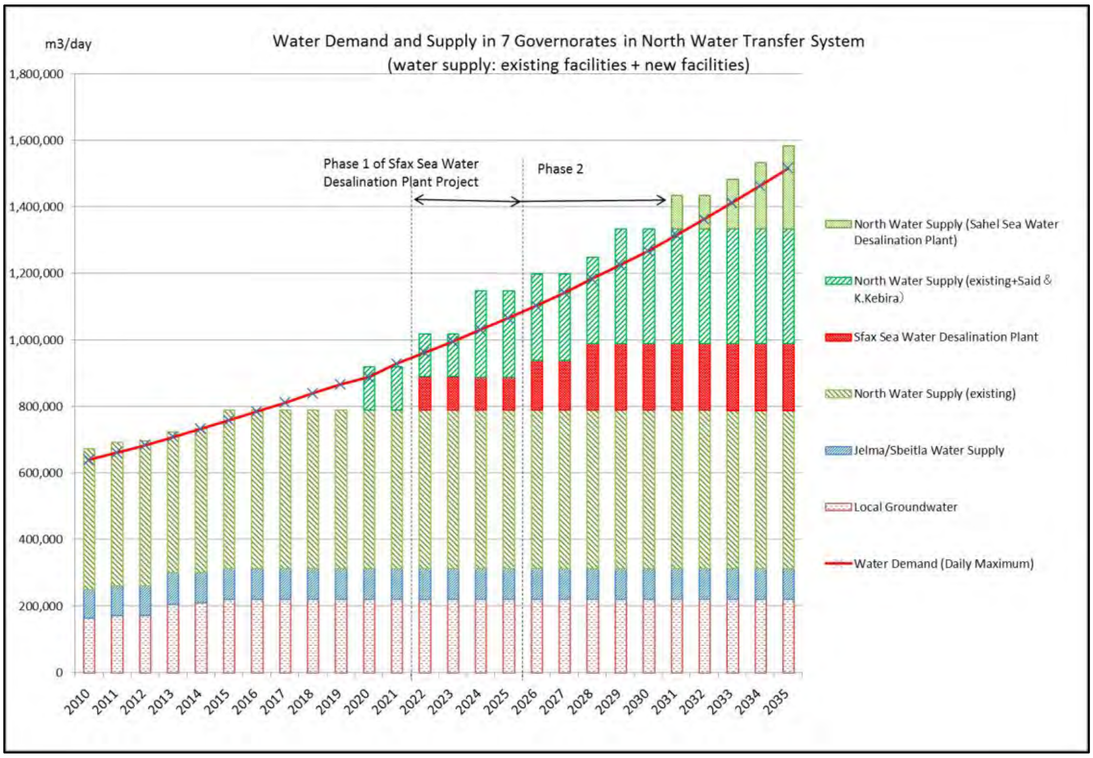
(m^3/day)		2015	2020	2022	2025	2030	2035
Available Water	Sahel Desalination Plant	0	0	0	0	0	250,000
	Saida/Kalaa Kebira WTP	0	129,600	129,600	259,200	345,600	345,600
	Sfax Desalination Plant	0	0	100,000	100,000	200,000	200,000
	North Water Transmission	476,800	477,600	477,500	477,200	476,800	476,300
	Jelma-Sbeitla Groundwater Transmission	91,600	91,600	91,600	91,600	91,600	91,600
	Local Groundwater	221,400	221,400	221,400	221,400	221,400	221,400
	Total	789,700	920,200	1,020,000	1,149,300	1,335,300	1,584,900
Daily Maximum Water Demand		757,800	887,500	961,800	1,065,700	1,267,400	1,515,600
Balance		31,900	32,600	58,200	83,600	67,900	69,200

Source: JICA Survey Team



Source: JICA Survey Team

Figure 4.4-2 Water Demand and Supply in Seven Governorates in North Water Transmission System (water supply: exiting facilities only)



Source: JICA Survey Team

Figure 4.4-3 Water Demand and Supply in Seven Governorates in North Water Transmission System (water supply: exiting facilities + new facilities)

Table 4.4-14 Water Demand and Supply in Seven Governorates in North Water Transmission System

(unit: L/sec.)

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Nabeul																										
Belli Treatment Plant	4,268	4,398	4,398	4,398	4,398	4,798	4,798	4,798	4,798	4,798	4,798	4,798	4,798	4,798	4,798	4,798	4,798	4,798	4,798	4,798	4,798	4,798	4,798	4,798	4,798	4,798
Local Resources +Tunis Unit	634	611	646	489	596	720	737	735	733	731	730	729	728	727	726	725	724	723	722	721	720	719	718	717	716	715
Total resources in Nabeul	4,902	5,009	5,044	4,887	4,994	5,518	5,535	5,533	5,531	5,529	5,528	5,527	5,526	5,525	5,524	5,523	5,522	5,521	5,520	5,519	5,518	5,517	5,516	5,515	5,514	5,513
Qpj	1,503	1,554	1,608	1,671	1,731	1,792	1,855	1,925	1,988	2,061	2,027	2,210	2,289	2,375	2,461	2,543	2,635	2,733	2,832	2,933	3,041	3,152	3,263	3,387	3,507	3,631
Balance of Nabeul	3,399	3,455	3,436	3,216	3,263	3,726	3,680	3,608	3,543	3,468	3,501	3,317	3,237	3,150	3,063	2,980	2,887	2,788	2,688	2,586	2,477	2,365	2,253	2,128	2,007	1,882
Kairouan																										
Local resources in Kairouan	1,085	1,085	1,085	1,091	1,091	1,119	1,119	1,119	1,119	1,119	1,119	1,119	1,119	1,119	1,119	1,119	1,119	1,119	1,119	1,119	1,119	1,119	1,119	1,119	1,119	1,119
Qpj	396	406	412	428	441	453	460	469	479	485	495	511	523	536	555	564	577	590	602	615	628	653	666	691	704	729
Balance of Kairouan	689	679	673	663	650	666	659	650	640	634	624	608	596	583	564	555	542	529	517	504	491	466	453	428	415	390
Sahel (Sousse+Monastir+Mahdia)																										
Local Resources of Sahel	528	614	614	794	866	952	952	952	952	952	952	952	952	952	952	952	952	952	952	952	952	952	952	952	952	952
Saida/K.Kebira Reservoirs+WTP （1500L/s + 1500L/s + 1000L/s)											1,500	1,500	1,500	1,500	3,000	3,000	3,000	3,000	3,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
Sahel Desalination Plant（100,000 m3/d+50,000m3/d+50,000m3/d+50,000m3/d)																						1,157	1,157	1,736	2,315	2,894
Arrival from Kairouan	689	679	673	663	650	666	659	650	640	634	624	608	596	583	564	555	542	529	517	504	491	466	453	428	415	390
Arrival from Northern Water	3,399	3,455	3,436	3,216	3,263	3,726	3,680	3,608	3,543	3,468	3,501	3,317	3,237	3,150	3,063	2,980	2,887	2,788	2,688	2,586	2,477	2,365	2,253	2,128	2,007	1,882
Total resources	4,616	4,748	4,723	4,673	4,779	5,344	5,291	5,210	5,135	5,054	6,577	6,377	6,285	6,185	7,579	7,487	7,381	7,269	7,157	8,042	7,920	8,940	8,815	9,244	9,689	10,118
Qpj in Sousse	1,398	1,436	1,481	1,522	1,570	1,617	1,668	1,719	1,773	1,817	1,874	1,931	1,991	2,052	2,115	2,175	2,239	2,308	2,381	2,448	2,521	2,597	2,676	2,756	2,835	2,917
Qpj in Monastir	1,161	1,189	1,227	1,272	1,310	1,348	1,392	1,430	1,475	1,519	1,570	1,620	1,671	1,722	1,776	1,830	1,893	1,944	2,010	2,074	2,137	2,201	2,270	2,337	2,413	2,483
Qpj in Mahdia	786	824	866	910	954	1,002	1,050	1,104	1,157	1,214	1,275	1,338	1,408	1,475	1,554	1,633	1,709	1,795	1,890	1,985	2,087	2,191	2,302	2,423	2,543	2,670
Total Qpj in Sahel	3,345	3,449	3,574	3,704	3,834	3,967	4,110	4,253	4,405	4,550	4,719	4,889	5,070	5,249	5,445	5,638	5,841	6,047	6,281	6,507	6,745	6,989	7,248	7,516	7,791	8,070
Balance of Sahel	1,271	1,299	1,149	969	945	1,377	1,181	957	730	504	1,858	1,488	1,215	936	2,134	1,849	1,540	1,222	876	1,535	1,175	1,951	1,567	1,728	1,898	2,048
Sidi Bouzid																										
Local resources in Sidi Bouzid	977	1,019	1,019	1,115	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060	1,060
Qpj	219	225	231	244	251	263	273	285	295	304	317	323	342	349	368	381	387	409	428	441	453	479	492	517	536	558
Balance of Sidi Bouzid	758	794	788	871	809	797	787	775	765	756	743	737	718	711	692	679	673	651	632	619	607	581	568	543	524	502
Sfax																										
Local Resources of Sfax	301	301	301	491	491	491	491	491	491	491	491	491	491	491	491	491	491	491	491	491	491	491	491	491	491	491
Sfax Desalination Plant Ph1/2 (100,000+100,000 m3/d)													1,157	1,157	1,157	1,157	1,736	1,736	2,315	2,315	2,315	2,315	2,315	2,315	2,315	2,315
Arrival from Northern Water	1,271	1,299	1,149	969	945	1,377	1,181	957	730	504	1,858	1,488	1,215	936	2,134	1,849	1,540	1,222	876	1,535	1,175	1,951	1,567	1,728	1,898	2,048
Arrival from Sbeitla-Jelma	758	794	788	871	809	797	787	775	765	756	743	737	718	711	692	679	673	651	632	619	607	581	568	543	524	502
Total resources in Sfax	2,330	2,394	2,238	2,331	2,245	2,665	2,459	2,223	1,986	1,751	3,092	2,716	3,581	3,295	4,474	4,176	4,440	4,100	4,314	4,960	4,588	5,338	4,941	5,077	5,228	5,355
Qpj	1,937	2,007	2,074	2,147	2,217	2,296	2,378	2,451	2,540	2,622	2,714	2,806	2,908	3,003	3,104	3,209	3,323	3,437	3,555	3,678	3,802	3,945	4,094	4,240	4,395	4,554
Balance of Sfax	393	387	164	184	28	369	81	−228	−554	−871	378	−90	673	292	1,370	967	1,117	663	759	1,282	786	1,393	847	837	833	801
Total																										
Existing Resources	7,793	8,028	8,063	8,378	8,502	9,140	9,157	9,155	9,153	9,151	9,150	9,149	9,148	9,147	9,146	9,145	9,144	9,143	9,142	9,141	9,140	9,139	9,138	9,137	9,136	9,135
Saida/K.Kebira Reservoirs+WTP	0	0	0	0	0	0	0	0	0	0	1,500	1,500	1,500	1,500	3,000	3,000	3,000	3,000	3,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
Desalination (Sfax+Sahel)	0	0	0	0	0	0	0	0	0	0	0	0	1,157	1,157	1,157	1,157	1,736	1,736	2,315	2,315	2,315	3,472	3,472	4,051	4,630	5,208
Total Resources	7,793	8,028	8,063	8,378	8,502	9,140	9,157	9,155	9,153	9,151	10,650	10,649	11,805	11,804	13,303	13,302	13,880	13,879	14,457	15,456	15,455	16,611	16,610	17,188	17,766	18,343
Total Qpj	7,400	7,641	7,899	8,194	8,474	8,771	9,076	9,383	9,707	10,022	10,272	10,739	11,132	11,512	11,933	12,335	12,763	13,216	13,698	14,174	14,669	15,218	15,763	16,351	16,933	17,542
Global Balance	393	387	164	184	28	369	81	−228	−554	−871	378	−90	673	292	1,370	967	1,117	663	759	1,282	786	1,393	847	837	833	801

Qpj: Daily Maximum Water Demand

Source: JICA Survey Team

Water demand shown in Figures 4.4-2 and 4.4-3 is prepared based on Table 4.4-8. The average unit water demand was discussed with the Greater Sfax and the other countries in Section 4.6.2.

Figure 4.4-2 indicates water balance of the demand and the supply in North Water Transmission System in case new facilities or new water sources development formulated by the Strategic Study are not implemented. Water supply for the existing facilities is estimated with the maximum conveyance amount. Under this condition, a large amount of water shortage is confirmed. The shortage will be at an amount of 97,000 m^3/d in 2020, 275,600 m^3/d in 2025, 477,700 m^3/d in 2030, and 726,400 m^3/d in 2035, respectively.

Figure 4.4-3 indicates the balance in case the new facilities, or new water sources development formulated by the Strategic Study are implemented. As a result, there is an excess amount of water supply at 32,600 m^3/d in 2030. Water shortage, however, occurs after 2031. In 2035, a target year of this project, the shortage is estimated at 180,800 m^3/d. In order to avoid this shortage, SONEDE has a scheme to provide a sea water desalination plant in Sahel in addition to the facilities planned in the Strategic Study. In Figure 4.4-3, the production of this plant is added to the supply after 2031.

4.4.4 Issue on Water Supply Plan in North Water Transmission System

(1) Issue on construction of Saida Reservoir and Sahel Reservoir (Kalaa Kebira Reservoir)

In the study of the MOA conducted by a Russian consultant, SELKHOZ PROMEX POEKT, Saida Reservoir was planned to be constructed in nationally-owned land in 1999. However, the MOA has postponed the construction of the reservoir due to some financial issue and the order of among the other projects.

A reservoir and water treatment plant in Sahel were planned under the study "Etude pour L'execution D'une Retenue D'eau Brute Dans la Region de Sahel (Study for Execution of Raw Water Holding in Sahel Region)" in 2010. The facilities are planned to be located in Kalaa Kebira.

Regarding the construction of the Saida Reservoir and Sahel Reservoir (Kalaa Kebira Reservoir), SONEDE explained the outline and the expected commencement of the operation from 2019 at the international donor conference in February 2014 held in Marseille, Spain in order to obtain a support from FADES.

In a discussion with the JICA Survey Team, SONEDE explained the proposed commencement of the operation at Saida Reservoir and Kalaa Kebira Reservoir and Water Treatment Plant in 2020. FADES expressed the concurrence in principle to the MOA and SONEDE for extending the loan following the schedule.

(2) Issue on construction of a sea water desalination plant in Greater Sfax

According to the Strategic Study, Sfax sea water desalination plant and Kalaa Kebira Reservoir was planned for the construction / completion by 2018 and 2019, respectively. However, in case SONEDE utilizes the JICA ODA loan for the desalination plant works, it is very difficult to start the operation of the plant in 2018 because of the administrative procedures of the loan arrangement. The earliest time for its operation is October 2022. As a result, the water shortage will occur between 2017 and 2022. The issue on this shortage is discussed in Section 4.4.

Issue on water shortage after 2031

As presented in Figure 4.4-3, the water demand can be satisfied by an additional facility of the sea water desalination plant in Sahel after 2032. Water source using sea water is the most applicable in increasing the supply. Therefore, it is considered that the new scheme for the construction of sea water desalination plant is appropriate.

SONEDE plans the location of the new plant in or near Sousse, where big water demand exists. The facilities, however, formulated by the Strategic Study will be constructed first. Then, the officials in Tunisia need to discuss the official plan for new plant after reviewing the demand.

4.5 Water Demand and Supply in Sfax Governorate

4.5.1 Water Demand and Supply in Sfax Governorate

Water in the Sfax Governorate is supplied from a part of North Water Transmission System. The water sources and the water treatment plants are explained in Section 4.4.2.

The large amount of water is conveyed to the Sfax Governorate by the North Water Transmission System and the Jelma-Sbeitla Groundwater Transmission System. However, it is projected that there will be an increase of consumption in the regions upstream of the Sfax Governorate. As a result, the supply amount to the Sfax Governorate is projected to decrease. Furthermore, it is expected that no water, presently being conveyed by the North Water Transmission System, may reach the Sfax Governorate during summer, the peak consumption period due to water demand increase in the upstream areas.

Water demand and supply were reviewed under the conditions stipulated. In this calculation, the peak adjustment factor which was applied for water demand projection for whole seven governorates is not applied to the Sfax Governorate. The results are presented in Tables 4.5-1 to 4.5-3, and Figures 4.5-1 and 4.5-2.

Table 4.5-1 Water Demand in Sfax Governorate

	2015	2020	2025	2030	2035
Population	999,500	1,062,000	1,124,600	1,187,100	1,249,600
Population Served	862,600	925,600	988,600	1,051,600	1,114,700
Per Capita Consumption (L/person/day)	126	140	156	176	199
Non Domestic Rate (%)	18	18	18	18	18
Average Non-Revenue Water (%)	23	22	21	20	20
Daily Average Demand (m^3/day)	158,100	186,800	220,800	261,600	313,400
Peak Factor (Daily Max/Daily Average)*	1.321	1.321	1.322	1.322	1.322
Daily Maximum Demand (m^3/day)	208,800	246,800	291,900	345,800	414,200

*: peak factor (1.4) x adjusting coefficient
Source: JICA Survey Team

Table 4.5-2 Water Balance in Sfax Governorate (existing facilities only)

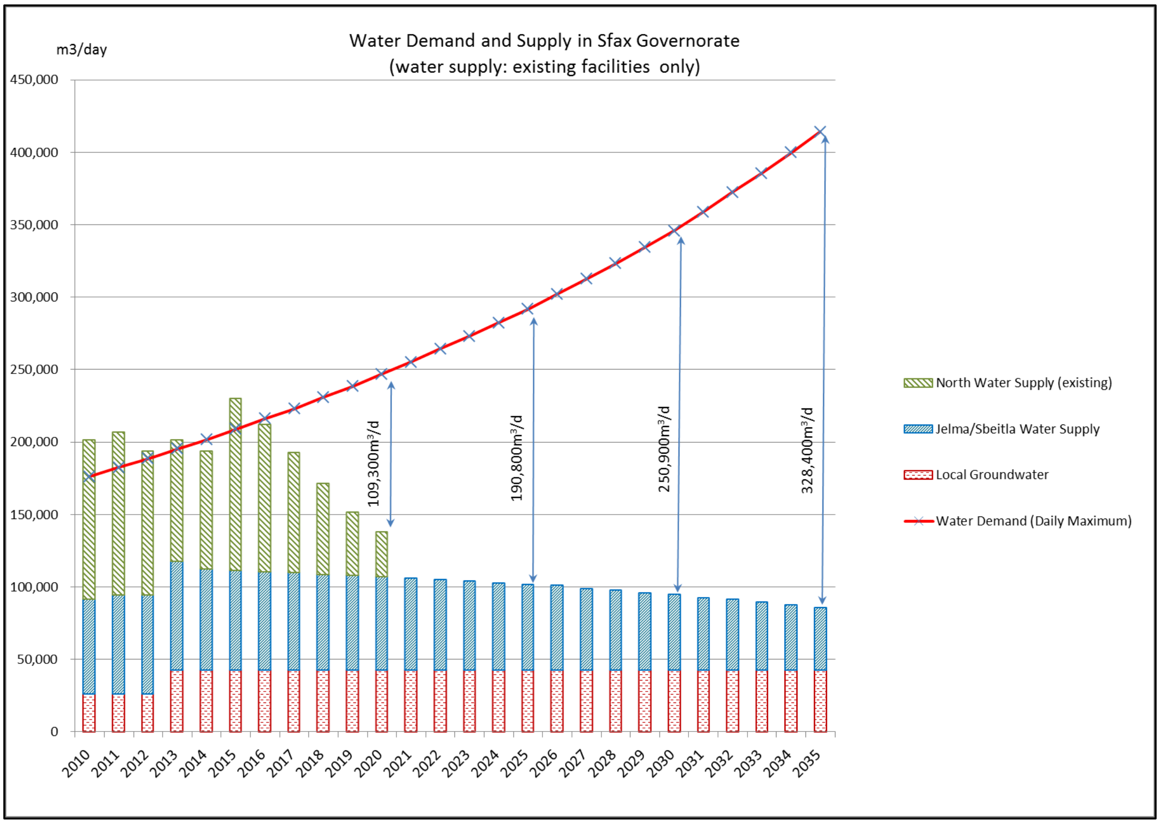
(m^3/day)		2015	2020	2022	2025	2030	2035
Available Water	North Water Transmission	119,000	30,900	0	0	0	0
	Jelma-Sbeitla GW Transmission	68,900	64,200	62,000	58,700	52,400	43,400
	Local Groundwater	42,400	42,400	42,400	42,400	42,400	42,400
	Total	230,300	137,500	104,500	101,100	94,900	85,800
Daily Maximum Water Demand		208,800	246,800	264,500	291,900	345,800	414,200
Balance		21,400	▲109,300	▲160,000	▲190,800	▲250,900	▲328,400

Source: JICA Survey Team (Note: Due to rounding, (available volume-demand) is not equal to Balance.)

Table 4.5-3 Water Balance in Sfax Governorate (existing facilities + new facilities)

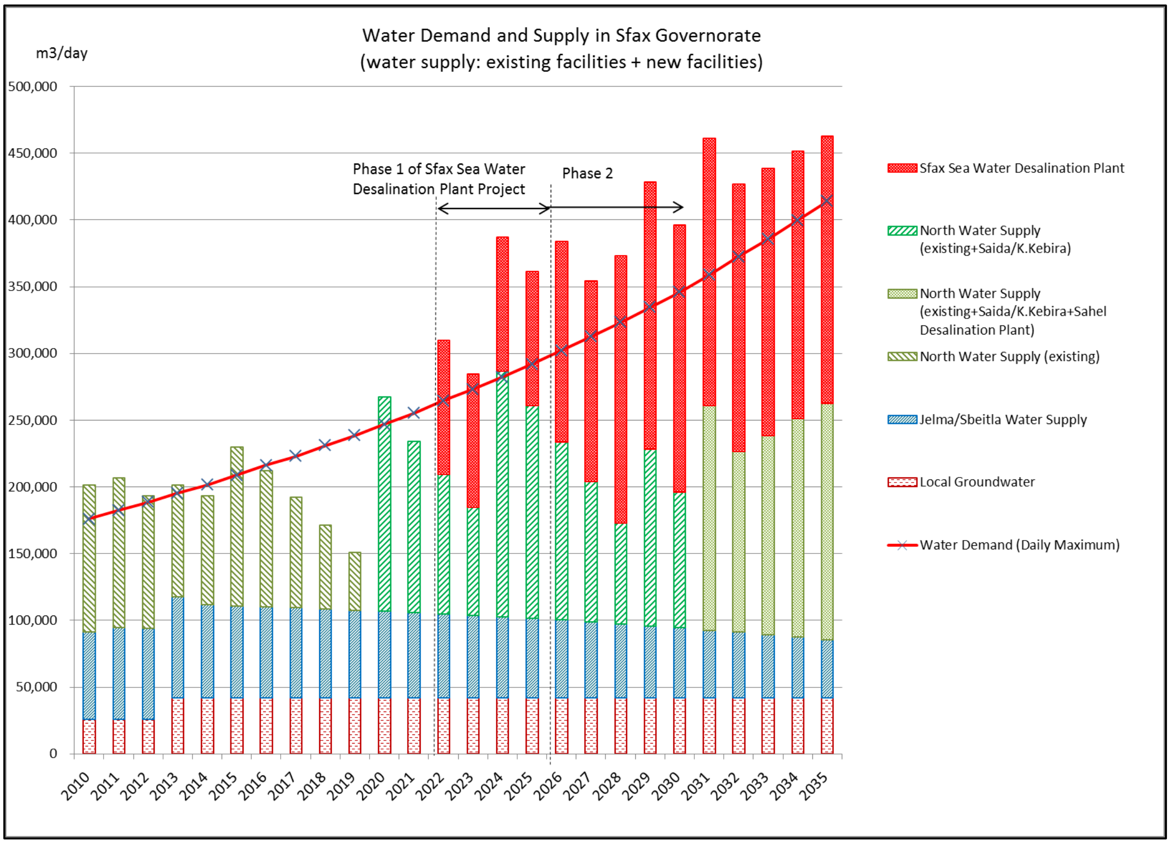
(m^3/day)		2015	2020	2022	2025	2030	2035
Available Water	Sfax Desalination Plant	0	0	100,000	100,000	200,000	200,000
	North Water Transmission	119,000	160,500	105,000	159,800	101,500	176,900
	Jelma-Sbeitla GW Transmission	68,900	64,200	62,000	58,700	52,400	43,400
	Local Groundwater	42,400	42,400	42,400	42,400	42,400	42,400
	Total	230,300	267,100	309,400	360,800	396,400	462,700
Daily Maximum Water Demand		208,800	246,800	264,500	291,900	345,800	414,200
Balance		21,400	20,300	45,000	69,000	50,600	48,500

Source: JICA Survey Team



Source: JICA Survey Team

Figure 4.5-1 Water Demand and Supply in Sfax Governorate (water supply: existing facilities only)



Source: JICA Survey Team

Figure 4.5-2 Water Demand and Supply in Sfax Governorate (water supply: existing facilities + new facilities)

Figure 4.5-1 indicates the water balance of demand and supply in the Sfax Governorate in case new facilities or new water sources development formulated by the Strategic Study will not be implemented. Water supply for the existing facilities is estimated with the maximum conveyance amount. Under this condition, a large amount of water shortage is confirmed. The shortage will be at 109,300 m^3/d in 2020, 190,800 m^3/d in 2025, 250,900 m^3/d in 2030, and 328,400 m^3/d in 2035, respectively.

Figure 4.5-2 indicates the water balance in case the new facilities or new water sources development formulated by the Strategic Study will be implemented. As a result, water supply amount satisfies the demand by the new facilities. However, as mentioned in Section 4.4.4(2), shortage will still occur from 2017 to 2019. The issue during this period is discussed in Section 4.7

Large variation of water supply volume from the North Water Transmission System is the result of the balance between yearly water demand increasing and water supply being increased through three times expansion of the Kalaa Kebira Water Treatment Plant. In addition, operation of the Sahel Seawater Desalination Plant will start from 2031.

4.5.2 Issue on Water Supply in Sfax Governorate

The issue on water supply plan in the Sfax Governorate is similar to the one in the Greater Sfax (see Section 4.6.3).

4.6 Water Demand and Supply in Greater Sfax

4.6.1 Present Water Supply System in Greater Sfax

The water facilities in the Greater Sfax were constructed for supplying water only to Sfax Ville in 1956, the year Tunisia gained independence. Every year thereafter, the service area has been expanded to the outer area of Sfax Ville. At the beginning, the water source was the groundwater in Sidi Bouzid which was relatively of good quality and with abundant flow. The groundwater was transmitted to two reservoirs of PK11 and PK10, then to Sfax Ville. Together with an expansion of the city, water supply was expanded and had to be supplied to higher altitude where newly developed residential areas sprung. Due to that reason, new expansion plan of water supply was formulated.

According to the "Plan of Distribution Networks and Distribution in Greater Sfax" prepared from 2003 to 2005, water was supplied from five reservoirs such as PK11, PK10, PK14, Bou Merra, and Sidi Salah EH (see Figure 4.6-1). The facilities were developed by following the Plan such as the expansion of Sidi Salah EH Reservoir and land acquisition for Sidi Salah EB Reservoir. Currently the Sidi Salah EB Reservoir is being constructed.

Figure 4.6-1 presents the existing distribution network. The expansion of distribution network is implemented in accordance with the "Plan of Distribution Networks and Distribution in Greater Sfax". The expansion is delayed as compared to the plan. At present, Lot 1 and 2 indicated in Figure 4.6-1 are being implemented. For rehabilitation of the existing pipes, there is no effective plan at this moment. One of the major reasons is that the rehabilitation is not considered as a serious issue is because the network performance rate is as high as 84% (see Table 4.6-1).

The Greater Sfax is poor in terms of water resources. It avoids having to deal with water shortages by optimally operating a system that transmits / supplies excess water to an area that has an impending shortage.

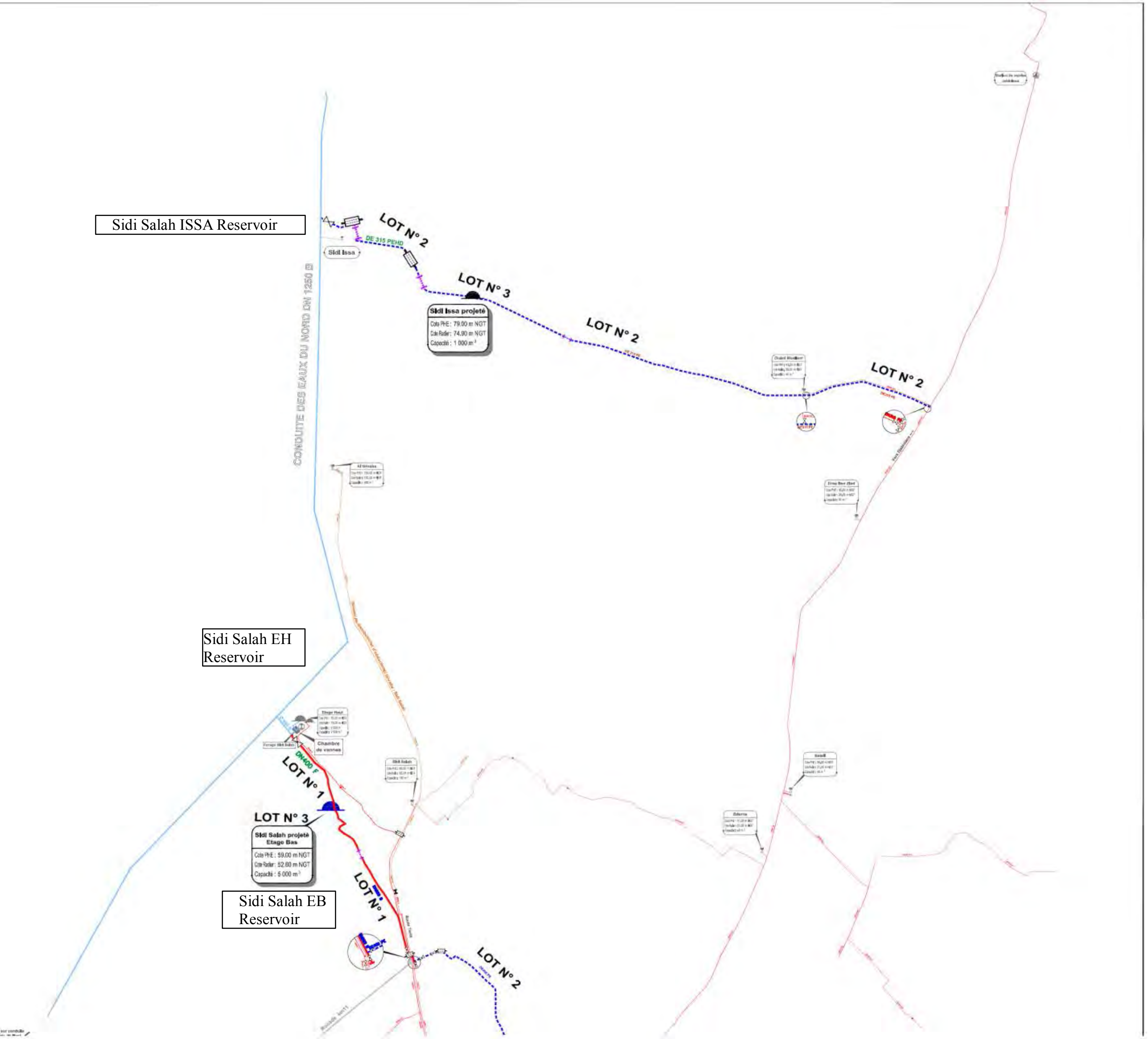


Figure 4.6-1

Outline of the Water Supply System Development Plan in Greater Sfax in 2013 (1/2)

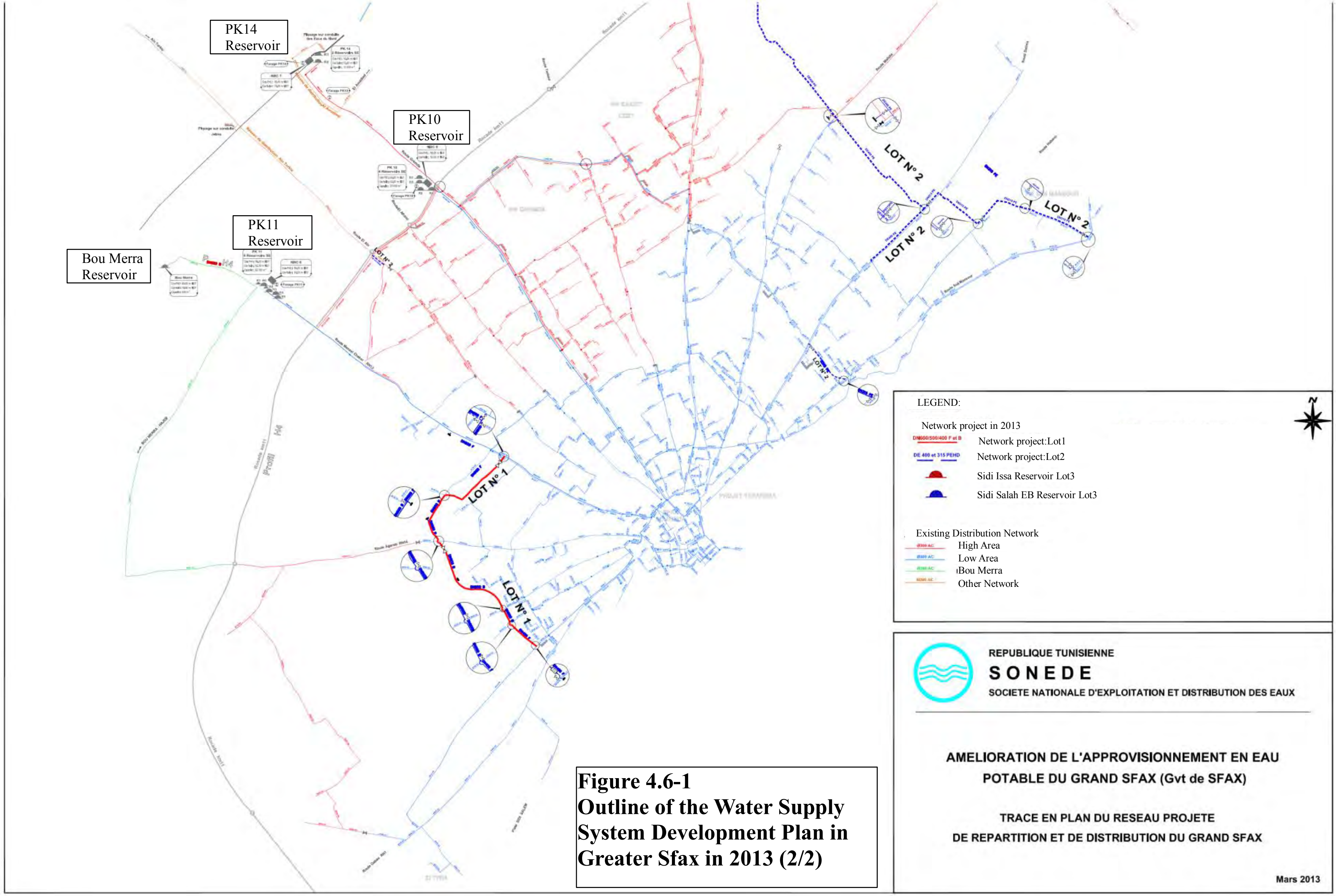


Figure 4.6-1
Outline of the Water Supply System Development Plan in Greater Sfax in 2013 (2/2)

Source: SONEDE

As shown on Table 4.6-1, more than half of the total length of distribution pipes in the Greater Sfax is occupied by asbestos cement pipe. Old pipes with more than 40 years age make up around 20% of total pipe length. Recent increasing tendency of breakage and leakage implies deterioration of said pipes. It is necessary to promote the replacement of old pipes, especially asbestos cement pipes.

Table 4.6-1 Present Status of Distribution Pipelines

Age and Materials of pipes as of September 2014

Diameter (mm)	Length (m)	Ratio	Length by Age (m)						Length by Materials (m)					
			0-10 (yrs)	11-20 (yrs)	21-30 (yrs)	31-40 (yrs)	41-50 (yrs)	51yrs or more	Asbestos Cement	PE/PVC	Cast Iron	Ductile Cast Iron	Concrete	Others
60	11,000	0.6%					6,000	5,000	6,000			5,000		
63	18,000	0.9%	3,000	14,000	1,000					18,000				
75	0	0.0%												
80	430,000	21.8%		50,000	109,000	149,000	110,000	12,000	400,000			30,000		
90	149,000	7.6%	75,000	67,000	7,000					149,000				
100	376,000	19.1%		1,000	195,000	155,000	18,000	7,000	357,000			19,000		
110	345,400	17.5%	101,000	67,000	4,700	172,700				345,400				
150	154,587	7.8%		22,187	32,000	40,000	59,000	1,400	81,187			73,400		
160	30,000	1.5%	10,000	14,000	6,000					30,000				
200	178,100	9.0%	40,800	14,400	15,000	42,300	47,500	18,100	100,800	59,200		18,100		
250	28,391	1.4%			17,000	5,391	6,000		22,391			6,000		
300	137,065	7.0%		3,565	36,700	50,500	26,300	20,000	115,265			21,800		
315	44,000	2.2%	36,000	6,000	2,000					44,000				
350	4,314	0.2%				1,314	3,000		1,314			3,000		
400	6,094	0.3%				1,694	4,400					6,094		
500	17,561	0.9%				12,000	5,561				5,561	7,300	4,700	
600	12,606	0.6%				5,500	7,106					5,500	7,106	
800	22,604	1.1%			1,000	3,000	18,604						22,604	
1000	5,240	0.3%				3,240	2,000						5,240	
1250	810	0.0%				810							810	
Total	1,970,772	100.0%	265,800	259,152	426,400	642,449	313,471	63,500	1,083,957	645,600	5,561	195,194	40,460	0
			13%	13%	22%	33%	16%	3%	55%	33%	0%	10%	2%	0%

Statistics breaks and leaks per year from 2002

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Network Performance per year:	84.4	84.5	87.4	87.6	87.5	86.6	86.5	84.7	80.7	79.8	79.4	84.0
Number of breakages per year:	706	791	836	881	642	679	872	845	741	789	683	711
Number of leakages per year:	9,150	8,920	9,531	8,376	8,601	8,749	11,027	11,525	13,102	10,663	10,717	14,818

Source: SONEDE (2014)

4.6.2 Water Demand and Supply in Greater Sfax

Water demand in the Greater Sfax is estimated as the population ratio between the Sfax Governorate and the Greater Sfax. Because the distribution data was not obtained, the demand was estimated with data between 2010 and 2012.

The Greater Sfax, where 2/3 of population in the Sfax Governorate lives, is mainly an urbanized area in the Sfax Governorate. In the future, the population in the Governorate is expected to increase. Basically water supply in the Greater Sfax is estimated as per conditions mentioned in Section 4.5.2. However, there are some special conditions in the Greater Sfax to be noted as follows.

1) On the way to the Greater Sfax, some amount of water from North Water Transmission System is distributed to north of the Sfax Governorate. The remaining water is conveyed to the Greater Sfax.
2) On the way to the Greater Sfax, some amount of water from Jelma-Sbeitla Groundwater Transmission System in Sidi Bouzid Governorate, the west of the Sfax Governorate is distributed to the western part of the Sfax Governorate. The remaining water is conveyed to the Greater Sfax.
3) The Greater Sfax is the main urbanized area in the Sfax Governorate. However, the water is not supplied to the Greater Sfax with the highest priority. The concept on the equal treatment to the residents is applied.

Water demand and supply were reviewed with the condition mentioned above. The result is presented in in Tables 4.6-2 to 4-6-4, and Figures 4.6-2 and 4.6-3.

Table 4.6-2 Outline of Water Supply Plan in Greater Sfax

	Present (2012)	Yr 2025	Yr 2030	Yr 2035
1) Service Area	3,069 ha	3,069 ha	3,069 ha	3,069 ha
2) Population Served	631,900	737,900	782,100	826,300
3) Maximum Daily Water Supply	117,200 m^3/d 1,356 L/s	187,900 m^3/d 2,175 L/s	224,400 m^3/d 2,597 L/s	270,900 m^3/d 3,135 L/s
4) Average Daily Supply	83,700 m^3/d 969 L/s	134,200 m^3/d 1,553 L/s	160,300 m^3/d 1,855 L/s	193,500 m^3/d 2,240 L/s
5) Average Per Capita Supply	132 L/d/person	182 L/d/person	205 L/d/person	234 L/d/person
6) Non-domestic use (%)	18	18	18	18
7) Non-revenue Water (%)	24	22	21	20
8) Per Capita Consumption	91 L/d/person	126 L/d/person	144 L/d/person	165 L/d/person

Source: JICA Survey Team

Table 4.6-3 Water Balance in Greater Sfax (existing facilities only)

(m^3/day)		2015	2020	2022	2025	2030	2035
Available Water	North Water Transmission	95,200	24,700	0	0	0	0
	Jelma-Sbeitla GW Transmission	31,000	28,900	21,700	20,600	18,300	15,200
	Local Groundwater	25,100	26,100	26,100	26,100	26,100	26,100
	Total	151,400	78,700	46,800	45,700	43,500	40,300
Daily Maximum Water Demand		133,700	157,900	169,500	187,900	224,400	270,900
Balance		17,700	▲79,200	▲112,700	▲142,200	▲180,900	▲230,500

Source: JICA Survey Team

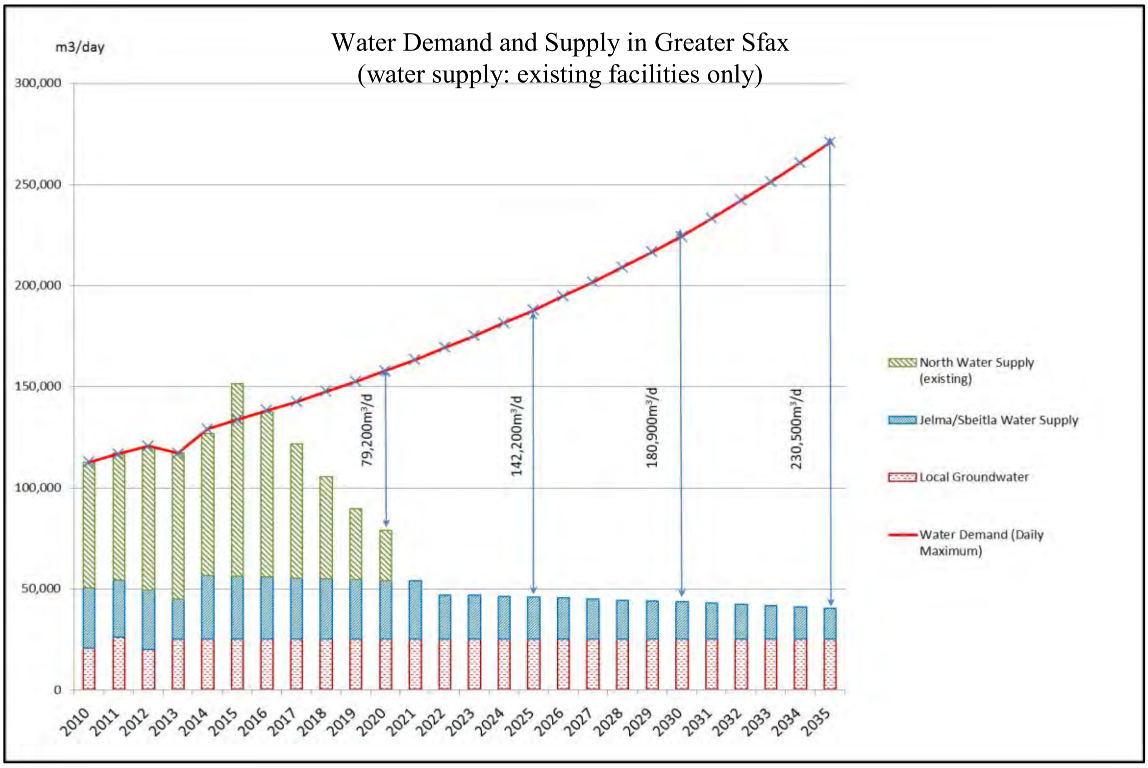
Table 4.6-4 Water Balance in Greater Sfax
(existing facilities + new facilities)

(m^3/day)		2015	2020	2022	2025	2030	2035
Available Water	Sfax Desalination Plant	0	0	100,000	100,000	200,000	200,000
	North Water Transmission	95,200	128,400	65,100	75,100	29,500	67,200
	Jelma-Sbeitla GW Transmission	31,000	28,900	21,700	20,600	18,300	15,200
	Local Groundwater	25,100	26,100	26,100	26,100	26,100	26,100
	Total	151,400	182,400	211,900	220,800	272,900	307,600
Daily Maximum Water Demand		133,700	157,900	169,500	187,900	224,400	270,900
Balance		17,700	24,500	42,400	32,900	48,500	36,700

Source: JICA Survey Team

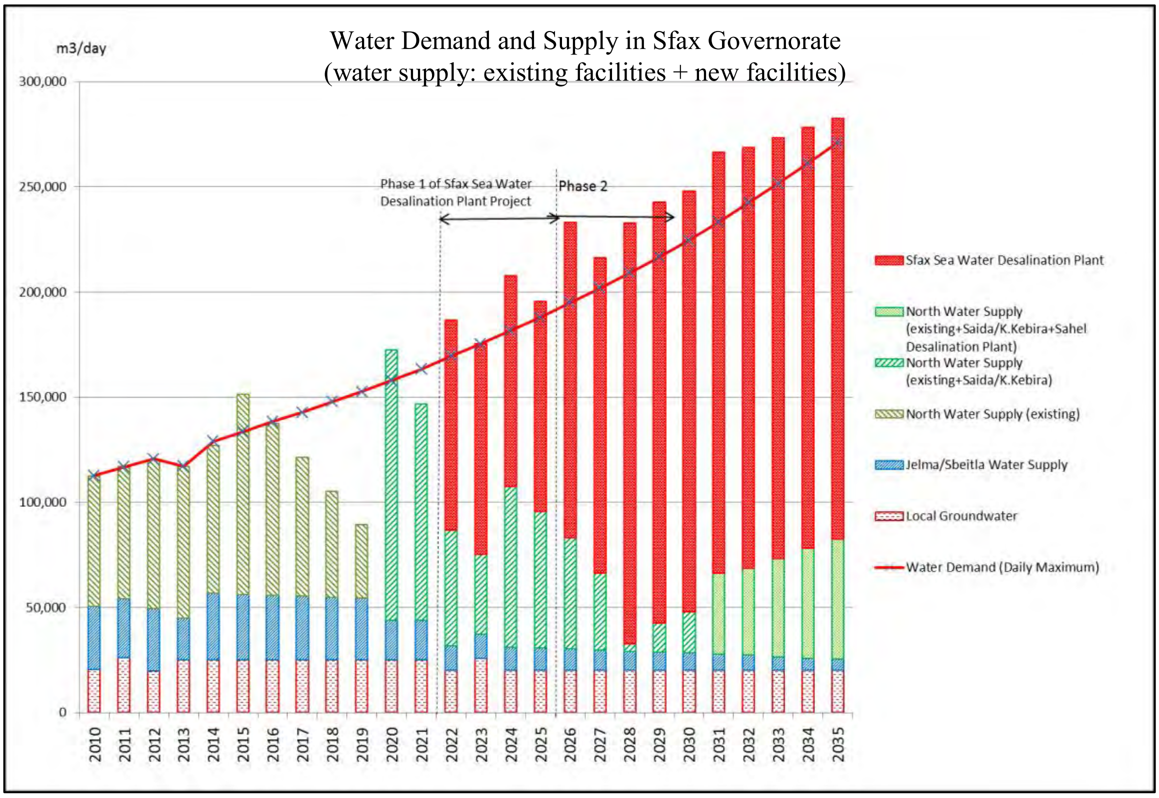
Figure 4.6-2 indicates water balance of demand and the supply in the Greater Sfax in case the new facilities or the development of new water sources formulated by the Strategic Study are not implemented. Water supply for the existing facilities is estimated under the maximum conveyance condition. Under this condition, a large amount of water shortage is confirmed. The shortage will be at an amount of 79,200 m^3/d in 2020, 142,200 m^3/d in 2025, 180,900 m^3/d in 2030, and 230,500 m^3/d in 2035, respectively.

Figure 4.6-3 indicates the balance in case the new water sources developments formulated by the Strategic Study are implemented. The water supply volume shown in Figure 4.6-3 was assumed with the conditions that water volume equivalent to half of pumpage in the Greater Sfax is reduced from water supply of the North water transmission system and the same from the Jelma-Sbeitla groundwater transmission system, As a result, water supply amount satisfies the demand by the new facilities. As mentioned in Section 4.4.4 (2), however, shortage will occur from 2017 to 2019. The issue on this water shortage is discussed in Section 4.7.



Source: JICA Survey Team

Figure 4.6-2 Water Demand and Supply in Greater Sfax (water supply: existing facilities only)



Source: JICA Survey Team

Figure 4.6-3 Water Demand and Supply in Greater Sfax
(water supply: existing facilities + new facilities)

Appropriateness of water demand per capita shown on Table 4.6-2 was reviewed. As a result, the estimated value was considered to be appropriate as presented by the following reasons:

i) Served populations estimated for 2012 to 2035 show an increase of 1.3 times, while per capita water demand increases 1.8 times; i.e. 91 L/capita/day in 2012 to 165 L/capita/day in 2035. Though the increase rates are different, the estimated value of the water demand per person is considered to be appropriate because the improvement of the future living standard can be brought in by an increase in consumption.

ii) Regarding per capita consumption in 2035, the North Water Transmission System's seven governorates, the Sfax Governorate, and the Greater Sfax shows different figures. The ratio is 1.00 : 1.24 : 1.02. Table 4.6-5 presents the per capita consumption in 2012, and that of the Sfax Governorate is higher than that of seven governorates. It is appropriate because of relatively high income level of the Greater Sfax as the second largest city in Tunisia.

Table 4.6-5 Population of Seven Governorates and Per Capita Consumption (Daily Average) (2012)

	Population			SONEDE Service Population			Domestic	Total
	Urban (1000)	Rural (1000)	Total (1000)	Urban (1000)	Rural (1000)	Total (1000)	(lpcd)	(lpcd)
Nabeul	517.2	262.2	779.4	517.2	163.3	680.5	97	136
Ratio				*100.0%*	*62.3%*	*87.3%*		
Sousse	528.4	120.3	648.7	528.4	95.4	623.8	108	140
Ratio				*100.0%*	*79.3%*	*96.2%*		
Monastir	539.3	0.0	539.3	539.3	0.0	539.3	90	124
Ratio				*100.0%*	-	*100.0%*		
Mahdia	177.1	217.9	395.0	177.1	161.2	338.3	105	130
Ratio				*100.0%*	*74.0%*	*85.6%*		
Sfax	624.2	338.9	963.1	624.2	199.9	824.1	114	139
Ratio				*100.0%*	*59.0%*	*85.6%*		
Kairouan	192.0	377.4	569.4	192.0	159.3	351.3	69	82
Ratio				*100.0%*	*42.2%*	*61.7%*		
Sidi Bouzid	106.6	311.7	418.3	106.6	91.7	198.3	82	100
Ratio				*100.0%*	*29.4%*	*47.4%*		
Total	2,684.8	1,628.4	4,313.2	2,684.8	870.8	3,555.6	99	128
Ratio				*100.0%*	*53.5%*	*82.4%*		

Source: RAPPORT DES STATISTIQUES, SONEDE lpcd: Litre Per Capita Per Day

iii) Regarding per capita consumption in the Greater Sfax, however, is lower than that of Sfax governorate. The reason of this lower consumption seems to be many students in the Greater Sfax. Students consume rather lower water volume and they leave Sfax for long vacation.

iv) According to Table 4.6-6, water consumption in Tunisia is relatively not high compared to the other countries. It cannot be simply concluded that water consumption is proportional to GNI per capita. However, it is clear that the tendency between two values exists. In Tunisia, the water consumption per capita has been increasing and the trend can continue in the future, as the increase of the living standard goes hand in hand with an economic development. For these reasons, the estimated values of the water consumption are considered to be appropriate.

Table 4.6-6 Per Capita Water Demands in Various Countries

Region	Country	Year	Per Capita Annual Water Consumption (m^3/person/year)	**Per Capita Water Consumption (L/person/day)**	GNI (US$/person/yr)	Population (million)
Africa	Algeria	2000	38	103	1,540	35.42
	Egypt	2000	62	169	1,470	84.47
	Morocco	2000	39	107	1,320	32.38
	Tunisia	**2000**	36	**98**	2,310	**10.37**
North/Middle America	USA	2005	193	528	46,350	317.64
Asia	Afghanistan	2000	14	39	210	29.12
	Bangladesh	2008	25	70	560	141.82
	India	2010	46	126	1,290	1,214.46
	Iran	2004	85	232	2,170	75.08
	Israel	2004	97	265	18,790	7.29
	Japan	2000	137	375	37,150	127.00
	Malaysia	2000	54	149	3,420	27.91
	Oman	2003	45	125	8,610	2.91
	Pakistan	2008	52	143	990	184.75
	Philippine	2006	62	171	1,300	93.62
	Turkey	2003	78	**215**	3,810	75.71
Europe	France	2000	83	228	24,270	62.64
	Spain	2002	111	303	15,120	45.32

Source: Prepared by JICA Survey Team based on FAO data

4.6.3 Issues on Water Supply Plan in Greater Sfax

(1) Water supply sources in Greater Sfax

Water supply sources in the Greater Sfax are; surface water in the North Water Transmission System, and groundwater in Sidi Bouzid Governorate and in the Sfax Governorate. Detailed explanations of each source are as follows:

i) In the north of Tunisia, the surface water can be utilized from dam reservoirs by storing relatively high precipitation. After the treatment at Belli Water Treatment Plant, the water is transmitted by the North Water Transmission System from the north to seven Governorates located at the central and the south areas. The Greater Sfax is located at the lowermost area of the system. Therefore, the remaining water flows to the Greater Sfax after extracting the necessary water volume in the upper stream.

ii) Groundwater produced in Jelma and Sbeitla located in Sidi Bouzid Governorate does not contain a high concentration of salinity. The groundwater is consumed in Sidi Bouzid Governorate, then transmitted to the Greater Sfax.

iii) Groundwater in the Sfax Governorate is pumped up from deep wells owned by SONEDE. Because of fear of exhausting groundwater resource, extraction is with the special permission from the MOA. The issues are the limited amount of the extraction and a high content of salinity at around 3000 mg/L as TDS.

As stated in Sections 1.5 and 5.1.1, SONEDE has operated five brackish water desalination plants in the Gabes Governorate and the Medenine Governorate. There is no desalination plant in the Sfax

Governorate and northward except the one in Kerkenah Island.

(2) Issues on water shortage in Greater Sfax

The Greater Sfax suffered serious water shortage in summer 2012. The reasons of the shortage were; i) the functions of the transmission pumping station in the North Water Transmission System were stopped due to planned power cut for five times from July 9 to 11, 2012, ii) a decrease in water transmission volume in North Water Transmission System due to an increase in water demand in the upper stream, and iii) a decrease in water transmission volume from Sidi Bouzid Governorate due to drought. In order to avoid recurrence of such situation SONEDE and STEG agreed to exempt the transmission pumping station in the North Water Transmission System from planned power cut.

Currently SONEDE extracts groundwater at a limited rate in order to supply only the required amount. The Greater Sfax, however, is believed to have serious shortage after 2018 due to decreased water volume to be transmitted from the North Water Transmission System and the Jelma-Sbeitla Groundwater Transmission System.

(3) Water Supply

Figure 4.6-2 presents the water supply in Sfax Water Supply System. The water supplies from the North Water Transmission System and the Jelma-Sbeitla Groundwater System to the Greater Sfax are expected to decrease caused by an increase in water demand in upstream areas of the North Water Transmission System every summer after 2021. As a result, the Greater Sfax will not receive any water from the North Water Transmission System from the said period onward.

(4) Water balance of demand and supply

As shown in Figure 4.6-2, the Greater Sfax will have the water shortage of 79,200 m^3/d in 2020 if new water resources will not be developed. It is obvious that the shortage will increase without new water sources.

4.7 Appropriateness of Capacity and Location of Sfax Seawater Desalination Plant

4.7.1 Capacity of Facility

As formulated in Strategic Study, the water demand in the seven governorates can be fulfilled by the Kalaa Kebira Water Treatment Plant and the Sfax Seawater Desalination Plant.

As mentioned in Section 4.4.2, the capacity of the facilities is planned to be increased by phases. Capacity of the Kalaa Kebira Water Treatment Plant will be increased to 4,000L/sec or 345,600 m^3/day through phased development.

For the Sfax Seawater Desalination Plant, phased development was planned by in the Strategic Study. As a result of examination, it was found that augmentation of the plant with a capacity of 100,000 m^3/d will meet to the demand till 2026. Only in 2023, however, water shortage requires temporary excessive pumpage of groundwater. If the phase 2 project with a total capacity of 200,000 m^3/d is completed in 2026, water supply capacity will meet the water demand up to 2035 as presented in Figure 4.4-3, provided the Sahel desalination Plant will be completed in 2031. Therefore, total capacity of the Sfax Desalination

Plant shall be 200,000 m^3/d when the target year is set as 2035. In this survey it is assumed that the capacity of the plant to be augmented is 100,000 m^3/d. Required augmentation capacity of the plant, however, is 35,000 m^3/d in 2026, 50,000 m^3/d in 2027, and 80,000 m^3/d in 2028. Therefore, it is possible to construct the plant with further sub-phases. It shall be judged based on the increase of demand and water supply capacity in the future.

However, there is water shortage in the seven governorates in the North Water Transmission System, especially four governorates including Sousse and southward, if the Kalaa Kebira water treatment plant is not constructed. In that case, the construction of the Sfax Seawater Desalination Plant with a full capacity of 200,000 m^3/d in Phase 1 should be considered, but be constructed and operated at 100,000 m^3/d at first for the following reasons.

- The construction cost of sea water desalination plant at 200,000 m^3/d is relatively high.
- SONEDE does not have any operational experience for the sea water desalination plant. Therefore, it is more practical to obtain the O&M technique of the sea water desalination plant through a smaller capacity of 100,000 m^3/d. After obtaining the technique and experience, the facility can be expanded.
- If the construction of the Kalaa Kebira water treatment plant is delayed and operated until 2023, the water supply will exceed 100,000 m^3/d. As a result, the Sfax Seawater Desalination Plant will not be operated because the production cost of water is more expensive than the Kalaa Kebira water treatment plant. At present, it has potential for being over financed if the Sfax Seawater Desalination Plant at 200,000 m^3/d is constructed in Phase 1.

4.7.2 Appropriateness of Location

The Sfax Governorate is located in the most down stream's tail end of the North Water Transmission System and the Jelma-Sbeitla Groundwater System. As a result, the water supply volume in the Sfax Governorate affects the water demand in the upstream areas. If the water demand in the upper stream increases, the supply flow to the Sfax Governorate decreases. Therefore, it is relevant to install a sea water desalination plant in the Greater Sfax, a largest urban area in the Sfax Governorate.

4.7.3 Measures against Water Shortage

Sfax seawater desalination plant is planned commence operations from October 2022 (see Chapter 10). While, commissioning of the Kalaa Kebira water treatment plant is expected in 2020. Before its operation, the water shortage is expected in the Greater Sfax from 2017 to 2019. There is no fundamental solution against this water shortage. However, there are some mitigation measures as described in the following.

(1) Countermeasure by supplier

1) Reduction of NRW

SONEDE has been making effort continuously for reducing NRW. This continuous effort can still increase transmission and distribution amount of water. Although NRW in the Greater Sfax is not relatively high at 16% in 2013, it is possible to utilize the limited resource as much as possible with continuous effort to reduce leakage.

2) Formulation of action plan on water shortage

Customer complaints due to water shortage will be more serious if the water supply is cut off for a number of hours without prior notice. For mitigating this aspect, Water Shortage Contingency Plan (WSCP) should be formulated. This plan shall consist of controlling water demand during the shortage and other necessary actions by SONEDE including a public information campaign to inform customers of strategies and actions to mitigate the negative impacts of the shortage. to national life, public property, industries, and tourism together with securing necessary public health. In general, WSCP will be prepared in stages.

<u>Ex. Phased water demand reduction plan</u>

This plan presents the countermeasures in four stages in a severity of the water shortage. The stages include various communication, internal operation, and demand control.

(i) Stage on advice: The customers shall be informed for the potential date when the shortage occurs.

(ii) Stage on self-action: When the water supply is not sufficient, the plan moves to the stage on self-action. In this stage, the mitigation amount until the target is dependent on voluntary cooperation by customers. The self-action by customers shall be proposed in this stage.

(iii) Stage on obligation: The plan moves to the stage on obligation if the stage on self-action does not achieve the target. The stage on obligation is to prohibit specific actions. Avoiding the difference in areas, the water stoppage shall be applied after the plan is disseminated.

(iv) Stage on emergency reduction: The stage on emergency reduction shall be applied with a combination of stage on obligation and the additional charge when the most serious situation occurs. This is the final stage, only applicable when severe shortage and emergency situation in facilities are observed.

3) Temporary use of groundwater

The further utilization of groundwater in the Greater Sfax is practically prohibited. If groundwater extraction is temporarily permitted for the five years between 2017 and 2021,water may contain high salinity. In order to utilize such water, the package type desalination plant will be required, which is explained below:

4) Installation of package-type sea water desalination plant

If the budget is available, it is proposed that a number of small package type sea water desalination plants are to be installed. In case this plant is installed, intake and discharge facilities shall be of temporary type because of emergency use. This type of the plant can be operated from place to place.

(2) Measures by customers

1) Public awareness program for water conservation

SONEDE has started the public awareness program directed to costumers in order to raise the water savings by distributing water saving stickers. It is recommended that the activities by CM on TV and the initiatives with the other organization be conducted in order to transform awareness to action of water saving in national wide.

The water demand in the seven governorates in the North Water Transmission System will reach to 865,900 m^3/d in 2019. The shortage is 75,300 m^3/d. If the water supply in the area of the upper stream satisfies the consumption, the shortage in the region will be equal to the shortage in the Greater Sfax. On the other hand, if the water consumption in the seven governorates is reduced at 9% by the efforts on the saving, the shortage in the Greater Sfax will not occur. In addition, no serious water shortage will also occur if the water consumption in Tunis, a capital of Tunisia, is reduced. In order to achieve the reduction, it is suggested that the public awareness of water conservation in Tunis be conducted.

a) CM on TV

CM on TV introduces the reduction of shower time, washing dishes by using basins, and installation of water saving apparatus at a tap and a shower head.

b) Water volunteer groups

Volunteers have important roles in the regions. Water volunteer groups consisted of volunteers and students who shall visit household. After observing the actual water utilization, they will introduce the procedure of water savings. The activities of the group are explained as an example:

At first, SONEDE or local government establishes community-based water volunteer groups. The groups will cooperate with SONEDE or schools to promote water conservation methods through public awareness programs. As a next step, the groups shall educate households not only focusing the water conservation procedure but also on simple water consumption monitoring. If the water consumption is monitored, leakage or water utilization issue may be predicted by comparing actual water consumption to the average.

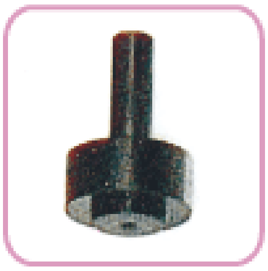
If leakage is observed at taps, the taps should be repaired immediately in order to reduce the loss. The water savings in daily life will be possible by carrying out by shortening shower time, recovery of rinse water from washing machine for utilization for toilet flushing or floor cleaning, reduction of toilet flush water.

2) Installation of water saving equipment

Water conservation devices stated below are effective to reduce daily water consumption.

- Water will be saved as much as 30 % if a small apparatus, made of O ring and mesh-type gauze, is inserted to a tap. This apparatus could contribute a significant water savings if household, schools, governmental buildings, and commercial buildings are installed. In 2010, 76,494 devices were provided by the environmental agency of Abu Dhabi government to tourist club area to reduce their water consumption[4].

- In Japan, it is recommended to use a water saving packing, alias washer, at a tap. The bottom part of the packing is bigger than that of normal packing as shown in Figure 4.7-1. This bottom shape of the packing enable reduction of water flow of a tap by 0 to 50% in middle-open condition.



Source: Waterworks Bureau, Tokyo

Figure 4.7-1 Water Saving Packing

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[4] http://gulfnews.com/news/uae/environment/saving-75b-litres-of-water-using-a-dh7-device-1.677234