Republic of Peru
Servicio de Agua Potable y Alcantarillado de Lima

THE PREPARATORY SURVEY ON NORTH LIMA METROPOLITAN AREA WATER SUPPLY AND SEWERAGE OPTIMIZATION PROJECT (II)

FINAL REPORT

September 2011

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD

NIPPON KOEI LATIN-AMERICA and the CARIBBEAN CO., LTD

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JPY: Japanese Yen (¥)
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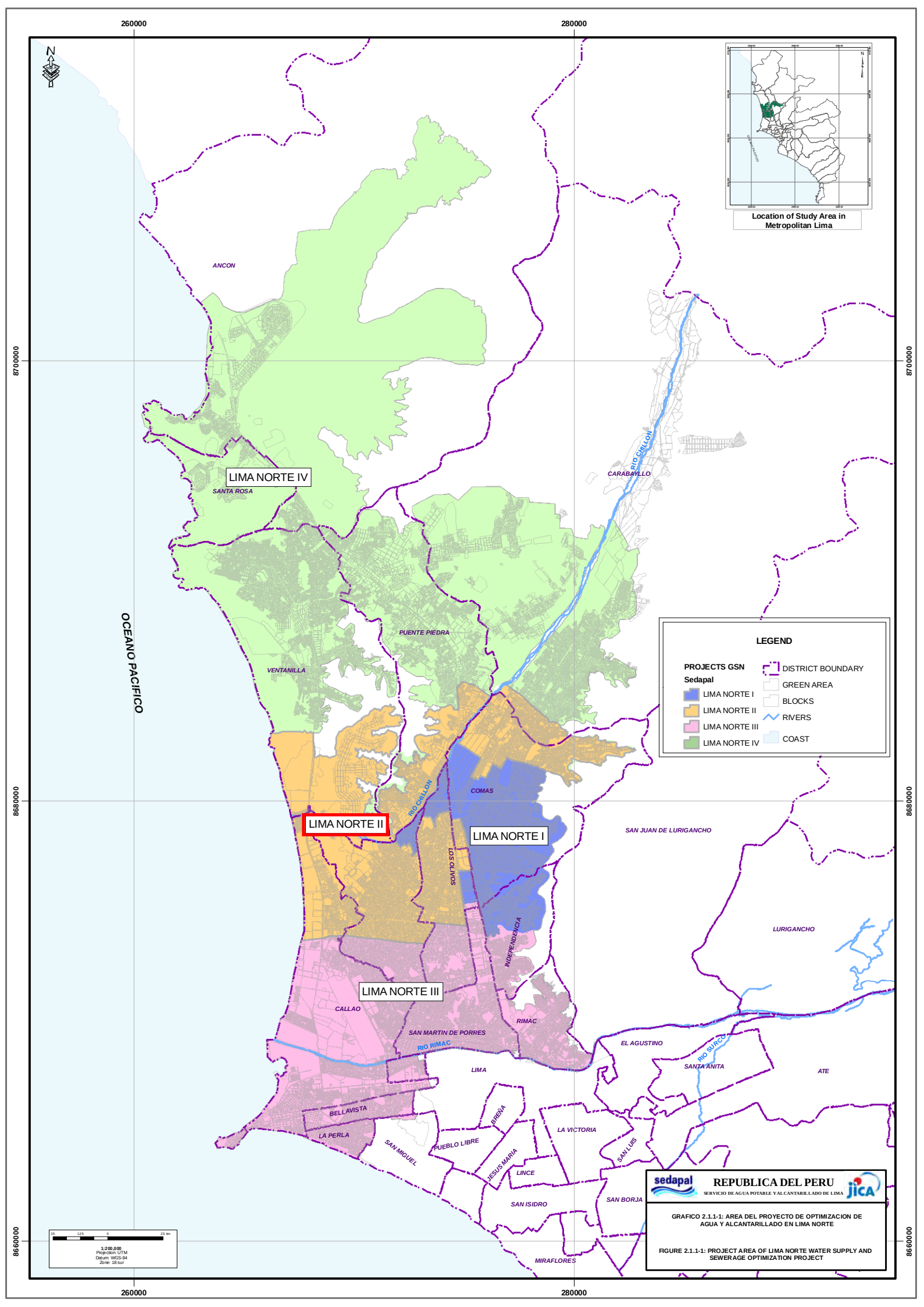
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Location of Study Area in Metropolitan Lima
ANCON
SANTA ROSA
LIMA NORTE IV
CARABAYLLO
RIO CHILLON
PUENTE PIEDRA
VENTANILLA
OCEANO PACIFICO
COMAS
LIMA NORTE II
LIMA NORTE I
LOS OLIVOS
INDEPENDENCIA
SAN JUAN DE LURIGANCHO
LURIGANCHO
LIMA NORTE III
CALLAO
SAN MARTIN DE PORRES
RIMAC
RIO RIMAC
EL AGUSTINO
RIO SURCO
SANTA ANITA
ATE
LIMA
BELLAVISTA
LA PERLA
SAN MIGUEL
PUEBLO LIBRE
BREÑA
JESUS MARIA
LINCE
LA VICTORIA
SAN LUIS
SAN ISIDRO
SAN BORJA
MIRAFLORES
LEGEND
PROJECTS GSN
Sedapal
LIMA NORTE I
LIMA NORTE II
LIMA NORTE III
LIMA NORTE IV
DISTRICT BOUNDARY
GREEN AREA
BLOCKS
RIVERS
COAST
1:200,000
Projection: UTM
Datum: WGS-84
Zone: 18 sur
sedapal
REPUBLICA DEL PERU
SERVICIO DE AGUA POTABLE Y ALCANTARILLADO DE LIMA
JICA
GRAFICO 2.1.1-1: AREA DEL PROYECTO DE OPTIMIZACION DE AGUA Y ALCANTARILLADO EN LIMA NORTE
FIGURE 2.1.1-1: PROJECT AREA OF LIMA NORTE WATER SUPPLY AND SEWERAGE OPTIMIZATION PROJECT

PREPARATORY SURVEY ON
NORTH LIMA METROPOLITAN AREA
WATER SUPPLY AND SEWERAGE OPTIMIZATION PROJECT (II)

FINAL REPORT

TABLE OF CONTENTS

SUPPORTING REPORTS

List of Tables

List of Figures

ABBREVIATIONS

AC	Asbestos Cement
CEI	Cost-Effectiveness Index
CSN	Simple Standardized Concrete
DGPM	General Directorate of Multi-Annual Programs in the Public Sector
DI	Ductile Iron
DIGESA	General Directorate for Environmental Health
DNS	National Sanitation Directorate
EIA	Environmental Impact Assessment
FOFO	Gulvanizd Iron
F/S	Feasibility Study
GSN	North Services Services Management Office
HDPE	High Density Polyethylene
IADB	Inter-American Development Bank
IBRD	International Bank for Reconstruction and Development
INEI	National Statistics and Information Institute
IRR	Internal Rate of Return
JFC	Japan Finance Corporation
JICA	Japan International Cooperation Agency
KfW	Kreditanstalt für Wiederaufbau, KfW Bankengruppe
m.a.s.l.	meters above sea level
MEF	Ministry of Economy and Finances
MPO	Master Plan for Optimization
MVCS	Ministry of Housing, Construction, and Sanitation
MWV	Marginal Water Value
NDPD	National Directorate of Public Debt
NPV	Net Present Value
NRW	Non-Revenue Water
O&M	Operation and Maintenance
ODA	Official Development Assistance
OMA	Office for Environmental Affairs
OPI	Programming and Investments Office
PAHO	Panamerican Health Organization
PAPT	Water for All Program
PIP	Public Investment Projects
PROMESAL	Program of Sanitation Improvement in Marginal Areas of Lima
PVC	Polyvinyl chloride
QMD	Daily Maximum Quantity
QMH	Hourly Maximum Quantity
PVC	Present Value of Costs
RNE	National Sanitation Standard
SCADA	Supervisory Control and Data Acquisition
SEDAPAL	Lima Water and Sanitation Service
SIAC	Integrated Commercial Management System
SNIP	National Public Investment System
SUNASS	National Sanitation Services Superintendency
VAT	Value Added Tax
WACC	Weighted Average Costo of Capital

WPI	Wholesale Price Index
WTP	Willingness to Pay
WTP	Water Treatment Plant
WWTP	Waste Water Treatment Plant

CHAPTER 1 EXECUTIVE SUMMARY

1.1 Name of the Project

"Optimization of the Infrastructure of the Water Supply and Sewerage Systems: Sectorization, Rehabilitation of Networks and Updating of the Cadastre of the North Service Management Office – Area of Influence of the Huachipa Plant – Areas of Drainage of the Sewers: Oquendo, Sinchi Roca, Puente Piedra and Sectors 83, 84, 85 and 212"

1.2 Project Purpose

(1) Realize Continuous Water Supply for Current and Future Demand in the Project Area

- To guarantee the measures to convey water from the Huachipa WTP, that has just started its operation, to the Project area through primary pipes.
- To provide the measures to convey water from the existing wells for emergency purpose in draught season to the Project area through primary pipes (gravity pipes and/or pumping lines).

(2) Improve Operation and Control of Water Supply System

- To sectorize the water supply system in the Project Area with macrometers and pressure control values for better operation.
- To bring the water supply facilities of the Project area under SCADA system for efficient operation and exact control.
- To rehabilitate reservoirs in order to bring them into proper working condition for better control of water pressure.
- To replace water supply pipes not having enough capacity to meet future water demand.

(3) Realize the Target of 25 % for NRW Ratio

- To replace inappropriate water supply distribution pipes (due to age and material damaging) and the pipes that certainty are causing water leakage in order to reduce technical water loss.
- To replace house connections in order to reduce technical water loss mainly caused by water leakage and commercial water loss mainly caused by illegal consumption.
- To install micrometers for exact registration of water consumption for exact and fair tariff collection and monitoring of NRW.

(4) Improve Service Level of Sewerage

- To identify and replace sewers those are in bad condition in order to reduce clogs and collapses.
- To replace sewer pipes not having enough capacity to meet future demand after the construction of Taboada Wastewater Treatment Plant

(5) Improve the Operation and Maintenance Management of SEDAPAL

- To provide necessary equipment for operation and maintenance of water supply and sewerage for improved facilities´ maintenance of SEDAPAL.
- To improve cadastre system of SEDAPAL, in the study area, for more efficient and preventive maintenance work.

- To establish a new team for planning of preventive maintenance to ensure a long-term vision and policy of SEDAPAL's facility maintenance utilizing the improved and updated cadastre system; the team should have the power to request sufficient budget for the implementation of maintenance works in order to maintain the proper function of the existing facilities.

1.3 Supply – Demand Balance of the Project

1.3.1 Demand Analysis

Future demand is analyzed for each sub-sector. It is summarized in two ways: i) water demand of the total study area, and ii) water demand in the water distribution area of the Huachipa Water Treatment Plant (hereinafter "Area of Influence").

Table 1.3.1-1: Target Sectors of the Analysis

District	Sectors included in the Influence Area*1	Sectors not included in the Influence Area*1
Callao	259	256, (258)*2
Ventanilla	-	(260, 261, 262, 263, 264, 265, 266)*2
Carabayllo	350, 351	-
Comas	345, 346, 347, 348A, 348B, 349A, 349B	-
Los Olivos	83A, 83B, 84A, 84B, 85A, 85B, 85C	-
Puente Piedra	368A, 368B, 369A, 369B, 370	361, 368B, 369B, 370
S.M. de Porres	212A, 212B, 213	(251, 252)*2, 253, (254, 257)*2, (255)*2
Total Number	22	19

*1: Some original sectors are proposed to be divided into new sectors in the Study.
*2: Sectors without existing networks
Source: JICA Study Team

The total water demand for the influence area of the Project is shown in Table 1.3.1-2

Table 1.3.1-2: Water demand for the influence area of the Project

YEAR		Total Population	Coverage	Served Population	Total Connections	DEMANDA AGUA					Storage Demand (m^3)
						m^3/day	l/sec	m^3/year	QMD (m^3/sec)	QMH (m^3/sec)	
Base	2009	614,830	64.83%	398,570	77,523	86,739	1,003.92	31,659,723	1.31	1.81	24,386
-5	2010	628,300	68.33%	429,322	83,345	90,192	1,043.89	32,920,135	1.36	1.88	25,250
-4	2011	641,033	71.84%	460,527	89,241	93,124	1,077.83	33,990,353	1.40	1.94	25,981
-3	2012	653,072	75.36%	492,129	95,220	95,799	1,108.79	34,966,726	1.44	2.00	26,647
-2	2013	664,471	78.87%	524,092	101,272	98,194	1,136.50	35,840,728	1.48	2.05	27,249
-1	2014	675,263	82.39%	556,368	107,391	103,473	1,197.60	37,767,555	1.56	2.16	28,568
0	2015	685,495	85.91%	588,932	113,570	94,831	1,097.58	34,613,244	1.43	1.98	26,408
1	2016	695,200	89.43%	621,749	119,805	92,313	1,068.44	33,694,284	1.39	1.92	25,780
2	2017	704,420	92.96%	654,802	126,089	90,659	1,049.29	33,090,379	1.36	1.89	25,361
3	2018	713,186	96.48%	688,068	132,419	94,908	1,098.48	34,641,518	1.43	1.98	26,426
4	2019	721,527	100.00%	721,527	138,790	99,125	1,147.28	36,180,698	1.49	2.07	27,480
5	2020	729,472	100.00%	729,472	140,434	100,384	1,161.85	36,640,219	1.51	2.09	27,795
6	2021	737,074	100.00%	737,074	142,010	101,668	1,176.72	37,108,926	1.53	2.12	28,117
7	2022	744,680	100.00%	744,680	143,587	102,821	1,190.06	37,529,807	1.55	2.14	28,404
8	2023	752,284	100.00%	752,284	145,164	104,095	1,204.81	37,994,800	1.57	2.17	28,723
9	2024	759,883	100.00%	759,883	146,742	105,337	1,219.18	38,447,972	1.58	2.19	29,033
10	2025	767,476	100.00%	767,476	148,318	106,609	1,233.89	38,912,111	1.60	2.22	29,355
11	2026	775,063	100.00%	775,063	149,893	107,907	1,248.92	39,386,043	1.62	2.25	29,675
12	2027	782,399	100.00%	782,399	151,412	109,104	1,262.78	39,823,091	1.64	2.27	29,976
13	2028	789,492	100.00%	789,492	152,878	110,238	1,275.90	40,236,751	1.66	2.30	30,263
14	2029	796,351	100.00%	796,351	154,291	111,428	1,289.68	40,671,257	1.68	2.32	30,558
15	2030	802,983	100.00%	802,983	155,654	112,634	1,303.63	41,111,232	1.69	2.35	30,857
16	2031	809,395	100.00%	809,395	156,969	113,793	1,317.04	41,534,271	1.71	2.37	31,151
17	2032	815,597	100.00%	815,597	158,238	114,919	1,330.08	41,945,456	1.73	2.39	31,428
18	2033	821,597	100.00%	821,597	159,462	115,992	1,342.50	42,337,127	1.75	2.42	31,694
19	2034	827,403	100.00%	827,403	160,645	117,076	1,355.04	42,732,565	1.76	2.44	31,970
20	2035	833,032	100.00%	833,032	161,788	118,107	1,366.98	43,109,044	1.78	2.46	32,225

Source: JICA Study Team

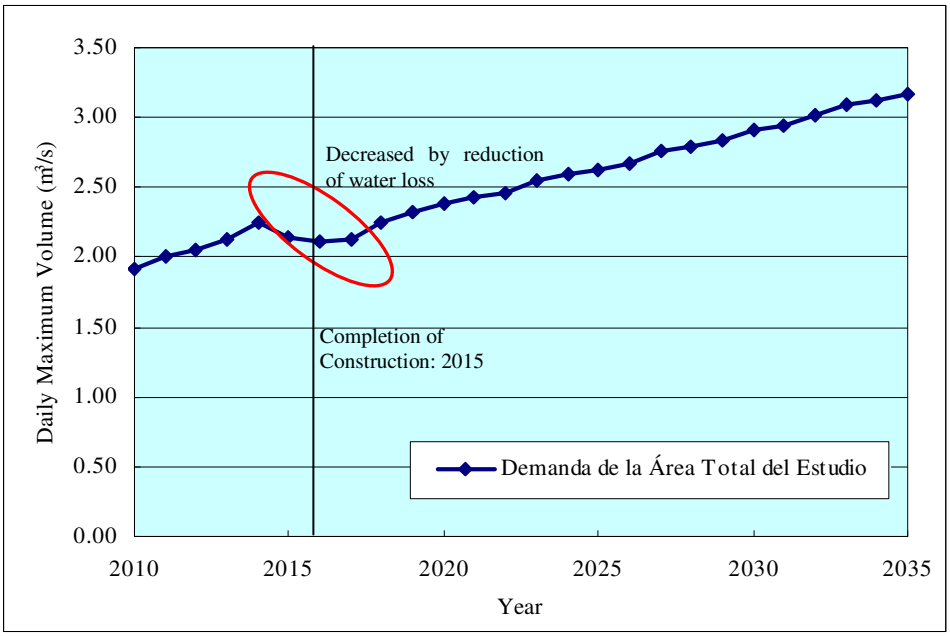
Figure 1.3.1-1 shows that the non-revenue water loss from the distribution system in typical sectors are 50% in the Study Area. As shown in the figure, the technical water loss shall be 20% after the Project from the current 40%, in order to achieve 25% of non-revenue water ratio target.

Therefore, the water demand will decrease immediately after the completion of the construction works of the project (year 2016), as shown in Figure 1.3.1-2.

				Present	After Project		
Total Production	Legal Consumption	Legal Revenue Consumption	Metered Legal Revenue Consumption	35%	75%	Revenue Water	Revenue Water
			Non-metered Legal Revenue Consumption	15%	0%		
		Legal Non-revenue Consumption	Metered&Non-metered Legal Non-revenue Consumption	10-15%	5%	Commercial Loss	Non-revenue Water
	Water Loss	Non-technical Loss	Error of Meter				
			Illegal Consumption	NRW: 50%	NRW: 25%		
		Technical Loss	**Loss in Distribution**	**35-40%** ⇨	**20%**	Technical Loss	
			Loss at Connections and Meters	**[Asssumption of Loss] Before Project: 40% After Project: 20%**			
			Loss at Reservoirs and Others				

1/ water loss assumed in the demand analysis of the Project (in case of sub-sector it is 50% ANF ratio)
Source: JICA Study Team

Figure 1.3.1-1: Distributed Water Classification and Presumed Water Loss Ratio in Demand Analysis



Source: JICA Study Team

Figure 1.3.1-2: Water Demand Analysis for the Influence Area with the Project

The amount of sewage discharged into the sewerage networks is assumed to be 80% of the water demand, according to the National Sanitation Standards (Reglamento Nacional de Estructuras, or RNE); this is the standard technical parameter that will be kept same throughout the project horizon.

1.3.2 Supply Analysis

The total supply of Lima Norte I and Lima Norte II is 2.9m3/s, coming from Huachipa WTP as shown in Table 1.3.2-1.

Table 1.3.2-1: Conditions of Supply Analysis

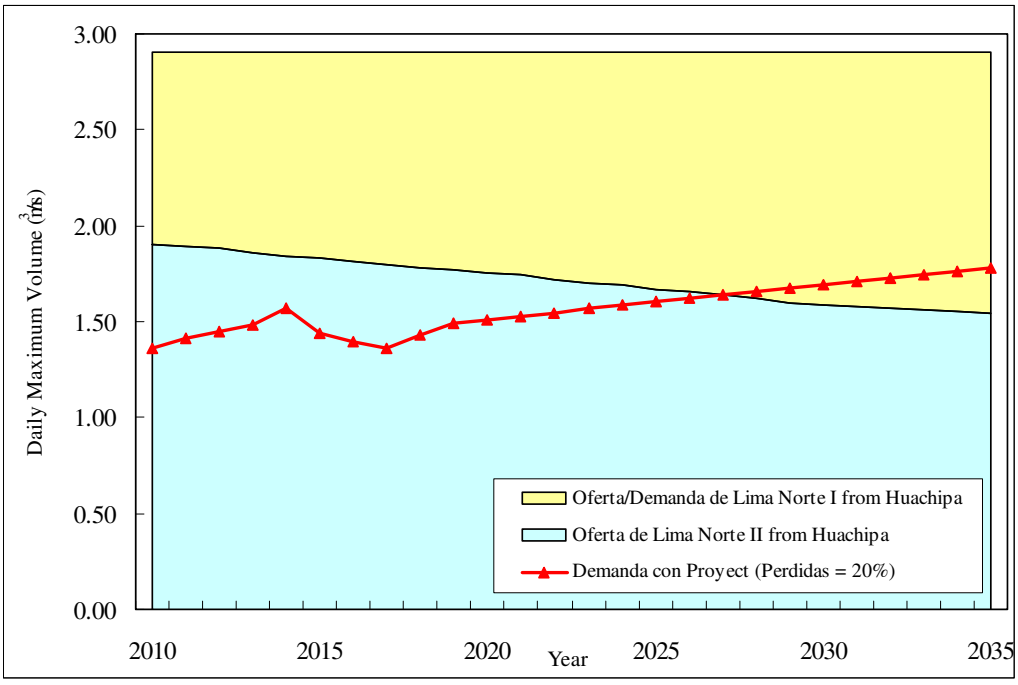
Conditions		Supply	Remarks
Production for Lima Norte Area	Huachipa WTP	2.9 m^3/s	
	La Atarjea WTP	-	To be considered if the supply of the Huachipa WTP is not enough
	Chillón WTP	-	
	Wells	0.0 m^3/s	Not to be counted as usual water source; for emergency purposes only.
Supply to Lima Norte I from Huachipa WTP		1.31 m^3/s in 2030	See Table 3.2.1-2

Source: JICA Study Team

1.3.3 Supply – Demand Balance

Production

Supply-Demand analysis of water requirement can be found by comparing water production with the water demand in the Area of Influence. After detecting the demand and balance, water will be supplied from other WTP to the Project Area of Influence. In Figure 1.3.3-1 is shown the supply-demand analysis of water production.



Source: JICA Study Team

Figure 3.3.1-1: Supply–Demand Analysis on Water Production

Deficit from the Huachipa WTP to the Area of Influence will be 0.24m^3/s in 2035. After evaluation of three options conceived, the recommended option (option 1)suggested to exclude Sectors 83A, 83B, 84B, 212A, 212B, and 213 (total water demand is 0.4m3/s in 2035) and

transfer them to the La Atarjea WTP distribution area. The water balance under this option is presented in Table 1.3.3-1.

Table 1.3.3-1: Supply after Modification of Distribution Area of the Influence Area

Year		Demand (m^3/s)	Supply (m^3/s)					Deficit (m^3/s)
		Demand of Lima North II	Huachipa WPP			Atarjea WPP	Total Supply to Lima North II	
			Supply to Lima North	Supply to Lima North I	Supply to Lima North II	Supply to Lima North II		
Base	2009	1.31	2.90	1.00	1.90	0.00	1.90	-
0	2015	1.43	2.90	1.07	1.83	0.40	2.23	0.80
1	2016	1.39	2.90	1.09	1.81	0.40	2.21	0.82
5	2020	1.51	2.90	1.15	1.75	0.40	2.15	0.64
10	2025	1.60	2.90	1.23	1.67	0.40	2.07	0.47
15	2030	1.69	2.90	1.31	1.59	0.40	1.99	0.30
20	2035	1.78	2.90	1.36	1.54	0.40	1.94	0.16

Source: JICA Study Team

Reinforcement matrix (Huachipa Los olivos)

Water offer for the northern Lima area (Lima Norte I and Lima Norte II projects) will be assured via a service optimization, by reducing the NAFW (Non – accounted for water) indicator (physical losses), thus, the saved water will be used to cover the future demand under the same current source conditions. However, according to SEDAPAL's Master Plan, there are two source increase projects: (i) the Chillón River source will be enhanced via a dam that would store water in high water (rainy) season for its later use during the low water (dry) season, and (ii) the Rímac River source will be enhanced via water transfer from the Mantaro River source as a supplement to the Marca I and III projects.

In spite of this , the vulnerability analysis shows that the occurence of a failure in one of the water treatment plants or in the relevant facilities would endanger the water supply for the northern area (including the Lima Norte II project); therefore, it is necessary that SEDAPAL has viable alternatives for a probable rationing management.

Subsequently, it is necessary that the Northern Branch main trunks are interconnected to the Atarjea, Los Olivos, and Chillón – Comas main trunks; therefore, a reinforced distribution backbone interconnecting the main trunks could be built.

Storage in Reservoirs

The supply-demand analysis of reservoir storage can be found by comparing reservoir capacity and required volume of storage for each sub-sector in the final year of the design period, which is 2035. Table 1.3.3-2 shows the result of the analysis which indicates that the capacities of reservoirs are not enough for seven sub-sectors.

Table 1.3.3-2: Supply-Demand Analysis for Reservoir Storage

Subsector	Reservoir	Suplí-Demand Balance in 2035			Evaluation
		Demand (m^3)	Suplí (m^3)	Deficit (m^3)	
83A-1	Villa Sol R-1	516	1,300	784	OK
83A-2	Villa del Norte R-1	910	1,800	890	OK
83B-1	Parque del Naranja R-1	465	1,400	935	OK
83B-2	Cueto Fernandini R-1	1,370	1,500	130	OK
84A-1	Olivos de Pro R-1	962	1,500	538	OK
84A-2	Programa Confraternidad R-2	664	1,600	936	OK
84B-1	Programa Confraternidad R-1	863	1,600	737	OK
84B-2	Comite Aposte	413	500	87	OK
85A	Puerta de Pro R-1	728	1,100	372	OK
85B-1	Rio Santa R-1	536	570	34	OK
85B-2	Pro	2,055	1,400	-655	NG
85B-3	Santa Luisa R-1	301	500	199	OK
85C	Pro	638	500	-138	NG
212A-1	Virgin de las Nieves R-4	839	1,500	661	OK
212A-2	Virgin del Rosario R-1	534	1,200	666	OK
212B-1	Rosario del Norte R-3	427	1,200	773	OK
212B-2	Jazmines de Naranja R-2	383	1,200	817	OK
213-1	Vipol Naranjal R-1	783	1,900	1,117	OK
213-2	Cerro eo Choclo R-2	62	100	38	OK
213-3	Cerro eo Choclo R-1	75	100	25	OK
259	Márquez R-522	744	1,200	456	OK
346-1	El Manantial R-1, R-2	234	2,200	1,966	OK
346-2	El Pinar R-1	592	1,200	608	OK
347-1	San Felipe R-1	550	670	120	OK
347-2	LA Alborada R-2, R-1	540	2,400	1,860	OK
348A	Collique R-1	352	1,100	748	OK
348B-1	Collique R-2	624	1,500	876	OK
348B-2	RE-01	103	100	-3	NG
349A-1	Collique R-3	608	1,100	492	OK
349A-2	Nueva Esperanza R-1	205	400	195	OK
349A-3	Collique R-4	354	1,000	646	OK
349B-1	Collique R-5	309	800	491	OK
349B-2	Collique R-6	375	800	425	OK
349B-3	Collique R-7, R-8	283	650	367	OK
350-1	Santa Isabel R-1	1,411	1,400	-11	NG
350-2	Santa Isabel R-2	1,408	1,500	92	OK
351-1	Los Angeles R-1	355	400	45	OK
351-2	Los Angeles R-2, R-3	255	250	-5	NG
351-3	Los Angeles R-4	83	100	17	OK
361	La Canpitania Parma Gallinazo PR-1	1,085	1,000	-85	OK
368A-1	RPA-6	970	2,000	1,030	OK
368A-2	RPA-1	199	500	301	OK
368B	RPA	1,300	2,650	1,350	OK
369A	RPA-7 La Ensenada	989	3,000	2,011	OK
369B	Laderas del Chillon	1,256	1,050	-206	NG
370	Shangrila R-1 CR-128	725	1,000	275	OK

Source: JICA Study Team

Primary and Secondary Networks

Table 1.3-3-3 shows supply – demand balance of secondary networks which have deficits. Its implementation is required in present Project.

Table 1.3.3-3: Supply-Demand Balance in Secondary Networks
(Km)

SSector	Demand	Supply	Balance
83 A	34.12	15.41	18.71
83 B	49.28	19.07	30.21
84 A	60.90	49.27	11.63
84 B	45.78	33.02	12.76
85 A	18.89	13.59	5.30
85 B	26.81	15.21	11.60
85 C	18.64	6.48	12.16
212 A	53.39	47.06	6.33
212 B	29.11	26.55	2.56
213	41.09	32.77	8.32
259	16.06	12.19	3.87
345	13.58	13.37	0.21
346	26.84	24.07	2.77
347	53.09	47.89	5.20
348 A	8.10	5.85	2.25
348 B	22.04	16.62	5.42
349 A	31.47	17.46	14.01
349 B	28.33	14.84	13.49
350	78.17	21.32	56.85
351	7.07	6.08	0.99
368 A	29.13	26.81	2.32
369 A	26.77	25.21	1.56
Total	**718.66**	**490.14**	**228.52**

Source: JICA Study Team

Secondary Collectors

Supply – demand balance for sewerage is shown in Table 1.3.3-4 which has deficit. Its implementation is required in present Project.

Table 1.3.3-4: Supply-Demand Balance for Sewerage in the Project Area

Drainage area	Demand of pipes (Km)	Supply of pipes in good condition (Km)	Balance (Km)
A16	7.52	7.52	
A18	11.53	11.53	
A19	5.73	5.73	
AD-0	1.70	1.70	
AD-01B	0.95	0.95	
AD-A1	30.31	20.84	9.47
AD-A2	24.16	21.22	2.94
AD-AG1	4.68	3.72	0.96
AD-AG2	29.91	6.04	23.87
AD-AG3	12.13	1.33	10.80
AD-AG4	26.44	14.39	12.05
ADC-1	10.08	8.57	1.51
ADC-2	13.52	11.50	2.02
ADC-3	4.97	4.22	0.75
ADC-4	6.91	5.87	1.04
ADC-5	13.70	11.65	2.05
ADC-6	11.38	9.67	1.71
AD-CA1	8.80	8.80	
AD-CA3	0.82	0.82	
AD-CH1	32.03	10.28	21.75
AD-CH2	12.58	6.57	6.01
AD-CH3	21.88	2.30	19.58
AD-CH4	30.87	30.87	
AD-CO1	20.84	2.85	17.99
AD-CO2	26.83	23.58	3.25
AD-M1	13.32	7.45	5.87
AD-N1	24.57	7.43	17.14
AD-N2	23.53	3.28	20.25
AD-P2	0.46	0.46	
AD-PL1	22.18	18.85	3.33
AD-PL2	22.59	19.57	3.02
AD-R1	14.81	2.32	12.49
AD-R2	17.36	2.57	14.79
AD-T1	14.54	4.57	9.97
AD-T2	6.61	6.26	0.35
AD-T3	0.04	0.03	0.01
AD-T4	12.54	6.35	6.19
AD-T5	10.06	5.03	5.03
AD-T6	2.61	1.31	1.30
PT1	22.99	22.99	
PT2	6.59	6.59	
PT3	13.00	13.00	
PT4	11.70	11.70	
PT5	8.78	8.78	
PT6	25.44	25.44	
PT7	7.54	7.54	
SA-57	0.03	0.03	
Total	**651.56**	**414.07**	**237.49**

Source: JICA Study Team

1.4 Technical description of the project

1.4.1 Beneficiaries

Project's area of influence is framed within the boundaries of the Comas, Carabyllo, Los Olivos, Puente Piedra, San Martin de Porres, Callao, and Ventanilla districts.

Total population in the Study Area is 622,650, and population in the area of influence or

benefited population with water supply service is 398,570 in the "base" year (2009); served population (89.4 %) in year "1" (2016) is projected to be 621,749 (119,805 connections.)

Based on the diagnostics of the current water supply and sewerage systems, only 64 % of the population in the entire study area and 64.8 % of the population in the study's area of influence, have water supply services.

1.4.2 Diagnosis

SEDAPAL has two water treatment plants, which are the La Atarjea Water Treatment Plant (La Atarjea WTP) and the Chillón Water Treatment Plant (Chillón WTP).

At present, the area with existing network within the Study Area is receiving water supply from the two WTPs mentioned above and also from the wells. Water distribution system from La Atarjea WTP is mainly supplying water to central and southern part of the Study area, which includes the districts of Callao, Los Olivos and San Martín de Porres. The water distribution system from Chillón WTP, on the other hand, is mainly supplying water to the northern part of the Study area, which includes the districts of Comas, Carabayllo and Puente Piedra. Besides, both distribution networks are interconnected each other in order to balance the production in the case some of them is not enough.

In this Study, 23 wells were identified that can be used after rehabilitation, in the event of amajor drought. This selection is based on the closeness of these wells to the reservoirs to be rehabilitated. From these 23 wells, 12 have complete pumping equipment, 5 have partial pumping equipment, and 6 have no equipment at all. Likewise, it is noticed that 3 wells are operating, 10 are used as reserve or emergency backup, and 10 wells are not operating due to their low quality water production.

In the study area, 26 of all 41 sectors have existing secondary water supply networks, and these are located in the Comas, Carabayllo, San Martín de Porres, Los Olivos, and Callao districts. Elevations in these areas range between 5.00 m.a.s.l. and 565 m.a.s.l. Total length of secondary networks in the study area is 773.45 km (between DN 50 mm and DN 315 mm.) There are four (4) types of pipes according to their materials, namely: Asbestos cement (AC), steel, ductile iron (FoFo) and Vinyl polychloride (PVC.). Prevailing materials are AC (46.73 %) and PVC (53.10 %). Out of all pipes, 12.9 % are over 25 years old, and 34. 6 % are less than 10 years old.

Secondary sewerage networks in the study area are made up of approximately 652 km of pipes with diameters ranging between 110 and 315 mm. Pipe materials are basically simple or plain concrete (67.7 %) and PVC (32.2 %). It must be pointed out that PVC pipes were not installed until year 2000 (so they are around 10 years old); simple concrete pipes are older, with ages ranging between 10 and 50 years old.

Problems in the water supply system

Based on the water supply and sewerage service diagnoses, current service rendering conditions within the project scope have found to show some deficiencies, as a result of the following problems:

(1) High Non Revenue Water Ratio

- The non-revenue water ratio in the entire Lima North Area is 50%. These ratios are much higher than the other areas of Lima, which are 35.1% in the Central Lima Area and 27.5 % in the South Lima Area.
- Within the non-revenue water ratio (50%), 40% is estimated to be the technical loss and the remaining 10% is the commercial loss ratio.
- In order to reduce the NRW ratio to 25%, it will be necessary to reduce the technical loss

ratio to 20% and the commercial loss ratio to 5%.

(2) Many Incidents

- Incidents in distribution networks and house connections, such as water leakage to the ground and settlement of pavement are reported.

(3) Non Continuous Water Supply Service

- There are some areas where 24-hour continuous water supply service has not been realized, such as sectors 348 and 349 (Comas) where the service continuity is between 3 and 7 hours, and for sector 259 (Márquez) the service hours are only 12.

Causes of mentioned problems of the water supply services are explained as below:

- Water pressures in primary networks tend to be continuously very high in Los Olivos, which can cause damage on pipe and water leakage.
- In some areas, water pressures in secondary networks are also too high, even in the sectors with pressure control valves; this is caused by the high pressure of primary networks.
- Existing water treatment plants (WTPs) cannot always satisfy the demand because the production of the WTPs is reduced significantly in the dry season.
- Electromechanical equipment of reservoirs and pumping stations are not operating properly, besides, some of them are out of service.
- Many of the 23 wells to be used for emergency purposes do not have pumping equipment or are not equipped required for suitable operation.
- Only 11 original sectors have valve pits for control of inflow to the sectors. In addition, only five of them can be controlled or monitored automatically, which is not sufficient for proper operation of the water supply system.
- There are some pipes with unsuitable pipe materials such as steel pipe, galvanized iron pipe and a type of PVC pipe (referred as “ITINTEC”).
- Some pipes are not satisfying the technical requirements of minimum earth cover, supporting bed, compaction and backfilling.
- Some pipes in Collique are seriously clogged by sediments derived from groundwater.
- AC pipes, which account for 47% of the total pipe length, may start to cause many incidents in the future, as 50% of them were installed more than 20 years ago.
- Many incidents that result in water leakage occur in house connections, especially at the corporation with the distribution pipes.
- None of the reservoirs have any equipment required for SCADA operation. Currently, all valves are manually operated.
- None of the wells have any equipment required for SCADA operation. Power panel boards are in very poor conditions: they lack electronic starters with speed variations. Some of the wells have incomplete panel boards with old technology that lacks Ethernet communications. All valves are manually operated.

<u>Problems in the Sewerage System</u>

The major problems identified for the secondary sewers are:

- Large numbers of incidents like clogs and collapses have been recorded in recent years

- Hydro Jet cleaning equipment could not be used for maintenance in some areas, because deteriorated pipes are easy to be broken by high pressure water flow.

The causes of above problems are identified as below:

- Some simple concrete pipes are very old; therefore, their life spam has already been completed.
- Evidence of serious corrosion in highest zones of the study areas was found.
- Visual inspection of pipes shows medium to serious damages in several areas.
- H2S gas in most of sampled manholes was found; existence of gas is directly related to decomposition of the pipe.
- In some cases manhole caps are missing.
- Low slope inclination causes the flow slowing down, waste water increase and the production of corrosive gas, consequently pipe decomposition.
- Besides, pipes damage caused by aging, pipes have been damaged more than expected because of lack of preventive maintenance (at the present, only corrective maintenance has been carrying out).

1.4.3 Alternative of Solution

(1) General works on the water supply system

Primary networks

Primary pipes shall be designed so that the Study Area can receive water supply from the Huachipa WTP and supply to the proposed sectors and sub-sectors.

Table 1.4.3-1 shows the construction items proposed for the primary networks (gravity pressure and pumping lines) to offer suitable conditions for water transportation from the Huachipa WTP to the project area through primary pipes.

Table 1.4.3-1: Quantity of Construction Works in the Primary Network

Item		Units	Quantity	Remarks
Gravity Pipes (primary)	DN 700 mm	m	1,538.49	Pipes are DI because of its higher strength than PVC
	DN 450 mm	m	744.83	
	DN 400 mm	m	3,148.97	
	DN 350 mm	m	1,595.11	
	DN 300 mm	m	963.37	
	DN 250 mm	m	6,358.14	
	DN 200 mm	m	6,860.69	
	DN 150 mm	m	2,196.35	
	SUB TOTAL	m	**23,405.95**	
Pumping lines (from wells to reservoirs)	DN 150 mm.	m	5,338.05	
	DN 200 mm	m	8,042.23	
	DN 250 mm	m	2,823.64	
	DN 300 mm	m	937.49	
	SUB TOTAL	m	**17,141.41**	
TOTAL			**40,547.36**	
Valve pits (valves for sector)	DN 200-700 mm	Units	0	Valves for sectors are to be installed at the reservoirs
Valve pits (pressure reduction)	DN 300 mm	Units	14	3 sluice valves in each pit
Air valve	DN 50-150 mm	Units	40	
Purge valve	DN 100-150 mm	Units	25	

Source: JICA Study Team

Reservoirs and pumping stations

Target rehabilitation and upgrading works include 27 reservoirs, 3 pumping stations locating beside the reservoirs and 1 independent pumping station. Among the 3 reservoirs with pumping stations, though 2 reservoirs have already been rehabilitated by SEDAPAL, but the pumping stations still need to be rehabilitated.

Table 1.4.3-2 shows the construction works for the reservoirs and pumping stations. Table 1.4.3-3 shows the list of reservoirs and pumping stations.

Table 1.4.3-2: Quantity of Construction Works in the Reservoirs and Pumping Stations

Item							Unit	Quantity
Type	Construction Items*							
	Civil	Electromechanical						
	A	B-1	B-2	B-3	B-4	C		
I	√	√	√				Nos	11
II	√	√					Nos	5
III	√			√	√		Nos	9
IV	√			√	√	√	Nos	1
V			√				Nos	1
VI						√	Nos	4*2
Total	Reservoirs						Nos	27
	Pumping stations beside the reservoirs						Nos	3
	Independent Pumping station						Nos	1

A : Civil Work
B-1: Electromechanical works (Renewal of equipment)
B-2: Electromechanical works (for connection with wells)
B-3: Electromechanical works (Rehabilitation of existing equipment)
B-4: Electromechanical works (Additional equipment)
C: Civil work on pumping house and electromechanical works of pumping facilities (Rehabilitation and additional equipment)
*1: Including one reservoir to be re-constructed
*2: 3 pumping stations beside the reservoirs and 1 independent pumping station
Source: JICA Study Team

Table 1.4.3-3: List of the Reservoirs and Pumping Stations in the Project

Sub-Sector	Code/Name		Volume (m^3)	Present Condition	Project*	
					Type	Component*
83A-1	R-800	VILLA SOL R-1	1300	Inoperativo	I	A, B-1, B-2
83A-2	R-801	VILLA DEL NORTE R-1	1800	Inoperativo	II	A, B-1
83B-1	R-996	PARQUE DEL NARANJAL R-1	1400	Inoperativo	II	A, B-1
83B-2	-	CUETO FERNANDINI R-1	1500	Inoperativo	II	A, B-1
84A-1	-	OLIVOS DE PRO R-1	1500	Inoperativo	I	A, B-1, B-2
84A-2	-	PROGRAMA CONFRATERNIDAD R-2	1600	Inoperativo	I	A, B-1, B-2
84B-1	-	PROGRAMA CONFRATERNIDAD R-1	1600	Inoperativo	I	A, B-1, B-2
84B-2	-	COMITÉ APOSTE	500	Inoperativo	I	A, B-1, B-2
	-	PATRIA NUEVA R-1	70	En operación	III	A, B-3, B-4
85A	R-805	PUERTA DE PRO R-1	1100	Inoperativo	I	A, B-1, B-2
85B-1	-	RIO SANTA R-1	570	Inoperativo	I	A, B-1, B-2
85B-2, 85C	R-997	PRO	1900	Inoperativo	II	A, B-1
85B-3	R-802	SANTA LUISA R-1	500	Inoperativo	II	A, B-1
212A-1	R-986	VIRGEN DE LAS NIEVES R-4	1500	Inoperativo	I	A, B-1, B-2
212A-2	-	VIRGEN DEL ROSARIO R-1	1200	Inoperativo	I	A, B-1, B-2
212B-1	-	ROSARIO DEL NORTE R-3	1200	Inoperativo	I	A, B-1, B-2
212B-2	-	JAZMINES DE NARANJAL R-2	1200	Inoperativo	I	A, B-1, B-2
213-1	CR-243	VIPOL NARANJAL R-1	1900	En operación	III	A, B-3, B-4
213-2	-	CERRO EL CHOCLO R-2	100	En operación	III	A, B-3, B-4
213-3	-	CERRO EL CHOCLO R-1	100	En operación	III	A, B-3, B-4
259	R-522	MARQUEZ R-522	1200	En operación	III	A, B-3, B-4
349A-2	CR-76**	Cisterna	-	En operación	VI	C
	R-927	NVA. ESPERANZA R-1	400	En operación	III	A, B-3, B-4
349A-3	R-924	COLLIQUE R-4	1000	En operación	VI	C
349B-1	R-925	COLLIQUE R-5	800	En operación	VI	C
349B-2	R-926	COLLIQUE R-6	800	En operación	IV	A, B-3, B-4, C
349B-3	R-820	COLLIQUE R-7	550	En operación	III	A, B-3, B-4
351-2	RP-3	LOS ANGELES R-3	100	En operación	III	A, B-3, B-4
351-3	RP-4	LOS ANGELES R-4	100	En operación	III	A, B-3, B-4
-	RP-2	Cerro Oquendo	5000	Inoperativo	V	B-2

* A-1: Civil works
B-1: Electromechanical works (Renewal of equipment)
B-2: Electromechanical works (for connetion to wells)
B-3: Electromechanical works (Rehabilitation of existing equipment)
B-4: Electromechanical works (Additional equipment)
C : Civil works in pumping house and electromechanical works of pumping facilities (Rehabilitation and additional equipment)
** Independent pumping station

Source: JICA Study Team

Wells

Table 1.4.3-4 shows works proposed for the wells that would operate in emergency situations, such as low water (dry) seasons, in the Project area. Table 1.4.3-5 shows the list of wells.

Table 1.43-4: Quantity of Construction Works in the Wells

Item	Unit	Quantity	Remarks
Electromechanical equipment renewal	Nos	3	Operating wells
Electromechanical equipment renewal, pumping house rehabilitation	Nos	20	Non-operating well

Source: JICA Study Team

Table 1.4.3-5: Wells in the Project

No.	Code	Status*	Reservoir	
			Name	Sub-sector
1	423	A	Villa Sol R-1	83A-1
2	474	A	Villa Sol R-1	83A-1
3	498	A	Villa Sol R-1	83A-1
4	720	A	Olivos de Pro R-1	84A-1
5	691	B	Programa Confraternidad 2	84A-2
6	692	C	Programa Confraternidad 2	84A-2
7	693	A	Programa Confraternidad 2	84A-2
8	695	A	Programa Confraternidad 1	84B-1
9	694	C	Programa Confraternidad 1	84B-1
10	618	A	Comité Aposte	84B-2
11	716	A	Comité Aposte	84B-2
12	696	C	Comité Aposte	84B-2
13	351	A	Puerta de Pro R-1	85A
14	717	C	Puerta de Pro R-1	85A
15	704	A	Rio Santa R-1	85B-1
16	280	C	Rio Santa R-1	85B-1
17	687	A	Virgen de Las Nievas R-4	212A-1
18	727	B	Virgen del Rosario R-1	212A-2
19	728	B	Virgen del Rosario R-1	212A-2
20	729	B	Virgen del Rosario R-1	212A-2
21	689	C	Rosario del Norte R-3	212B-1
22	688	B	Jazmines de Naranjal R-2	212B-2
23	569	D	Cerro Oquendo RP-2	-

*: A: With Complete Pumping Equipment, B: With Partial Equipment, C: Without Pumping Equipment, D: Operating
Source: JICA Study Team

Facilities for SCADA System

Table 1.4.3-6 shows the facilities (reservoirs, pumping stations, wells, and pressure reducer valves) that are proposed to operate under the SCADA system in the Project; this will result not only an efficient operation and accurate checking but also they will get integrated to SEDAPAL's system.

Table 1.4.3-6: Quantity of Works for Target Facilities for SCADA System in Water Supply Facilities

Item	Unit	Quantity	Remarks
(1) Reservoirs			
-Installation of equipment	Nos	26	All reservoirs except for Cerro Oquendo and Patria Nueva to be rehabilitated in the Project, and Collique-8
-Integration to the system*	Nos	65	All reservoirs related to the Project Area
(2) Pumping Stations			
-Installation of equipment and integration to the system	Nos	4	CR-76, Collique R-4, CR-96 (Collique R-5), Collique R-6
(3) Wells			
-Installation of equipment and integration to the system	Nos	23	Including 1 renewal (569)
(4) Pressure Reducing Valves			
-Installation of equipment and integration to the system	Nos	11	5 new valve pits and 6 existing valve pits without equipment
-Integration to the system*1	Nos	14	Including 3 existing valve pits to be rehabilitated (84A, 212A&B, and 213)

*1: Facilities integrated to the SCADA system to start operation under the system
Source: JICA Study Team

(2) Secondary networks of water supply

Priorities for Pipes to be Renewed

Priorities and quantities for pipes to be renewed are presented in Table 1.4.3-7.

As a conclusion of the Study, it is proposed to replace at least 15 % of secondary pipes by a priority order, for achieving to NRW percentage of 25 % (Project goal). In this sense, renewal of pipes under Categories A, B, and C (1st and 2nd priority) would not be enough to meet the non revenue water reduction goal (especially the technical loss reductions.) This situation could change if Category D (3rd priority) is included (AC pipes over 25 years old). With Category D inclusive, it represents an accumulated percentage of 23.15% of total pipe renewal.

Table 1.4.3-7: Priorities for Pipes to be Considered for Renewal

Priority	Category		Quantity			
			Each Category		Accumulation	
			Length*1 (km)	%*2	Length*1 (km)	%*2
1	A B	Pipes without enough capacity. Pipes with material problems and Pipes with installation problems	35.60	4.60%	35.60	4.60%
2	C	Network pipes of AC	75.54	9.77%	111.14	14.37%
3	D	AC pipes over 25 years old	67.88	8.78%	179.02	23.15%
4	E	AC pipes between 15 and 25years old	94.08	12.16%	273.10	35.31%

*1: Pipes that can belong to multiple categories rank in a higher priority category, so that double counting is avoided.

*2: Percentage against the total pipe length (773.45 km)

Source: JICA Study Team

Upgrading and Renewal Plan for Secondary Pipes

Table 1.4.3-8 presents pipe length for upgrading and renewal in secondary networks by sub-sector, based on the hydraulic calculations and studies on the pipe conditions above.

Table 1.4.3-8: Summary of the Planned Upgraded and Renewed Pipes in the Project (km)

Sector	Sub-sector	Length (Km)
83 A	83 A-1	6.5
	83 A-2	10.6
83 B	83 B-1	6.19
	83 B-2	20.61
84 A	84 A-1	3.26
	84 A-2	6.03
84 B	84 B-1	7.99
	84 B-2	2.24
85 A	85 A	3.79
85 B	85 B-1	1.62
	85 B-2	2.36
	85 B-3	4.6
85 C	85 C	9.14
212 A	212 A-1	1.21
	212 A-2	2.11
212 B	212 B-1	0.24
	212 B-2	0.32
213	213-1	4.27
259	259	1.86
346	346-2	0.91
347	347-1	0.58
	347-2	1.34
348 A	348 A	1.79
348 B	348 B-1	4.22
	348 B-2	0.13
349 A	349 A-1	3.09
	349 A-2	2.1
	349 A-3	6.71
349 B	349 B-1	5.63
	349 B-2	3.52
	349 B-3	2.4
350	350-1	31.01
	350-2	19.56
351	351-3	0.19
368 A	368 A-2	0.77
369 A	369 A	6.5
Total		**179.02**

Diameter after upgraded or renewed: 100 – 300mm

Source: JICA Study Team

Table 1.4.3-9 shows pipe lengths by material and accessories for secondary networks, required for satisfying future demand capacities, and reducing physical losses and leakages to suitable levels.

Table 1.4.3-9 Secondary Networks and Accessories of Water Supply

Item	Unit	Quantity	Remarks
1. Rehabilitation and renewal of existing pipes			
1-1 Chloride of polyvinyl (AC replacement)	km	156.91	100 – 300mm
1-2 Chloride of polyvinyl (PVC replacement)	km	22.11	100 – 300mm
Sub-Total		179.02	
2. Installation of new pipes			
2-1 Ductil Iron (DI)	km	13.25	250 – 400mm
2-2 Chloride of polyvinyl (PVC)	km	36.25	100 – 200mm
Sub-Total	km	49.50	
Pipes - TOTAL		228.52	
3. Valves and accesories (911valves)			
3-1 Pressure reducing valve, new and replacement	Unit	5	100-150mm
3-2 Air valve, new and rehabilitation	Unit	38	25mm
3-3 Drain valve, new and rehabilitation	Unit	12	100-300mm
3-4 Sluice valve, new and rehabilitation	Unit	580	
3-5 Hydrant valve, new and rehabilitation	Unit	276	150-200mm
Valves - TOTAL		911	

Source: JICA Study Team

(3) Water supply connections and meters

According to the results of existing infrastructure diagnosis, about 90% of the incidents in the Study Area are reported on the house connections. Moreover, from SEDAPAL's experience on secondary pipe maintenance works, it is commonly known that there is high water loss at the diversion device, due to the device's structural problems and poor construction. It is, therefore, important to replace connection pipes together with the diversion device, in order to reduce water loss. Table 1.4.3-10 shows the number of the connections to be renewed by sectors.

Table 1.4.3-10: Number of House Connections to be Renewed in the Project

Sector	Number of Connections
83 A	4,096
83 B	5,341
84 A	7,586
84 B	5,690
85 A	2,184
85 B	2,099
85 C	1,657
212 A	5,428
212 B	2,970
213	3,201
259	2,282
345	415
346	2,605
347	3,845
348 A	841
348 B	2,212
349 A	2,983
349 B	2,295
350	7,287
351	1,035
368 A	2,058
369 A	2,179
Total	**70,289**

Source: JICA Study Team

Table1.4.3-11 presents a summary of number of connections to be renewedby type of material; therefore, it is equal to the number of house meters to be installed.

Table 1.4.3-11: Quantity of Construction Works in the House Connections and Micrometers

Item	Unit	Quantity	Remarks
House Connection Renewals (PVC, 15-25mm)	Nos	54,031	Average pipe length per connection is 6m.
House Connection Renewals (PE, 15-25mm)	Nos	16,258	Average pipe length per connection is 6m.
Total	Nos	70,289	See Table 1.4.3-10
Micrometer Installations (Type B: Multiple Flow Type)	Nos	10,537	Sectors 259, 345, 348 A and B, 349 A and B, 350 and 351

Source: JICA Study Team

4) Improvement of Sewerage Networks

For sewerage pipe replacement, lacks of hydraulic capacity of pipes and deteriorations of the pipes by corrosion have been considered as evaluation tools.

Two methods of pipe construction has been proposed:

- Tunnel method, or "without trench" method.
- Traditional method, or "with trench" method.

Table 1.4.3-12 shows the comparative costs per meter of replaced pipe for both the methods. This includes construction of new manholes or rehabilitation of existing ones.

Table 1.4.3-12: Comparative Costs for Pipe Installation Methods

Description	Cost (Soles) per one meter installation						
	Re-position of Pavement (m)	Pipes and Accessories Ø 200 mm (m)	Installation of Pipes and Accessories Ø 200 mm (m)	Provisional Works (m)	New Manholes (m)	Rehabilitated Manholes (m)	Total (m)
"Without Trench" Method			256.61	16.7		16.7	290.01
"With Trench" Method	54.89	29.00	50.17	16.70	52.8		203.56

Source: JICA Study Team

Table 1.4.3-13 shows the length of secondary collectors to be renewed, by execution method, as well as the number of connections and manholes needed to satisfy future demand of wastewater collection capacity and to reduce clogs and collapses.

Table 1.4.3-13: Renewal of secondary networks of sewerage and connections

Category	Unit	Quantity	Remarks
1. Renewal of existing pipes (PVC)	km	237.49 [1/]	200-300 mm
1.1 With trench (30%) 1.2 Without trench (70%) 2. Connections and manholes	km km	71.21 166.28	200-300 mm 200-300 mm
2-1 Connections	Nos	33,736	
2-2 Manholes (from 1.5 m to 3 m depth)	Nos	4, 717	3,302 new and 1,415 rehabilitated

[1/] Equivalent to 55,5% of the existing CSN pipe
Source: JICA Study Team

(5) Acquisition of equipments

Table 1.4.1-14 shows items of equipment to be purchased for SEDAPAL's operation, maintenance, and improved commercial management.

Table 1.4.3-14 Equipment for Maintenance Works to be Purchased in the Project

No.	Items	Quantity
1	Equipment for Water Leakage Detection	
1)	Vehicle	2
2)	Correlator with accessories (red and blue radio)	2
3)	Wheel meter	2
4)	Acoustic Water Leak Detector	2
5)	Metal Detector	2
6)	Geophones	4
7)	Generator	2
8)	Drill	2
9)	Miscellaneous Tools	2
10)	Pre locators (Mobile)	200
11)	Data capture	2
12)	Workstation platform including CAD/GIS	2
2	Equipment for Sewerage Cleaning	
1)	Mini hydro jet with vehicle	2
2)	8.50 m3 Hydro Jet equipment	3
3)	6 m3 Hydro Jet equipment	3
4)	16 m3 capacity tank truck	3
5)	8 to 10 m3 capacity tank truck	3
6)	Nozzles 15 ° for Hydro jet	6
7)	Nozzles 35 ° for Hydro jet	6
3	Equipment for Pipe Inspection	
1)	Computer and Software	1
2)	TV inspection unit for potable water (equipment + mobile unit)	3
3)	TV inspection unit for sewerage (equipment + mobile unit)	3

Source: JICA Study Team

(6) Summary of works of water supply and sewerage

Table 1.4-3.15 shows a summary of the water supply and sewerage works to be executed by the Project, including activities for the optimization of the management, operation, maintenance, and service commercialization to be performed by the Northern Services Management Office and the Comas and Callao O & M Teams.

Table 1.4.3-15: Summary of Works of the Project [1/]

No	Item and Specifications	Unit	Quantity
I.	**Optimization of Water Supply System**		
I-1	Development of primary network		
	- Primary pipes (Ductile Iron Pipe, 150-700mm)	km	40.55
	- Pressure reducing valve pit	Unit	14
I-2	Improvement of reservoirs and pumping stations		
	- Rehabilitation of reservoirs	Unit	27
	- Rehabilitation of pumping stations	Unit	4
I-3	Improvement of secondary networks		
	- Upgrading and renewal of existing pipes	km	179.02
	- Installation of new pipes	km	49.50
I-4	Rehabilitation of house connections and installation of micrometers		
	- Renewal of existing house connections (PVC, PE)	Unit	70,289
	- Installation of micrometers	Unit	10,537
I-5	Rehabilitation of wells	Unit	23
I-6	Introduction of SCADA		
	- Reservoirs	Unit	26
	- Pumping stations	Unit	4
	- Wells	Unit	23
	- Pressure reducing valve pit	Unit	11
II.	**Optimization of Sewerage System**		
	- Upgrading and renewal of existing simple concrete pipes (PVC, 100-350mm)	km	237.49
	- Rehabilitation of manholes	Unit	1,415
	- Construction of new manholes	Unit	3,302
	- Renewal of house connections (PVC)	Unit	33,736
III.	**Optimization of Business Management of SEDAPAL**		
III-1	Procurement of equipment for maintenance work		
	- Equipment for water leakage detection (Acoustic water leakage detector and leakage detection system)	Unit	2
	- Equipment for Sewer cleaning (Hydro jet and Tank Truck)	Unit	8
	- Equipment for Pipe inspection (TV inspection unit)	Unit	6
III-2	Improvement of information management system		
	- Inventory survey	Unit	1
	- Support on upgrading information management system	Unit	1
III-3	Establishment of new team for preventive maintenance	Unit	1

*: Including activities for the optimization of SEDAPAL management
Source: JICA Study Team

1.5 Cost of the project

Investment costs are made up of the following items:

- Potable water general works
- Rehabilitation of reservoirs, pumping stations, and wells
- Rehabilitation and/or renewal of secondary networks and connections, and water supply network sectorization
- Potable water automation and control system
- Rehabilitation and/or renewal of secondary network and sewerage manholes
- Operation and maintenance equipment
- Activities for environmental mitigation, social intervention, and updating of facility technical cadastre
- Engineering consultancy services to prepare works, detailed design study, procurement of equipment, assistance during biddings, and supervision of works

General expenses, (14.2%), contractor's profit (10%), and General Sales Tax (18%), as well as administration costs to be incurred in by the 'project executing unit', are also included.

Project total cost that includes all the above mentioned items, amounts S/. 497,644 thousand (JPY 15,922 million = USD 175,350 thousand), as shown in Table 1.5-1.

Investment makeup is as follows:

1) Water supply general works	: 6.1%
2) Rehabilitation of reservoirs, pumping stations, and wells	: 5.7%
3) Water supply automation and control system	: 2.1%
4) Rehabilitation and/or renewal of water secondary networks	: 27.1%
5) Rehabilitation and/or renewal of sewerage secondary networks	: 22.5%
6) Equipment for operation and maintenance	: 3.7%
7) Environmental mitigation, social intervention, and technical cadastre	: 4.3%
8) Engineering consultancy services	: 12.1%
9) Project administration	: 1.2%
10) IGV (General Sales Tax)	: 15.3%

Project implementation has been foreseen for the 2012 – 2016 period.

Table 1.5-1: Project Investment Costs
(Currencies at market prices, as of June 2010)

ITEM	DESCRIPTION	Unit	Quantity	Total Cost	
				Nuevos Soles	US $
1	GENERAL WORKS			23,539,637	8,294,446
1.1	PRELIMINARY AND PROVISIONAL WORKS	glb		631,298	222,445
1.2	PRIMARY PIPELINES NETWORK FOR WATER SUPPLY			22,908,339	8,072,001
1.2.1	PAVEMENT WORKS	m	33,249	1,843,095	649,434
1.2.2	PIPE AND ACCESSORIES SUPPLY	m	40,547	13,399,884	4,721,594
1.2.3	PIPE AND ACCESSORIES INSTALLATION	m	40,547	4,779,138	1,683,981
1.2.4	VALVE PIT AND ACCESORIES INSTALLATION AND SUPPLY	glb		2,886,222	1,016,992
2	REHABILITATION OF RESERVOIR,PUMPING STATION AND WELLS			22,168,652	7,811,364
2.1	WATER SUPPLY			22,168,652	7,811,364
2.1.1	EQUIPMENT AND REHABILITATION OF RESERVOIR	Unit	27	9,281,135	3,270,308
2.1..2	EQUIPMENT AND REHABILITATION OF PUMPING STATION	Unit	4	2,114,539	745,081
2.1.3	EQUIPMENT AND REHABILITATION OF WELLS	Unit	23	10,772,979	3,795,976
3	AUTOMATION AND CONTROL SYSTEM			8,281,770	2,918,171
3.1	AUTOMATION AND CONTROL SYSTEM FOR WATER SUPPLY	glb		8,281,770	2,918,171
4	SECONDARY PIPELINES NETWORK FOR WATER SUPPLY			105,045,527	37,013,928
4.1	PRELIMINARY AND PROVISIONAL WORKS	glb		4,751,212	1,674,141
4.2	REHABILITATION OF SECONDARY NETWORK (TRENCH METHOD)			40,484,608	14,265,190
4.2.1	PAVEMENT WORKS	m	187,386	8,804,955	3,102,521
4.2.2	PIPE AND ACCESSORIES SUPPLY	m	228,520	13,235,465	4,663,659
4.2.3	PIPE AND ACCESSORIES INSTALLATION (AC-PVC)	m	156,910	9,963,816	3,510,858
4.2.4	PIPE AND ACCESSORIES INSTALLATION (PVC-PVC)	m	22,110	1,151,897	405,883
4.2.5	INSTALLATION OF DI PIPES AND ACCESORIES	m	49,500	3,119,749	1,099,277
4.2.6	SUPPLY AND INSTALLATION OF VALVE PIT	glb		4,208,727	1,482,991
4.3	REHABILITATION OF HOUSE CONNECTION	Unit	70,289	52,895,975	18,638,469
4.4	PROVISIONAL CONNECTIONS	glb	-	5,498,191	1,937,347
4.5	MICROMETER SUPPLY AND INSTALLATION	Unit	10,537	1,415,541	498,781
5	SECONDARY PIPELINES NETWORK FOR SEWERAGE			87,236,647	30,738,776
5.1	PRELIMINARY AND PROVISIONAL WORKS	glb		5,469,777	1,927,335
5.2	REHABILITATION OF SECONDARY NETWORK (TRENCH METHOD)			30,791,225	10,849,621
5.2.1	PAVEMENT WORKS	m	136,350	7,577,391	2,669,976
5.2.2	PIPE AND ACCESSORIES SUPPLY	m	166,280	4,894,960	1,724,792
5.2.3	PIPE AND ACCESSORIES INSTALLATION	m	166,280	8,358,623	2,945,251
5.2.4	MANHOLE REHABILITATION	Unit	1,415	1,181,129	416,184
5.2.5	MANHOLE CONSTRUCTION	Unit	3,302	8,779,122	3,093,419
5.3	REHABILITATION OF SECONDARY NETWORK (TRENCH-LES METHOD)	m	71,210	15,318,999	5,397,815
5.4	REHABILITATION OF HOUSING CONNECTION	Unit	33,736	31,296,410	11,027,629
5.5	PROVISIONAL CONNECTIONS	glb		4,360,236	1,536,376
6	EQUIPMENTS FOR O&M			14,164,385	4,990,974
6.1	EQUIPMENT FOR PREVENTIVE MAINTENANCE	glb		1,619,245	570,558
6.2	HYDROJET FOR SEWERAGE CLEANING	glb		11,191,738	3,943,530
6.3	EQUIPMENT FOR LEAKAGE REDUCTION	glb		1,353,402	476,886
7	ENVIRONMENTAL IMPACT MITIGATION, SOCIAL INTERVENTION AND TECHNICAL CADASTRE			16,587,379	5,844,742
7.1	ENVIRONMENTAL MITIGATION	glb		3,521,631	1,240,885
7.2	SOCIAL INTERVENTION	glb		6,728,560	2,370,881
7.3	TECHNICAL CADASTRE	glb		6,337,188	2,232,977
DIRECT COST				**277,023,997**	**97,612,402**
INDIRECT COST					
	GENERAL EXPENSES			39,218,946	13,819,220
	PROFITS			27,702,400	9,761,240
	SUBTOTAL			**66,921,346**	**23,580,460**
CONSTRUCTION COST				**343,945,342**	**121,192,862**
INTANGIBLES					
	DETAIL DESIGN			21,153,035	7,453,501
	SUPERVISION			33,549,625	11,821,573
	ENVIRONMENTAL IMPACT ASSESMENT			272,731	96,100
	ENVIRONMENTAL MONITORING			3,344,132	1,178,341
	ADMINISTRATION COSTS			5,602,530	1,974,112
	SUBTOTAL			**63,922,053**	**22,523,627**
SUBTOTAL				**407,867,396**	**143,716,489**
VAT(18%)				**73,416,131**	**25,868,968**
TOTAL				**481,283,527**	**169,585,457**

Source: JICA study team and detailed budget Appendix B4

1.6 Project Benefits

For the Project, the following benefits have been identified:

- Resource savings from minor water pipes and connection repairs, as well as insurance payments for accidents in the pipelines and connections.
- Decrease in technical water loss in networks and connections (water reclamation).
- Higher water consumption in the restricted sectors.
- Postponement of water source and yield investments
- A better supply quality, continuity, and pressure to the current population, increased willingness to pay (WTP) for a better potable water service.
- Incorporation of new users

1.7 Social Evaluation of the project （Economic Evaluation）

Cost – Benefit methodology is applied in order to carry out the Project´s social evaluation. Net Present Value (NPV) and Internal Rate of Return (IRR) are used as profitability indicators. A social discount rate of 10% was used for cost and benefit updating, as defined by MEF (Appendix SNIP 10 – Evaluation Parameters), as well as a minimum social performance rate for public investment projects.

In addition to the cost – effectiveness methodology, the investment per capita cost at market prices is also applied for the sewerage system (secondary networks, house connections) in the Project.

Steps taken for social cost and benefit identification include:

- Comparison between the “with” and “without” project situations.
- Distinction between costs, incremental benefits (increased consumption), maintenance cost savings, insurance payments for accidents on pipes and connections, and benefits for reclaimed water volume (avoided costs related to marginal reductions in technical water loss).

Conversion of costs and benefits from market prices to social prices was carried out, using factors suggested by the DNS (Appendix B.)

Through this procedure, an economic cash flow at social prices was set up to identify net social benefits for the project evaluation period.

A list of the pre-conditions and assumptions for analysis is shown below:

- The water supply and sewerage project evaluation period is 20 years (2016 – 2035.) The investment phase should be completed in the third quarter of 2016.
- “Cost – Benefit” methodology is used for water supply project evaluation. “Cost – Effectiveness” methodology will be applied for the sewerage project.
- Benefits are taken into account for the social flow, as only the last quarter of 2016 and on a whole annual basis for the remaining years (2017 – 2035).
- Economic benefits derived from an increased willingness to pay by the existing users are as follows: 70 % for the water supply service and 30 % from the sewerage service. This makeup will prevail at the current rates for these services.
- All costs and benefits are expressed at social prices as of June 2010, and for market price

conversion to social prices, factors suggested by DNS were used.

- Water network infrastructure has an economic life span of 50 years. Therefore, the project will carry on generating net benefits for the next 30 years after the end of 20 years evaluation period. However, the social flow has taken into account the future benefits' updated value for the next 10 years only, as a conservative measure.
- A social discount rate of 10.0 % is used to calculate NPV.
- Investment cost per capita (market price) is calculated for the sewerage project (secondary networks and connections), for comparison purposes with the reference value shown in Appendix SNIP 09 (Parameters and Technical Regulations for Formulation purposes – urban area sanitation projects.)
- Costs for future potable water and sewerage connections are not incremental to the Project. Therefore, they are not taken into account for social flow.

Results of the Social Evaluation

Water supply project

From the net flow of the economic evaluation, a net present value (NPV) can be obtained amounting to S/. 41.5 million, as well as a 12.8% internal rate of return (IRR) that exceeds the discount rate used for the updating of total flow.

Table 1.7-1: Evaluation results of the water supply project
(Nuevos soles at social prices of June 2010)

Indicator	Annual Total Benefits	Total Investment and Reposition of Equipments	Net Flow
Present Value (10%)	224,105,182	182,571,816	41,533,366
IRR			**12.8%**

Source: JICA Study Team

Sewerage project

Table 3.7.3-2 shows that the investment value per capita for the Project (networks and connections) is US$ 205. This value is slightly less compared to the reference value in Appendix SNIP 09"Sewerage network and connection extension without primary works," which amounts to USD $224 / inhabitant in urban areas; therefore, the proposed investment is acceptable.

Table 1.7-2: Per Capita Investment in Sewerage Secondary Networks and Connections
(Nuevos Soles at Market Prices of June 2010)

Concept	Units	Networks and connections
Investment (networks)	(S/.)	125,266,795
Investment (connections)	(S/.)	52,238,962
Average beneficiary population (networks)	inhabitants	569,005
Beneficiary population (Connections)	inhabitants	144,244
S/. per capita investment (networks)	S/. inhab	220
S/. per capita investment (Conections)	S/.inhab.	362
S/. per capita total investment	S/. inhab	582
US$ per capita investment	US$/inhab	205
Per capita cost – urban area	US$/inhab.	224

Source: JICA Study Team

1.8 Private Evaluation (Financial Evaluation)

Financial evaluations were carried out in order to measure the impact of the Project´s investments on the economic-financial situation, under the following assumptions: i) income and incremental cost generation within the project scope, and ii) loan conditions and terms from each and every funding agency that will participate in the funding of project execution.

The following assumptions are taken into account for the preparation of the financial cash flow in the evaluation period:

Income

Income generated by the service-providing company in the ”with” project situation comes from the billing of potable water and sewerage services for a larger volume of available potable water to be supplied to other sectors close to the project area. The larger volume of water available to SEDAPAL is the volume of water reclaimed as a result of a decrease in technical losses, both in the network and the connections; this reclaimed volume is 20 % of the total water demand for the project.

The annual calculation of reclaimed water volume is the difference in the total demand (thousands of cubic meters per year), between the “with” and “without” project situations throughout the evaluation period for the project (20 years). It is assumed that 75% of the reclaimed water will be billed to the users in other distribution areas close to the project area.

In order to obtain the income from reclaimed potable water and sewerage, billing amount was multiplied with the average rate[1] of S/. 2.43 / m^3. This tariff is updated with the tariff increases as approved by SUNASS in June 2010; specifically the increases are 2.0 % in 2011 and 2.0 % in 2012. This tariff is kept consistent throughout the 2016 – 2035 evaluation period.

Collection has a 98 % average effectiveness, and a 2 % average default.

Income for new future potable water and sewerage connections and their relevant billing is not incremental to the project. Therefore, it is not included in the economic flow.

Costs / Expenditures

Costs in the “with” project situation have mainly considered as decreased costs in maintenance and repair of the water and sewerage network and connections. This minimizes operational corrective maintenance interventions by SEDAPAL, as well as insurance payments for any accidents caused by water networks and connections that mainly affect people’s homes These costs represent cost reductions (resource savings) for the utility in terms of cash flow.

Reclaimed water commercialization costs have been taken into account (incremental costs), including charges for sewerage. These costs in the “with” project situation should be taken by SEDAPAL, as a larger volume of water is required to supply areas close to the project.

SUNASS input for sanitation service regulation was also taken into account. This input represents 1 % of the incremental income.

Project investments have been taken into account, in compliance with the works execution schedule. Re-investment of equipment of control, electrical mechanic, leakage, collector cleaning also has been considered.

[1] Average combined tariff for potable water and sewerage of S/. 2.43/m^3 as of June 2010 (including fixed charges), *Gerencia de Desarrollo e Investigación* (Development and Research Management), SEDAPAL 2010.

Considerations and Evaluation Results

The project evaluation period is 20 years (2016-2035). The works detailed design will be prepared in 2012 and 2013; works will be executed in 2013, 2014, 2015, and 2016 (third quarter.

A 3.92 % WACC was used for the economic and financial net flow updating, as calculated by SUNASS, for SEDAPAL's use in its Tariff Study during the 2010 – 2014 period.

All incomes and costs are shown at prices as of June 2010.

All incomes and costs are shown without including Sales Tax (VAT).

Fixed assets (water supply and sewerage networks that are made operational by SEDAPAL after they have been incorporated to SEDAPAL), have a 50 – year depreciation period, and intangibles have a 5 – year depreciation period, according to SEDAPAL accounting practices. Therefore, by 2035 (year 20), at the completion of the project evaluation period, as assets will still operative; therefore, SEDAPAL will continue raising net income (after taking away distribution and commercialization costs) for rendering sanitation services.

In this sense, an updated value for future net consistent income has been taken into account for the financial evaluation, throughout the next 10 – year period, at a 3.92 % discount rate. This value is shown as an income in 2035 (year 20).

The project financial evaluation normal results show a positive net present value (NPV) of S/. 19.7 million, and a 4.4% economic internal rate of return (EIRR) against a 3.92 % discount rate. Therefore, the project is economically feasible to SEDAPAL.

Net flow of the economic evaluation and disbursements from the international cooperation funding agencies, such as JICA and KfW, have been taken into account for the financial evaluation. Financial conditions for loans, as well as the amounts and the debt service (interests, amortization of the principal, and commissions for non – disbursed balances) are also considered. These amounts are part of the funding flow for the project financial evaluation during the project evaluation period.

The project's financial evaluation with consideration of possible funding conditions results show that SEDAPAL improves its position, resulting in a positive financial net present value (FNPV) of S/.34.4 million and a financial internal rate of return (FIRR) of 6.5%, against a 3.92 % discount rate, mainly as a result of the financial leverage generated by the favorable financial conditions for the bank loans.

1.9 Sustainability

In order to guarantee the success of the Project and achieve the desired benefits throughout the project planning period, a sustainability analysis is carried out, which is defined as the ability of a Public Investment Project to maintain the acceptable flow level of net benefits throughout its planning period. This can be expressed in quantitative and qualitative terms upon evaluation of the institutional, legal, economic, technical, environmental, and socio-cultural aspects, among others.

It is SEDAPAL´s responsibility to carry out the monitoring of the feasibility study until project viability has been obtained, and it also must ask the Ministry of Economy and Finances to manage the financing from entities of the funding cooperation (JICA, IBRD and KfW) and to provide the corresponding contracts between the Ministry of Economy and Finances, in representation of the Peruvian Government, and the cooperating agency.

The Executing Unit in the investment stage of the project is the Sanitation Improvement Program Team in the Marginal Areas of Lima (PROMESAL: *Equipo del Programa de Mejoramiento Sanitario de las Áreas Marginales de Lima*), an office that depends functionally

on the General Management Department of SEDAPAL. This Team has the technical capacity and the management capacity for the administration and supervision of development for all activities during project implementation; this development is foreseen to begin once the Project viability has been declared, and after the signing of loan contracts with the funding entities (JICA, IBRD, and KfW).

In addition to the physical works, social monitoring and environmental education activities will be developed which will be proposed from the results of the feasibility study and successful experiences of SEDAPAL in other projects; this costs have been included in the project costs.

The North Services Management Department shall be in charge of the operation of the project infrastructure; its objective is to render sanitation services once the facilities have been received from the contractors, and it is responsible for the operation and maintenance of these facilities, using the necessary technical, logistic, and installed capacities. Purchase of collector cleansing equipment, leakage detection equipment, and portable residual chlorine control equipment has been contemplated as part of the project investment. These equipments will be used to support the operation and maintenance of the water supply and sewerage services. In this way, SEDAPAL's capacity in the project operation phase will be strengthened.

For the execution of the project, there are numerous international engineering consultant firms in the Peruvian market with sufficient experience in the sanitation sector who can elaborate the technical works file; as well as international contractors for the specialized execution of sanitation works, especially the renovation of sewerage networks and water supply sectorization.

The resources required for the operation and maintenance of the rehabilitated and improved infrastructure shall be covered by the revenue collected from the water and sanitation services and the resources saved due to lower maintenance costs and payment of disaster insurance for breakages of the water supply networks that usually, prejudices the users.

The JICA Study Team carried out a socio-economic study through a survey by sampling in the households that have continuous (24 hour) water service and those that have restricted water service (less than 12 hours). According to the results of said study, the families are willing to pay for a better service. The households that do not have water service 24 hours a day are willing to pay an average of S/. 8.18 per month. On the other hand, the families that have water service rationed by hours are willing to pay an average of S/. 13.57 per month.

In this study, the analysis was also carried out for the users´ capacity to pay for the water and sewerage service against the norm set by the international organizations; which indicate that the amount to pay should not exceed 5% of the available income of the families benefited by the project.

The average family income according to the socio-economic survey information in the project zone is S/. 1,019 soles monthly, meaning that the average estimated capacity to pay for water and sewerage service is a maximum of S/. 51.0 per month including VAT. Currently, the families are bearing fees of S/. 42.90 for water and sewerage services with an estimated consumption of 17.90 cubic meters per month (consumption of 142 L/d/inhab). This amount is sufficiently under 5% of the average family income.

The beneficiaries do not participate in the design or the formulation of the project. In the execution stage, they shall participate by means within their reach, collaborating with the normal development of the construction processes and complying with the pertinent indications and recommendations, as well as participating with interest in the campaigns for publication and in the anticipated social intervention. At the same time, they shall participate in the operation stage, making good use of the services and installations, as well as appropriately fulfilling the payment of the fees and making reports and operative complaints that help the Operation and Maintenance teams in Comas and Callao to optimize the scope of their

operational duties.

1.10 Environmental Impact

In compliance with the effective requirements and procedures in Perú, activities for the project's environmental approval have been started. On behalf of SEDAPAL (the project proponent), a request has been submitted to the Ministry of Housing, Construction, and Sanitation's Environmental Office (OMA, in Spanish) on July 23rd, 2010 for an initial request and environmental classification. On October 6, 2010, OMA classified this Project as a Category II project that involves a semi-detailed EIA requirement. Based on the classification given to the project, the EIA's ToR was prepared. During the detail design stage, with the approval from National Sanitation Directorate (DNS, in Spanish), DNS -authorized and -registered environmental consultants will carry out the Environmental Impact Assessment (EIA). After its successful evaluation, DNS will approve EIA.

A preliminary environmental evaluation was also carried out. This preliminary evaluation stated that the project's overall environmental impact is positive, as it ensures a water supply and sewage collection that are safe and reliable. There are a few negative impacts, though, but these are temporary, they occur during the construction phase, and their mitigations are easily executable.

An impact matrix has been prepared to evaluate potential impact. A total of 18 environmental parameters were evaluated against 17 activities. The matrix is shown in Table 1.10-1.

Table 1.10-1: Environmental Impact Assessment Matrix

				Project activities - Construction phase																
				General works of potable water				Rehabilitation of reservoirs, pumping stations and wells			Secondary network and house connections of potable water, reservoirs / sector						Secondary network and house connections of sewerage			
				Preliminary and provisional works	Potable water lines for general works	Automation and control	Electric power supply	Equipment and rehabilitation of reservoirs	Equipment and rehabilitation of pumping stations	Equipment and rehabilitation of wells	Rehabilitation of potable water networks	Potable water house connections	Pressure reducing valve pits	Provisional connections	Leakage pre-locators	Operation equipment	Sewerage networks	Sewerage house connections	Pavement	Operation equipment
Environmental Component	Abiotic	Soil	Modification of terrain	7	4	3	5	6	6	7	4	4	3	3	3	4	5	4	4	4
			Erosion	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			Quality of soil	7	5	3	5	5	4	7	5	4	4	4	3	4	5	4	6	4
			Change of use of soil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Water	Quality of surface water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			Quality of groundwater	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Air	Generation of particles	4	6	3	3	7	5	7	9	3	3	4	3	4	5	3	7	4
			Generation of gas	4	6	3	3	7	5	7	5	3	3	4	3	4	5	3	7	4
			Generation of noise	3	3	4	4	6	7	7	5	3	3	3	2	3	3	3	5	3
	Biotic	Flora	Coverage of plants	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Fauna	Bird life	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Social-Economic	Social	Way of life	3	2	1	2	3	3	3	7	4	2	4	2	3	5	5	6	3
			Public security and health	3	5	3	2	4	3	4	9	5	-	-	-	-	4	4	6	-
			Employment security and health	3	6	3	4	6	4	6	9	5	3	3	3	3	5	5	6	3
		Economic	Generation of employment	4	5	3	3	6	5	6	5	5	4	4	4	3	5	5	3	3
			Economy dynamic (other economic activities)	2	5	2	3	6	5	6	4	3	2	2	3	3	4	5	3	3
	Cultural	Aesthetics	Modification of landscape	3	3	-	-	6	7	7	3	3	3	3	2	-	3	3	5	-
		Cultural	Archaeological zones	4	6	-	-	4	-	4	5	-	-	4	-	-	5	-	4	-

Source: JICA Study Team

Also a preliminary Environmental Management Plan (EMP) was prepared which consist of the following: i) Prevention, Mitigation and/or Correction Program, ii) Monitoring Program and iii) Cost Estimates for implementation of EMP.

The mitigation plan against the negative impacts is given in Table 1.10-2.

Table 1.10-2: Environmental Mitigation Plan

Environmental Impact	Mitigation Measure Proposed
1. Air pollution due to dust and exhaust gas	▪ Put a moistened canvas over the surplus soil materials stored on site before they are transported to the authorized disposal site. ▪ Adequately moisten the unpaved roadways and areas where daily Project activities may stir up dust. This moistening should take place at least twice a day, and more frequently when prevailing atmospheric conditions require it, which shall be decided and reprogrammed by the Supervisor. ▪ Perform periodic maintenance on machinery, vehicles and equipment utilized in order to guarantee it is in good condition and to reduce the emission of gases.
2. Pollution from Asbestos piping	▪ The removal, transportation and final disposal of asbestos cement piping shall be performed by a DIGESA certified agency.
3. Increase in noise levels due to project activities	▪ The equipment and machinery shall have constant maintenance to ensure proper operation condition. The equipment should be used in such a time frame ensuring minimum disruption.

Environmental Impact	Mitigation Measure Proposed
	▪ If necessary, a sound barrier should be installed.
4. Possible change in soil quality	▪ Implement a collection system for waste generated in each of the worksites and machine yards. ▪ Install systems to manage and dispose of grease and oils. For this, it will be necessary to comply with the established solid waste program. ▪ The soils contaminated by hydrocarbon, etc. should be removed immediately and properly disposed.
5. Public disturbances due to project activities.	▪ Inform the public about the type of machinery that will be used and the hours they will be running. ▪ Take steps to coordinate and conciliate with inhabitants living near the worksite, through the use of flyers and official reports, with relation to the activities that will take place, with a timeline that will not affect the public's normal activities. ▪ To ensure minimum disruption to vehicular and pedestrian traffic, proper traffic sign must be placed. ▪ Movement of trucks should be planned not to coincide with rush hour traffic.
6. Occupational Health and Safety risks (accidents)	▪ Follow the Occupational Health and Safety Regulations, S.D. Nº 009-2005-TR (article 20). ▪ Provide all work personnel with personal protective gear according to the activities, especially for those workers dedicated to drilling the tunnel and transporting asbestos material. ▪ Train work personnel about safety regulations for each activity to be carried out. ▪ Establish a work schedule that guarantees the performance and mental stability of personnel. ▪ Implement environmental measures proposed in the Contingency Program in the case of the occurrence of work accidents, before, during and after the event. ▪ Carry out constant inspections of the support structures and the trench interior in the zones with identified slope instabilities. ▪ Fence in the work area and do not allow access to unauthorized persons. ▪ Establish medical services and a first aid kit.
7. Improvement in local economy	▪ Maintain the policy of informing the local population about employment. ▪ Establish a rotating schedule for hiring personnel.
8. Liquid and solid waste management	▪ The final disposal of the effluents from the portable bathrooms used by the workers during Project construction shall be carried out properly. ▪ Solid waste generated should be collected and disposed properly.
9. Archeological Site	▪ Plan should be prepared to safeguard and implement the plan.

Source: JICA Study Team

EMP costs which also include monitoring for protection of archaeological sites, are shown in Table 1.10-3.

Table 1.10-3: EMP Cost Estimates (Preliminary)

Major Items	Estimated Cost (in N. Soles)
Preventive measures	1,845,520
Wastes management	79,240
Monitoring Program	1,596,870
Total	**3,521,630**
Miscellaneous	500,000
Total	**4,021,630**

Source: JICA Study Team

1.11 Organization and Administration for Project Implementation

For the organization and management of Project implementation, the following stakeholders participate with the roles described below:

SEDAPAL: The Executing Unit of the Project shall be PROMESAL, the Team that depends directly on the General Management Department, and shall have the duty of technical, financial, and contractual administration of the project, in internal coordination with the line and support Management Departments and the SEDAPAL Teams, and in external coordination with JICA and KfW for the payment of loans; as well as the National Directorate of Public Debt (NDPD), a line organization of the Ministry of Economy and Finances for the control of the payment of external loans and its respective services for the corresponding debts.

Through the Management and Selection Processes Control Team, SEDAPAL shall contract a Consultant firm for the elaboration of the technical works file for the project, which includes the development of the administrative requirements for the tendering of works and supplies, according to the number of lots required by the Implementation Plan. In the same way, this Team shall provide public tendering to contracting firms for the execution of works; as well as the acquisition of goods (equipment for the operation and maintenance works).

The North Services Management Team (GSN) and the Callao and Comas operation and maintenance teams shall have active responsibility in the investment phase and direct responsibility in the operation phase.

FONAFE: The unit in charge of regulating SEDAPAL´s business activity in the pre-investment phase is the OPI FONAFE, whose responsibility includes approving the feasibility study of the project and requesting the declaration of viability from the DGPI (Dirección General de Políticas de Inversiones, or General Directorate of Investment Policies). In the investment phase, it shall give its opinion with respect to the results of the technical works file before beginning of the execution of project works.

Ministry of Economy and Finances (MEF): Through the DGPI, it shall declare project viability, and it shall give its opinion before the approval on the conditions of the external debt operations with JICA, KfW and IBRD. Likewise, through the NDPD (National Directorate of Public Debt), it shall negotiate the loans with JICA, KfW and IBRD, and it shall give its opinion before the approval on conditions of the external debt operations with said organizations; later, it shall sign loan contracts for the financing of the project with JICA, KfW and IBDR in representation of the Republic of Peru.

In the investment phase, the DGPI shall give its opinion with respect to the results of the technical works file before the beginning of execution.

During the investment phase, the NDPD shall control the payment of loans and respective debt services in the operation phase of the project.

Ministry of Housing, Construction, and Sanitation: Through the OPI Vivienda, it shall give its opinion regarding the project´s feasibility study before declaration of project viability by the DGPI. Likewise, it will ratify the legal devices for the approval of the debt operation with JICA and KfW.

In the investment phase, through the National Sanitation Directorate (Dirección Nacional de Saneamiento, or DNS), it shall issue the corresponding directorial resolution approving the Environmental Impact Study, whose study level shall be according to the Classification approved by said directorate.

In the operation phase, it shall regulate as appropriate in order to improve the quality of the water and sewerage services.

SUNASS: In the operation phase, it is the regulatory body for the sanitation services rendered

by SEDAPAL, approving the Master Plan for Optimization and developing the Tariff Study for the approval of the Tariff Formula (adjustment or increase) and the Tariff Structure and Management Goals for the five-year period from 2015 to 2019, which shall include the project investments.

Japan International Cooperation Agency – JICA: It is an organization for Japan official development assistance. This agency financed the pre-feasibility study (perfil) and this feasibility study. Once project viability has been declared by the authorities in the Peruvian Government, it shall negotiate and sign the Loan Contract with the Ministry of Economy and Finances for the partial funding of project execution.

In the investment phase, it shall make the payments to SEDAPAL for the development of the technical file and execution of works. Likewise, before the contracts are signed for consultant, works, and acquisition of goods, it shall grant the non-objection for the awarding of the corresponding successful bids.

International Bank for Reconstruction and Development – IBRD: The IBRD is one of the institutions of the World Bank. Once project viability has been declared by the authorities in the Peruvian Government, it shall negotiate and sign the Loan Contract with the Ministry of Economy and Finances for the partial funding of project execution.

In the investment phase, it shall make the payments to SEDAPAL for the development of the technical file and execution of works. Likewise, before the contracts are signed for consultant, works, and acquisition of goods, it shall grant the non-objection for the awarding of the corresponding successful bids.

Kreditanstalt Fur Wiederaufbau Bankengruppe-KfW: It is an organization of the German official financial cooperation. Once project viability has been declared by authorities in the Peruvian Government, KfW shall negotiate and sign the Loan Contract with the Ministry of Economy and Finances for the partial funding of project execution.

In the investment phase, it shall make the payments to SEDAPAL for the execution of works. Likewise, before the contracts are signed for works and acquisition of goods, it shall grant the non-objection for the awarding of the corresponding successful bids.

1.12 Implementation Plan

(1) Pre-investment activities

The pre-investment phase activities include: i) an evaluation of the feasibility study carried out by the SNIP entities (EPI SEDAPAL, OPI FONAFE, OPI VIVIENDA, and DGPI), that will lead to the declaration of Project viability, ii) a funding agreement between MEF and the cooperating agencies that would fund the Project (JICA, IBRD, and KfW), as well as the resource transfer agreements between MEF and SEDAPAL.

It is foreseen that the feasibility study is completed and approved by SEDAPAL by March 2011, and that the Project's viability is stated in September 2011

(2) Consulting services activities

Breakdown of these activities is as follows: i) call for international consultancy firm pre-qualification and relevant short listing, ii) invitation to submit technical and financial bids, iii) evaluation of bids, iv) contract awarding and subscription, with approval from the funding agency (agencies).

Once the consulting contract has been subscribed, the consultancy firm will develop the following activities:

- Development of the Detailed Design study[2] of the works and equipments for Packages A, C, and B, including a TV camera inspection to the sewerage networks. Detailed Design study completion and approval for packages A and C are scheduled for March, 2013, and for package B, for September 2013. It includes presentation of SNIP-15 format to OPI-FONAFE and DGPI[3].
- Preparation of pre-qualification and works tender and equipment procurement for Packages A, C, and B.
- Assistance to SEDAPAL in the works bidding and equipment procurement process (answering to queries, bid evaluations, contract negotiations)
- Works supervision during the construction, as well as environmental monitoring, social intervention, and the updating of the technical cadastre of the facilities (the consultancy firm(s) will prepare the as-built drawings for the works.)

(3) Pre-construction activities

Pre-construction activities include the following: i) preparation of the Works technical file, preparation of the pre-qualification, works bidding, and equipment purchase documents, ii) call to public tender for works and equipment in Packages A, C, and B, iii) bid evaluations, iv) granting and subscription of works and equipment procurement contracts, with approval from the funding agency (agencies.)

Pre-construction activities must be completed for Packages A and C in November 2013, and for Package B, in June 2014.

(4) Construction activities

Construction period for this Project is estimated at 36 months, of the expected start is December 2013, and should be completed by the end of December 2016, as shown in Table 1.12-1. It includes as-built drawing submitting activities (laying out drawings), and the liquidation of the relevant contracts.

(5) Operations Startup Activities

Operations startup for the Project works to be carried out by the Comas and Callao Network Operation and Maintenance Teams is foreseen for December 2015, for Package A works, and December 2016, for Package B works.

Table 1.12-1: Packages and Duration of Works Construction and Equipment Supply

Package	Type of Bid	Duration	Start	End
Package-A: General Works Primary Networks, Reservoirs, Pumping Stations, Wells and SCADA system		24 months	January 2013	December 2015
Package-B-1 to B-5: Water supply and sewerage secondary Networks		30 months	July 2014	December 2016
Package-C: Procurement of O&M Equipment		9 months	January 2013	September 2014

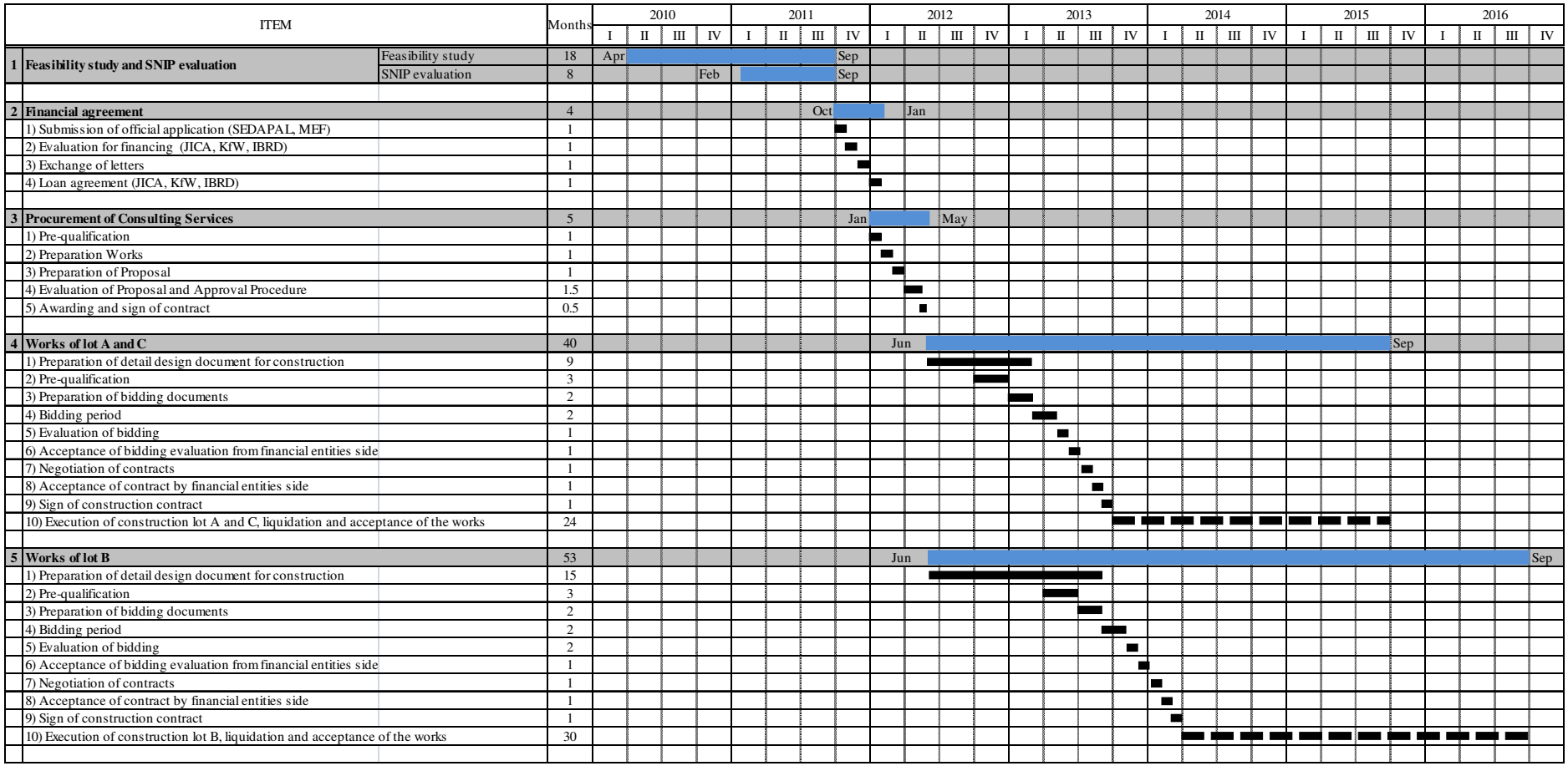
Source: JICA Study Team

[2] It includes: descriptive memory, technical specifications, works execution drawings, quantifications, works budget, works budget determination date, reference value, Price analysis, appraised Works progress calendar, polynomial formulas, topography, soil study, geological study, environmental impact study, archaeological remains study, and other studies.

[3] Consistency report between detail design and feasibility study (Article 24.2 of SNIP regulation (R.D N° 003-2011-EF/68.01

(6) Physical and financial goals

Figure 1.12-1 and Table 1.12-3,4 show the financial and physical progress schedule by packages during the implementation period.



1/ Includes preparation of consistency with the feasibility study (Format SNIP -15)

Source: JICA Study Team

Figure 1.12-1: Implementation Plan of the Project

Table 1.12-2: Financial Progress of the Project Components
(Nuevos Soles June 2010)

Ítem	Description	Total	2012	2013	2014	2015	2016
	Package A						
1	General works of potable water	34,486,873		4,310,860	17,243,437	12,932,576	
2	Rehabilitation of reservoirs, pumping stations, wells and automation	44,611,555		5,576,444	22,305,777	16,729,334	
	Package B						
3	Secondary networks and water connections	153,897,517			46,169,256	61,559,008	46,169,253
4	Secondary networks and sewerage connections	127,806,521			38,341,957	51,122,609	38,341,955
	Package C						
5	Equipment for O&M	20,751,609				20,751,609	
	Intangibles						
6	Costs of environment mitigation, social intervention and technical cadastre	24,301,429		2,025,119	8,100,476	8,100,476	6,075,358
7	Detail design of works and environment impact study	25,282,404	9,480,901	15,801,503			
8	Supervisión of works and environment monitoring	43,534,634		3,627,887	14,511,545	14,511,545	10,883,657
9	Management of the project	6,610,985	521,920	1,043,840	2,087,680	1,913,706	1,043,839
	Total	**481,283,527**	**10,002,821**	**32,385,653**	**148,760,128**	**187,620,862**	**102,514,063**

Source: JICA Study Team

Table 1.12-3: Physical progress of the Project components [1/]

Ítem	Description	Total	Unit	2012	2013	2014	2015	2016
	Package A							
1	**General works of potable water**							
1.1	Primary network of water pipes (trench method)	40,547	m		5,068	20,274	15,205	
2	**Rehabilitation de reservoirs, pumping stations, wells and automatization**							
2.1	Equipment and rehabilitation of reservoirs	27	Unit		3	13	10	
2.2	Equipment and rehabilitation of pumping stations	4	Unit		1	2	1	
2.3	Equipment and rehabilitation of wells	23	Unit		3	11	9	
2.4	Automation and contro – potable water	Global	%		12%	50%	38%	
	Package B							
3	**Secondary networks and water connections**							
3.1	Rehabilitation of secondary network of potable water (trench method)	228,520	m			68,560	91,414	68,546
3.2	Rehabilitation of house connections – potable water	70,289	Unit			21,087	28,116	21,087
3.3	Provisional connections of water	Global	%			30%	40%	30%
3.4	Suplí and installation of micrometers	10,537	Unit			3,161	4,215	3,161
4	**Secondary network and sewerage connections**							
4.1	Rehabilitation of secondary network of sewerage (trench method)	166,280	m			49,950	66,600	49,730
4.2	Rehabilitation of secondary network of sewerage (jacking method)	71,210	m			21,402	28,536	21,272
4.3	Rehabilitation of house connections – sewerage	33,736	Unit			10,121	13,494	10,121
4.4	Provisional connections of sewerage	Global	%			30%	40%	30%
	Package C							
5	**Equipment for O&M**	Global	%				100%	
	Intangibles							
6	**Costs of environmental mitigation, social intervention and technical cadastre**	Global	%		8%	33%	33%	25%
7	**Detail design for works and environmental impact study**	Global	%	37%	63%			
8	**Supervisión of works and environmental monitoring**	Global	%		8%	33%	33%	25%
9	**Management of the project**	Global	%	8%	16%	32%	29%	16%

1/ Most representative components of works

Source: JICA Study Team

1.13 Funding

Funding for project execution foresees the use of resources from the Japanese Government financial cooperation through JICA, the International Bank for Reconstruction and Development (IBRD), and the German Government financial cooperation through the KfW Bankengruppe. These agencies are to sign agreements with SEDAPAL and the Peruvian Government (PG).

Financial conditions for a JICA loan would expected to be as follows:

- Interest rate: 1.40 % annual.
- Commission charges: 0.10 % annual.
  (for undisbursed balances)
- Charges for outlay period extensions: 0.20% of the undisbursed amount multiplied times the number of years.
- Debt repayment period: 18 years
- Grace period: 6 years

Financial conditions for an IBRD loan would be as follows:

- Interest rate: LIBOR (6 months) + fixed spread.
- Commission charges: 0.35 % annual (with a 0.50 % discount).
  (for undisbursed balances)
- Debt repayment period: 10 years
- Grace period: 5 years

Financial conditions for a KfW loan would be as follows:

- Interest rate: 5.46 % annual.
- Commission charges: 0.25 % annual.
  (for undisbursed balances)
- Debt repayment period: 12 years
- Grace period: 3 years.

Proposed funding scheme for the project is shown in Table 1.13-1. It is noted that 82,6% of the project total cost will be funded with resources from JICA, IBRD, and KfW, and the remaining 17,4% will be funded by SEDAPAL's own resources. The funding makeup by agencies is as follows: JICA accounting for 47,2%, which is equal to a loan amounting to 80.0 million US Dollars (7,264.1 million Yens), IBRD accounting for 17.7%, which is equal to 30 million US Dollars, KfW accounting for 17.7%, which is equal to 30 million US Dollars (24.6 million Euros); the remaining would be covered by SEDAPAL's own resources. Average exchange rates[3] for the currencies used are effective as of June 30th, 2010.

[3] Exchange rate for purchase – sale of 1 USD = S/. 2,838 = Yen 90,80 = Euros 0,819, Bank and Insurance Companies Superintendent's Office (SBS) – Perú, June, 2010.

Table 1.13-1: Project Funding Scheme by Source
(Currencies as of June 2010)

Source	2012		2013		2014		2015		2016		Total	
	USD	%	USD	%	USD	%	USD	%	USD	%	USD	%
SEDAPAL	614,893	17.4%	1,990,811	17.4%	9,144,581	17.4%	11,533,428	17.4%	6,301,744	17.4%	29,585,457	17.4%
JICA	2,909,709	82.6%	5,383,214	47.2%	24,727,234	47.2%	31,186,750	47.2%	15,793,094	43.7%	80,000,000	47.2%
BIRF			2,018,705	17.7%	9,272,713	17.7%	11,695,031	17.7%	7,013,551	19.4%	30,000,000	17.7%
KfW			2,018,705	17.7%	9,272,713	17.7%	11,695,031	17.7%	7,013,551	19.4%	30,000,000	17.7%
Total	**3,524,602**	**100%**	**11,411,435**	**100%**	**52,417,240**	**100%**	**66,110,240**	**100%**	**36,121,939**	**100%**	**169,585,457**	**100%**

Source: JICA Study Team

1.14 Log Frame

The Log Frame matrix shows a consistency between the Project goal and the solution that is being set out; in addition, it shows results indicators that will allow for measuring the Project impact.

Table 1.14-1: Log Frame Matrix

	Narrative Summary of Objectives	Objectively verifiable indicators	Means of Verification	Assumptions
END	To improve quality of life for population in the Project's area of influence	By year 5, 100 % of the population are content with the water supply and sewerage service quality offered by SEDAPAL	Project impact evaluation survey	No social problems in the areas around SEDAPAL's scope
PURPOSE	To successfully offer a suitable water supply, sewerage, and operational management service in the project's area of influence	By year 2 after implementation, total number of claims (both commercial and operative) have an 80 % decrease in the area of influence.	SEDAPAL Statistical Annual Report.	No external factors (disasters) that affect / deteriorate the infrastructure
COMPONENTS	Water supply service improvement	• Technical or physical losses show up to a 25 % decrease in operation year 1, and up to a 20 % decrease during the remaining years of the project horizon (2035) • Service continuity is on a 24-hour basis and with sufficient pressure for all sectors by operation year 1. • Operative claims for breakages and water leakage have an 80 % decrease by operation year 2 of the Project	Annual report from the Leakage Control and Reduction Team, the Commercial Management Team, and the Network Operation and Maintenance Team in Callao and Comas	Operative budgets are allotted for water network operation, and system is interconnected to the Huachipa WTP distribution system
	Wastewater collection service improvement	Clogs in networks and connections decrease down to 0.5 interventions per km by year 5 of the Project implementation. Operative claims for clogs and overflows have an 80 % decrease by year 5 of the Project implementation.	Annual report from the Network Operation and Maintenance Team in Callao and Comas	Budgets for Project operation are available, and primary collection and wastewater final disposal systems show no operational problems
	The North Services Management (GSN) develops an efficient water supply and sewerage service management in the project's area of influence	By year 1 of Project operation, the North Services Management has 100 % budgeted resources and maintenance equipment to develop a suitable preventative maintenance management. In this way, the Leakage Control and Reduction Team carries out all water leakage detection and control actions.	SEDAPAL Statistical Annual Report	Economic resources and staff available for Project operation
ACTIVITIES	General works and rehabilitation for reservoirs, pumping stations, and Wells	• Installation of DI primary distribution pipes, DN 150 mm to DN 700 mm, 40.55 Km and 107 pressure reducing valves, air valves, purge valves and sluice valves. • Cost: S/. 34.5 million.	Works appraisal and liquidation report	Economic resources available for Project execution

	Rehabilitation for reservoirs, pumping stations, and Wells	Civil, hydraulic Works, equipment and rehabilitation for pumping stations, including automation and hydraulic equipment for 27 reservoirs, 4 pumping stations and 23 wells. Cost: S/. 32.5million	Works appraisal and liquidation report	Economic resources are available for Project execution
	Potable water supply system rehabilitation (secondary networks, connection, and meters)	• Rehabilitation of 179.02 Km of pipes, installation of inlet to sector pipes pf 49.50 Km of, DN 100 mm to DN 400 mm, 228.52 km, including pressure reducing valves, air valves, drain valves and hydrants. • Renewal of 70,289 connections • Installation of 10,537 new meters Cost: S/. 153.9 million	Works appraisal and liquidation report	Economic resources are available for Project execution.
	Automation and Control System	• Automation and control – potable water Cost: S/. 12.1 million	Valuation and liquidation of works	Available economic resources for the execution of the project
	Wastewater collection system rehabilitation (sewerage secondary networks and house connections).	• Rehabilitation and/or renewal of existing sewerage networks in 237.49 Km, PVC, DN 200 to DN 400 mm: 166.28 km (trench) and 71.21 km PVC (trench- less). • 3,302 new manholes installation and 1,415 manholes rehabilitation • Renewal of 33,736 connections Cost: S/. 127.8million	Works appraisal and liquidation report.	Economic resources are available for Project execution.
	Water supply and sewerage operation and maintenance team	• Procurement of 2 mini hydro jet equipments, with vehicle, 6 hydro jet equipments, 6 m3 to 8 m3 with a tank truck for sewerage cleaning • Procurement of 3 mobile equipment for TV camera inspection to sewerage networks. • Water supply leakage detection equipment: 2 leakage location correlators, 4 geophones, and 200 mobile pre-locators and an equipped vehicle • Computer equipment. Cost: S/. 20.8million	Equipment Reception (Handover) and Contract liquidation report.	Economic resources are available for Project procurement of equipment
	Environmental mitigation, social intervention, and facility cadastre	• Mitigation measures during Works construction phase. • Environmental monitoring and follow-up during construction . • Archaeological monitoring during construction • Social awareness raising to population during Works execution. • Technical cadastre to facilities, includes as-built drawings Cost: S/. 24.3 million	Monthly report on environmental monitoring, archaeological remains, and social intervention programs. As-built drawings, records, and descriptive memory.	Economic resources are available for Project execution. Population and municipalities participate actively.
	a) Technical file includes environmental and archaeological remains studies. **b) Works supervision and environmental monitoring and follow-up.** **c) Project management.**	• Detailed design studies for works, includes EIA and CIRA. Cost: S/. 25.0 million • Supervision of works and environmental monitoring • Social monitoring Cost: S/. 43.9 millones • Project administration, technical, and financial management Cost: S/. 6.6 million	Approval reports of detailed design studies for Works and procurement of equipment Works supervision approval report Project management report	Economic resources are available for Project execution The Executing Unit continues as an entity depending on General Management Office

Source: JICA Study Team

1.15 Conclussions and recommendations

- The project's objective is to successfully accomplish a suitable water supply, sewerage, and operational management service in the Study area, as part of SEDAPAL's Northern

Services Management performance goals. Improvement in the study area could become a management model and could be implemented in all areas of Northern Services Management.

- In that sense, the best method must be made of the commissioning of the Huachipa WTP; in this way, the project will optimize the distribution system's operational control and will reduce technical losses towards the 20 % goal in the project's operation year 2.
- The Project includes improving and renewing 179.02 km (22.1 % of the existing network's total length) of water supply secondary networks, as well as installing 49.55 km of new pipelines, 70,289 connections and 10,537 new meters. It also includes installing 40,5 km of primary networks, and rehabilitating reservoirs (27), pumping stations (4), and wells (23). This involves civil works, installation of electromechanical equipment, automation, and SCADA system control.
- Renewal of 237.49 km (36.5 % of the existing network's total length) has been foreseen for secondary sewerage networks. 30 % of this renewal will use the pipe jacking /pipe blasting method and 70 % will use the open cut method. Renewal of 33,736 connections is also foreseen.
- Total Project cost, all components included, amounts to S/. 481,284 thousand (JPY 15,398 million = USD 169,585 thousand).
- With regard to the project's economic (social) evaluation results: NPV is S/. 41,5 million, and IRR is 12,8%. Investment value per capita for the project (networks and connections) is USD 205. This value is lightly less than compared to the reference value of USD 224 / inhabitant in urban areas as mentioned in SNIP Attachment 09 "Sewerage Network and Connection Extension without Primary Works". Therefore, proposed investment for project is acceptable.
- Financial evaluation results, from SEDAPAL's point of view, involve an ENPV of S/. /. 19.7 million and an IRR of 4.4% against a 3.92 % discount rate. Therefore, the project is financially viable for SEDAPAL. The project's financial evaluation with possible funding conditions results show that SEDAPAL's position would improve, with a FNPV of S/. 34.4 million, and an IRR of 6.5% against a 3.92 % discount rate. This is basically the result of the financial leverage generated by the favorable financial conditions from bank loans.
- Project implementation is expected to be start from 2012, and works should be completed by 2016. Operation is foreseen to be started around the last quarter of 2016.
- Project execution funding is foreseen to be based on resources from the Government of Japan's financial cooperation, via JICA, the International Bank for Reconstruction and Development (IBRD), and the Government of Germany's financial cooperation via KfW Bankengruppe. All of these agencies are to sign agreements with SEDAPAL and the Peruvian Government (PG).
- Proposed funding scheme for the Project will involve resources from JICA (USD 80 million), IBRD (USD 30 million), KfW (USD 30 million), and the remaining amount that is equal to 17,4% (USD 29.6 million) will come from SEDAPAL's own resources.
- Project viability is recommended to be granted, as this feasibility study has proven that the Project is both socially and commercially profitable; and this is compatible with the sanitation sector policy alignments.

CHAPTER 2 GENERAL ASPECTS AND PROJECT IDENTIFICATION

2.1 Name of the Project

The name of the JICA Study is "North Lima Metropolitan Area Water Supply and Sewerage Optimization Project (II)". This is equivalent to the Feasibility Study (F/S) for the Project, which is officially named by the Peruvian authority as "Optimization of the Infrastructure of the Water Supply and Sewerage Systems: Sectorization, Rehabilitation of Networks and Updating of the Cadastre of the North Service Management Office – Area of Influence of the Huachipa Plant – Areas of Drainage of the Sewers: Oquendo, Sinchi Roca, Puente Piedra and Sectors 83, 84, 85 and 212".

In the last few years, SEDAPAL, the entity responsible for water supply and sewerage in Lima, has been developing projects and executing works aimed at the rehabilitation and improvement of the water supply and sewerage networks, including the sectorization of the water distribution network, for an efficient system operation that results in better client service.

In 1995, works under the project "Rehabilitation of the Water Supply and Sewerage System" were executed in different districts of Lima and Callao through the Loan Agreement 3811-PE between the Republic of Peru and the International Bank for Reconstruction and Development (IBRD, part of the World Bank group) and the Loan Agreement PE-P11 between the Republic of Peru and the Overseas Economic Cooperation Fund of Japan (OECF) (now the Japan International Cooperation Agency – JICA). However, many areas still have systems that present operational problems and considerable technical losses of water.

To provide better services, SEDAPAL has regional administrations and one of them is North Service Department (GSN), which focuses on the northern Lima area. Within the strategy of SEDAPAL to have enough production capacity and assure an adequate service for the growing population of northern part of Metropolitan Lima, projects for the north area of the city are being developed, such as the construction of the Huachipa Water Treatment Plant (WTP) and the construction of the North Brunch transmission pipe *(Ramal Norte)*. These are being financed by the Japan Bank for International Cooperation (JBIC - now JICA).

However, within the administrative area of the North Service Department (GSN) of SEDAPAL, the levels of non revenue water (NRW) reach around 50%. This situation must be reversed to optimize the projects aim to increase supply, such as the Huachipa WTP. Due to this reason, network optimization turns out to be very urgent. In order to address this problem on a more localized basis, GSN divided its administrative zone into 4 parts, calling Lima Norte I, II, III and IV. The boundaries of these 4 zones are shown in Figure 2.1.1-1.

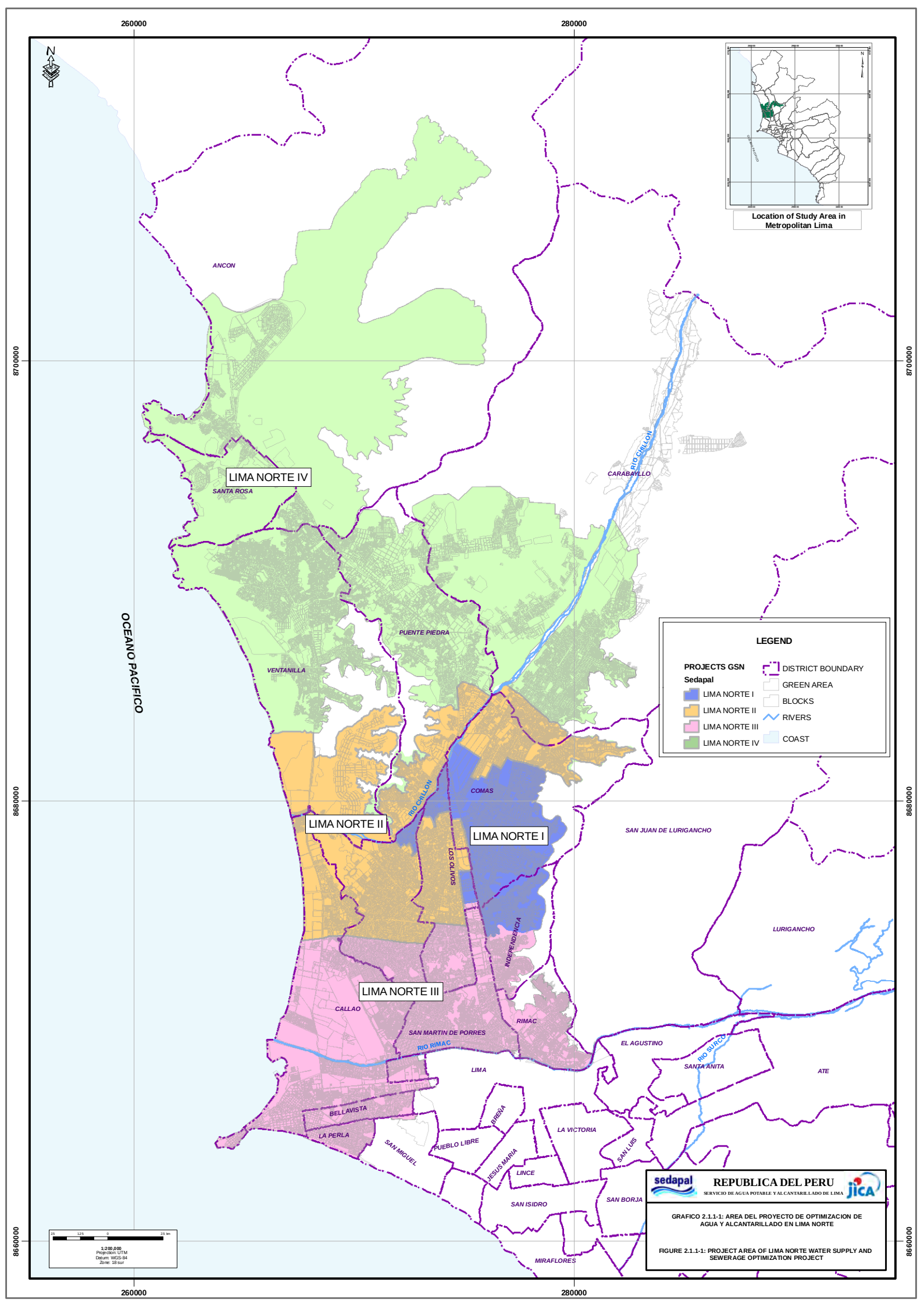
In September 2009, the Peruvian Government and the JICA signed a loan agreement for 5,550 million Japanese Yens (approximately 50 million dollars), which will allow SEDAPAL to finance the works of replacement, improvement and optimization of the old water supply and sewerage networks of Lima Norte I area. This area includes the drainage area of the Comas-

Chillón primary sewer. The project will benefit approximately 380 thousand inhabitants of the districts of Comas, Independencia, San Martin de Porres and Los Olivos.

The above-mentioned loan will finance the consultancy services for the detail designs (project files, as called by the Peruvian authority) and the supervision of works, as well as part of the investment. The total cost of the project is approximately 200 million dollars; and the remaining portion will be financed by the KfW of Germany, the World Bank and the SEDAPAL.

The Lima Norte I covers only part of the total GSN area and it was realized that there are other parts within the GSN area that also requires network rehabilitation, replacement and network optimization. In response to the Peruvian Government request, JICA agreed to finance a pre investment study for the Lima Norte II area at the level of pre Feasibility Study (Pre F/S, called *Perfil* by the Peruvian authority) named "Optimization of the Infrastructure of the Water Supply and Sewerage Systems: Sectorization, Rehabilitation of Networks and Updating of the Cadastre of the North Service Management Office – Area of Influence of the Huachipa Plant – Areas of Drainage of the Sewers: Oquendo, Sinchi Roca, Puente Piedra and Sectors 83, 84, 85 and 212". A contract for consultancy was signed between JICA and a consultant on March 30, 2009, thus commencing the second stage of optimization within GSN area. The first draft of this study was ready by September, 2009. After several scrutiny conducted by various agencies and subsequent revision and updating, the then DGPM (currently renamed as Directorate General of Investment Policies, DGPI under the Ministry of Economy and Finance, MEF) approved the Perfil Study and authorized the preparation of F/S on February 28, 2011.

Concurrently, the Peruvian Government requested JICA to carry out a Feasibility Study Project for the Lima Norte II area at the level of F/S (this Study). JICA agreed to this request and a contract was signed on December 17, 2009. JICA entrusted the Study to the consultant Nippon Koei and the field work has been started from April, 2010. The Final Report of this JICA Study will also serve as the basis of the F/S report of the Project.


260000
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Location of Study Area in Metropolitan Lima
ANCON
SANTA ROSA
LIMA NORTE IV
CARABAYLLO
RIO CHILLON
PUENTE PIEDRA
VENTANILLA
OCEANO PACIFICO
COMAS
LIMA NORTE II
LIMA NORTE I
LOS OLIVOS
INDEPENDENCIA
SAN JUAN DE LURIGANCHO
LURIGANCHO
LIMA NORTE III
CALLAO
SAN MARTIN DE PORRES
RIMAC
RIO RIMAC
EL AGUSTINO
RIO SURCO
SANTA ANITA
ATE
LIMA
BELLAVISTA
LA PERLA
SAN MIGUEL
PUEBLO LIBRE
BREÑA
JESUS MARIA
LINCE
LA VICTORIA
SAN LUIS
SAN ISIDRO
SAN BORJA
MIRAFLORES
LEGEND
PROJECTS GSN
Sedapal
LIMA NORTE I
LIMA NORTE II
LIMA NORTE III
LIMA NORTE IV
DISTRICT BOUNDARY
GREEN AREA
BLOCKS
RIVERS
COAST
1:200,000
Projection: UTM
Datum: WGS-84
Zone: 18 sur
sedapal
REPUBLICA DEL PERU
SERVICIO DE AGUA POTABLE Y ALCANTARILLADO DE LIMA
JICA
GRAFICO 2.1.1-1: AREA DEL PROYECTO DE OPTIMIZACION DE AGUA Y ALCANTARILLADO EN LIMA NORTE
FIGURE 2.1.1-1: PROJECT AREA OF LIMA NORTE WATER SUPPLY AND SEWERAGE OPTIMIZATION PROJECT

2.2 Formulating and Executing Unit

The executing unit for the Project is SEDAPAL. It was originally created as the Water Supply and Sewerage Company of Lima in 1855, for the administration of the water supply and sewerage services for the city of Lima. In 1962 it became COSAL (Sanitation Corporation of Lima), which changed its legal name to ESAL (Sanitation Company of Lima) in 1971. In 1981 this was transformed into SEDAPAL (Water Supply and Sewerage Service of Lima), which is currently in operation. SEDAPAL is in charge of the 49 districts that constitute the city of Metropolitan Lima and the Constitutional Province of Callao. Out of these, SEDAPAL provides total service to 46 districts while it provides partial service to 3 districts. The names and address of the responsible persons for this Project are given below.

Name of the Formulating Unit	:	*Servicio de Agua Potable y Alcantarillado de Lima - SEDAPAL*
Sector	:	*Fondo Nacional de Financiamiento de la Actividad Empresarial del Estado - FONAFE*
Name of the responsible officer	:	Ing. Samuel Trujillo - Manager of Development and Research
Address	:	Autopista Ramiro Priale Nº 210 – El Agustino
Phone Number	:	317-3018 / 317-3019
Fax	:	317-3406
Email	:	strujillo@sedapal.com.pe

Name of the Executing Units	:	*Servicio de Agua Potable y Alcantarillado de Lima – SEDAPAL*
Sector	:	*Fondo Nacional de Financiamiento de la Actividad Empresarial del Estado - FONAFE*
Name of the responsible officer	:	Econ. Jorge José Barco Martínez - Gerente General
Address	:	Autopista Ramiro Priale Nº 210 – El Agustino
Phone Number	:	317-3121 / 317-3007
Fax	:	317-3406
Email	:	jbarco@sedapal.com.pe

2.3 Participation of the Relevant Entities and Beneficiaries

In this section, the interests and problems are identified for the entities directly involved in relation to the Project.

2.3.1 Water Supply and Sewerage Service of Lima - SEDAPAL

SEDAPAL is an autonomous organization of the Ministry of Housing, Construction and Sanitation and its main purpose is to provide water supply and sanitation services in the Metropolitan Lima. SEDAPAL is also responsible to promote the system sustainability, expand the coverage, and improve the quality of the service.

As the sanitation service rendering company, its main mission is to contribute to the improvement of the living standard of the population. In addition it is also responsible for:

- Administrating the water resources.
- Collecting and disposing of wastewaters.
- Preserving the environment .
- Promoting, facilitating and financing the construction of water supply and sewerage systems in its area of influence.
- Formulating and approving the pre investment studies, as well as supervising the implementation of the water supply and sewerage facilities.
- Facilitating the financial resources for the development of the capacity building and organization of the community.
- Assuring the timely supply of safe water to the coverage population.

2.3.2 Ministry of Housing, Construction and Sanitation

This is the regulatory entity regarding housing, urban development, construction of infrastructure and sanitation. This ministry is in charge of promoting the sustainability of the water supply and sewerage network, the expansion of the coverage, and the improvement of the service quality in coordination with the regional and local governments. In addition, this ministry is in charge of formulating the relevant plans and programs. Through its Office of Planning and Budget (Office of Investment Programming), it evaluates and approves the pre investment studies of the sector and requests the Ministry of Economy and Finances (MEF) to authorize subsequent study or investment following National Public Investment System (SNIP) guideline which was prepared by MEF in 2000.

Since the present Project involves external loan finance, this ministry shall seek the approval and Declaration of Viability of the Project from the General Directorate of Investment Policies under the (MEF).

2.3.3 National Sanitation Authority (DNS)

As a line organization of the Vice Ministry of Construction and Sanitation (VMCS), this department is in charge of policies, plans, programs and norms related to the sanitation services, with the purpose of expanding the coverage and improving the service quality of water supply, sewerage, and excreta disposal. It also reviews and approves the environmental impact studies for the projects of Housing, Construction and Sanitation.

2.3.4 Ministry of Health (MINSA)

The Ministry of Health has the mission of protecting personal dignity, promoting health, preventing diseases and assuring integral health care for all population of the country, through their representative establishments (local health authorities), such as health care centers and health care posts. Moreover, this ministry regularly monitors the water quality through

processes conducted by the Directorate General of Environmental Health (DIGESA) and others. They also participate in the formulation of sanitary policies in agreement with the relevant public sectors.

2.3.5 Ministry of Economy and Finances (MEF)

This ministry has the objective of optimizing the public economic and financial activities, establish the macro economic activity and accomplish the sustainable economic growth of the country. This ministry, through the Directorate General of Investment Policies (DGPI), is entitled to approve the pre investment study at the level of Pre F/S (*Perfil)* and authorize the development of the pre investment study at the level of Feasibility, or, if it is the case, declares the viability of the Project.

In the framework of the Project, MEF participates as the guarantor of the external funds to be arranged, for example from JICA and/or World Bank.

2.3.6 Directorate General of Investment Policies (DGPI)

This is the line organization in charge of directing, integrating, following up and evaluating public investments including the programming of such public investment, and the promotion of integral development in relatively underdeveloped areas. Furthermore, this office is in charge of declaring the viability of projects to be financed with external loans and recommending their execution for both public investments and private finance.

2.3.7 The National Superintendence of Sanitation Services (SUNASS)

SUNASS is a decentralized public organization under the Cabinet Ministry. It is the regulating entity of the sanitation sector with administrative, functional, technical, economic and financial autonomy. It carries out the functions of supervising, regulating, controlling, penalizing and resolving controversies and claims from the users, in accordance with the scopes and limitations established by law. The scope of SUNASS includes both public and private utilities.

2.3.8 National Fund for the Financing of the Public Business Activity (FONAFE)

FONAFE is a public company under the MEF, created by Act No. 27170, in charge of regulating and directing public business activities. This organization supports and coordinates the financing of investment projects. The Programming and Investment Office (OPI) of FONAFE, in the framework of SNIP, will be in charge of evaluating the pre investment studies and requesting the DGPI of MEF to approve the *Perfil* and authorize the preparation of the pre investment study at the level of Feasibility, or, if it is the case, to declare the viability of the Project.

2.3.9 District Municipalities in the Area of the Project

The districts municipalities in the area of the Project (Carabayllo, Comas, Los Olivos, Puente Piedra, San Martín de Porres, Callao and Ventanilla) participate in the framework of their

authority and responsibility as described in Act N° 27972 – *Ley Orgánica de Municipalidades en Materia de Saneamiento, Salubridad y Salud (*Organic Act of Municipalities, on Sanitation, Health and Health care); Article 80 Item 4.1: *"Administrar y reglamentar directamente o por concesión el servicio de agua potable, alcantarillado y desagüe"*. (Administrate and regulate the water supply and sewerage services, directly or by concession)

2.3.10 Japan International Cooperation Agency - JICA

JICA is in charge of executing the technical cooperation program of the Japanese government, and financing investments and consultancy services for the development of economic and social infrastructure, as well as for the protection of the environment and the conservation of natural resources. This cooperation is defined as government to government. Since its creation in 1974, JICA has been supporting the socio-economic development and the development of human resource in developing countries including Peru.

In the context of the Project, JICA contributed for the Pre F/S investigation. JICA is also contributing this Study with both financal and technical expertise, and this Study will serve as the F/S for the Project. For the execution, JICA is expected to provide considerable support by providing a financial loan under preferential conditions, besides the technical assistance for the adequate implementation of the Project.

2.3.11 International Bank of Reconstruction and Development (IBRD)

The International Bank for Reconstruction and Development (IBRD) aims to reduce poverty in middle-income and creditworthy poorer countries by promoting sustainable development through loans, guarantees, risk management products, and analytical and advisory services. IBRD provides loans to governments and public companies, always with a government (or sovereign) guarantee of reimbursement. The funds for these loans come, mainly, from bonds issued by the World Bank in the global capital market – usually between US$12 and 15 billion per year.

In the context of the Project, it is expected that IBRD will contribute in the execution.

2.3.12 Kreditanstalt Fur Wiederaufbau (KfW)

The aim of Kreditanstalt Fur Wiederaufbau (KfW) is to promote the economic development of developing countries by making long-term financing. This agency finances investments and consulting services for the development of economic and social infrastructure, as well as for the protection of the environment and the conservation of natural resources. This cooperation is defined as government to government.

In the context of the Project, it is expected that KfW will contribute in the execution.

2.3.13 Project Beneficiaries

The direct beneficiaries of the Project are the service users of the areas influenced by the Project. The benefitted population does not participate directly in the stage of identification

and design of the project, but they have contributed to this through their complaints and reports. However, in the course of EIA, public opinion will be collected and reflected in the project detailing stage.

In the stage of execution, they will participate by respecting the safety indications placed by the contractor in the surroundings of the work site and by cooperating with the contractor to mitigate the impact of the works on the pedestrian and traffic flow and on the urban landscape.

In the stage of operation and maintenance, the beneficiaries participate by using the facilities and services appropriately. Moreover, they contribute to the sustainability of the services through their monthly payments and their complaints regarding failures and anomalies that may occur.

2.3.14 Ministry of Environment (MINAM)

The Ministry of Environment has the objective of preserving environmental quality and assuring a balanced environment appropriate for the development for the present and future generations. With this purpose, it promotes and ensures the sustainable, responsible, rational and ethical use of natural resources and the environment that supports it, and contributes to social, economic and cultural sustainable development of the human individual, in permanent harmony with its environment. Likewise, this ministry shall promote sustainable development, through control and conservation measures regarding environmental quality, urban planning and environmental management. This ministry also promotes actions of basic sanitation and solid waste management that assure adequate environmental quality in the urban centers and especially in tourist destinations.

2.3.15 Contractors of SEDAPAL

Contractors are companies hired by SEDAPAL to conduct several activities. (i) CONCYSSA (Construcciones Civiles y Sanitarias S.A) is in charge of the maintenance of the water and sewerage networks, preventive and corrective maintenance of valves and fireplugs, cleansing and disinfection of storage facilities, tank trucks; as well as of construction of house-connections for water supply and sewerage. (ii) AZB – HCI is in charge of the Implementation of the Integral System of Commercial Activities (SIAC) which includes the supply and installation of meters, initial maintenance, corrective actions, as well as the integral management of persuasive actions.

2.3.16 Summary

The involved entities and the benefited population will participate according to their interests and strategies to solve the conflicts (for example, deficient water supply and sanitation services), as well as fulfilling the agreements and commitments made. Table 2.3.16-1 shows the analysis of the beneficiaries and involved entities, including interests, problems, resources and directives.

Table 2.3.16-1: Interests, Identified Problems and Commitments of the Involved Parties

Group	Interests	Identified Problems	Resource and Directives
Ministry of Housing Construction and Sanitation	Wellbeing of the population through the water supply and sewerage services provided by SEDAPAL	The quality of the services in the area of influence is below the sector objectives.	Verification of the pertinence of the proposal and its agreement with the policies of the Sector.
SEDAPAL	Administrate and operate appropriately the systems of production, distribution, collection, loss-reduction and increase of sales.	Bad condition of the networks, discontinuity of the service, considerable loss of water.	Resources and faculties to operate and maintain the water supply and sewerage service.
Ministry of Economy and Finances– MEF	Adequate and efficient allocation of resources for social wellbeing.	Loss of resources due to the deficient operation of the systems in the area.	Verification of the technical, economic, social and financial viability of the proposal.
FONAFE	In charge of regulating and directing the public business management.	SEDAPAL does not have the necessary financial resource for the financing of investments that improve the services.	Support and coordination with the financial entities for the financing of the Project. Approval and verification of the technical, economic, social and financial viability of the Project.
Ministry of Environmental Affairs (MINAM)	It is in charge of looking after the environmental quality conservation, and ensuring a right to enjoy a balanced environment by the present and future generations.	Environmental and natural resource degradation	To verify the proposal's relevance and compliance with the sector's policies.
Population of the districts under the North Service Center	To have a good water supply service (continuity, pressure and quality) and sewerage.	Insufficient water quantity, low pressures, blockages, leaks, hours of insufficient service, wastewater overflow and deterioration of road condition due to pipe collapse	Support to the Project, cooperating with the execution, using the service appropriately, and committing to the payment of the monthly service rate.
District Municipalities– NSC	To have a good water supply service (Continuity, pressure and quality) and sewerage.	Insufficient water quantity, low pressures, blockages, leaks, and hours of insufficient service. Problems in urban transportation due to the deterioration of public roads and floors. Dissatisfaction of the population due to having a restricted service.	Support to the project with norms and actions that promote and adequate use of the services and the conservation of the infrastructure.
International Cooperation Agencies: JICA, Kfw, IBRD and others	Contribute to the well being and improvement of the life quality of the population.	Lack of financial resources for the execution of the program for the partial or total replacement of old and deteriorated sanitary infrastructure.	Provision of reimbursable financing with the guarantee of the State and favorable long-term financial conditions; grace period, preferential interest rates; as well as technical support and advice.
Health Care Centers of the districts under the NSC	Contribute to the improvement of health, reducing the demand of health care.	Lack of the necessary staff and infrastructure for responding to the populations demands, due to the low water quality.	Monitoring of health indicators and report the improvement of the life quality of the population.
SUNASS	Efficient rendering of the water supply and sewerage services.	High number of complaints due to deficient water supply and sewerage service rendering	Supervise, regulate, control, sanction and solve controversies and complaints of the users.
Contractors of SEDAPAL for the maintenance of the water supply and sewerage systems	To be awarded contracts that are viable to be implemented and that assure them a reasonable profit, with manageable risks.	An updated technical commercial cadastre is not available. Its activities are limited to the contract. They do not include all the activities of the Department. Activities of rehabilitation and expansion are not conducted.	In charge of the preventive and corrective maintenance of the water distribution and collection systems; as well as the activities of the Integral Commercial System (SIAC)

Source: JICA Study Team

2.4 Reference Framework

2.4.1 Rationale

The rehabilitation works of the water supply and sewerage network respond to the need of improving the deteriorating infrastructure in different localities of Metropolitan Lima, where there are problems such as: bursts of the network pipes, water losses, sewerage overflows, sewer clogging and sewer collapse. The main problems arising from these include high non revenue water, high operation and maintenance cost and public sufferings. In some cases, these issues lead to commercial and operational complaints by third parties, thereby increasing the expenses in insurance policies, premiums and deductibles. These issues also cause deterioration of SEDAPAL's image, degradation of the environment and the public roads, and increase of the risks to the public health.

In many parts of Metropolitan Lima, the water supply facilities have exceeded their useful life period and showing signs of deterioration; a situation clear from increasing reported pipe failures. Likewise, some of the sewerage facilities also have exceeded their useful lifetime registering failures. However, not all the networks need to be rehabilitated.

In the last few years SEDAPAL has been developing projects and executing works that aim at the rehabilitation and improvement of the water supply and sewerage networks, as well as the sectorization project. The sectorization process requires isolating and defining a specific area, enabling the regulation of the entrance flow, monitoring the pressure and the chlorine concentration in the supplied water, as well as the identification of losses in the network within the defined sector. Also, having such defined sectors allows the preventive and corrective maintenance in the network without interrupting the service in a larger area.

The projects of sectorization are complemented with the SCADA System (Supervisory Control And Data Acquisition, a remote process monitoring and operation control system) which allows the monitoring of the entrance flow and the pressures in each sector, as well as determining the quality of the supplied water, through the modern network of telemetry. The main center of SCADA is located in La Atarjea.

In another development, preparation of the cadastral maps of the water supply and sewerage networks have been started from 1995, and now covers 95% of the administrative area, as of December of 2006.

With this situation, SEDAPAL now intends to rehabilitate and replace old and defective facilities for maximum network optimization. As explained in Section 2.1, this Project aims at network optimization for Lima Norte II area. Further, in the Lima Optimization Master Plan (PMO: *Plan Maestro Optimizado, SEDAPAL, 2009),* it is proposed that the maximum non revenue water (NRW) should not be more than 25%. Hence, this Project also aims at reducing the NRW at a level of 25% or below.

This report contains the results of the analysis conducted according to the terms of reference and the regulations established in Act 27293: National Public Investment System (SNIP, prepared by MEF, 2000). Main topics are as follows;

- Diagnosis of socioeconomic and demographic conditions of the Project area.
- Diagnosis of the water supply and sewerage systems, supply methods and drainage areas, and identification of constraints that prevent the maximum use of the installed capacity. Diagnosis of commercial and institutional aspects is also included.
- Analysis and proposal of solutions for the improvement of the water and sewerage infrastructure.
- Plan for the implementation.

2.4.2 Reference Background Database

For the preparation of the Report, the following information sources were used:

- Pre investment Study at the level of Perfil for the "Optimization of the Infrastructure of the Water Supply and Sewerage Systems: Sectorization, Rehabilitation of Networks and Updating of the Cadastre of the North Service Management Office – Area of Influence of the Huachipa Plant – Areas of Drainage of the Sewers: Oquendo, Sinchi Roca, Puente Piedra and Sectors 83, 84, 85 and 212". Development and Investigation Department – North Service Department of SEDAPAL, Nippon Koei LAC, January, 2010.
- Pre investment Study at the level of Feasibility "Optimization of the Water Supply and Sewerage Systems, Sectorization, Rehabilitation of Networks and Updating of the Cadastre – Area of Influence of the Huachipa Plant – Comas – Chillón Drainage Area". Development and Investigation Department – North Service Department of SEDAPAL, October 2008
- "Optimization of the Water Supply and Sewerage Systems, Sectorization, Rehabilitation of Networks and Updating of the Cadastre – Area of Influence of the Huachipa Plant – Comas – Chillón". Development and Investigation Department –North Service Department of SEDAPAL, Caduceo Consultores S.A., Lima, September 2007.
- Information on existing situation of the networks: age, material, valves and accessories.
- Information on current situation of the Sectorization Process.
- Definite Study for the Sectorization of the Central System of Distribution of La Atarjea Centro (Asociación Binnie & Partners- Binnie & Livesey & Asociados S.A. BLASA), which has Manuals of Operation and Maintenance for the sectorization and the SCADA System.
- Information on projects executed in the last few years for the rehabilitation of water supply and sewerage networks.
- Information on projects under execution for the rehabilitation of water supply and sewerage networks.
- Statistics of bursts, blockages, replacements and repairs of water supply and sewerage

pipes.

- Description of the operational problems and identification of their possible causes.
- Number of users, average consumption, connections with and without meters, amount of non-revenue water, average water demand per user groups.
- Drawing of the sectors and water and sewerage networks.
- Inventory of the water supply and sewerage network

Also, as part of the diagnosis and according to the terms of reference, the following activities were carried out:

- Evaluation of the water supply and sewerage infrastructure regarding its physical status, age, capacity, and current operation regime, for both primary and secondary networks.
- Evaluation of the current sources of water supply and distribution.
- Current situation and evaluation of the operation of the water and sewerage networks.

Based on the evaluation carried out on the current conditions, main problems have been defined. Alternate solutions have then proposed and best solution is identified from the technical, social, economic and environmental evaluations.

2.4.3 Legal Framework

The Project responds to the policies and strategic objectives of the Sanitation Sector, which aim to expand the coverage, as well as improving the quality of the water supply and sewerage services. These policies are defined in the Multi Annual Strategic Sectoral Plan of the Sanitation Sector for 2008-2015 *(Plan Estratégico Sectorial Multianual del Sector Saneamiento 2008-2015*). The investment in the Project is expected to improve the management system and the economic and financial viability of SEDAPAL. This is in line with the functional policies of the National Public Investment System (SNIP) and the General Act of Sanitation Services.

The Project also complies with the social objective of SEDAPAL; i.e., rendering the water supply and sewerage services to the population of the provinces of Lima and Callao, and improving the continuity and sustainability of the supplied services. In this sense, the proposed Project is compatible with the policies of the company, as defined in the Optimization Master Plan (PMO: *Plan Maestro Optimizado, SEDAPAL, 2009)*.

a) Act Nº 26338, General Law of Sanitation Services (*Ley Nº 26338: Ley General de Servicios de Saneamiento*) (July/24/1994)

b) Supreme Decree N° 023-2005-Vivienda, Regulations of the General Law of Sanitation Services, Act Nº 26338 (*Decreto Supremo Nº 023-2005-ViviendaTexto Único Ordenado del Reglamento de la Ley General de Servicios de Saneamiento, Ley N° 26338)* (December/1/2005)

c) Supreme Decree N° 010-2007-Vivienda, Modifying the Regulations of the General Law of Sanitation Services *(Decreto Supremo Nº 010-2007-Vivienda modificando el Texto Único Ordenado del Reglamento de la Ley General de Servicios de Saneamiento).*

(April/20/2007).

d) Supreme Decree N° 002-2008-Vivienda, Modifying Art. 103° of the Regulations of the General Law of Sanitation Services *(Decreto Supremo Nº 002-2008-Vivienda Modificando el Art. 103º del Texto Único Ordenado del Reglamento de la Ley General de Servicios de Saneamiento*. (February/7/2008).

e) Supreme Decree N° 031-2008-Vivienda, Modifying the Regulations of the General Law of Sanitation Services *(Decreto Supremo Nº 031-2008-Vivienda Modificando el Texto Único Ordenado del Reglamento de la Ley General de Servicios de Saneamiento*. (November/30/2008).

f) Act N° 28870, Law for Optimizing the Sanitation Utilities Management *(Ley Nº 28870: Ley para optimizar la gestión de las Entidades Prestadoras de Servicios de Saneamiento* (August/2006)

g) Supreme Decree N° 006.2007-EF, Regulation of Act Nº 28870 of February 5th, 2007. *(Decreto Supremo N° 006.2007-EF, Reglamento de la Ley 28870 del 5 de febrero del 2007)*

h) Law Decree Nº 25965; Law for the Creation of the National Superintendence of Sanitation Services (*Decreto Ley Nº 25965: Ley de Creación de la Superintendencia Nacional de Servicios de Saneamiento)* (December/19/1992).

i) General Regulations of *SUNASS*, Supreme Decree Nº 017-2001-PCM (*Reglamento General de la SUNASS, Decreto Supremo Nº 017-2001-PCM)* (February/21/2001).

j) Supreme Decree N° 023-2002-PCM, Modifying the General Regulations of *SUNASS (Decreto Supremo N° 023-2002-PCM, Modifican el Reglamento de la Ley General de la SUNASS)*. (April/4/2002).

k) Supreme Decree N° 035-2006-PCM, Approving the TUPA of SUNASS (Decreto Supremo N° 035-2006-PCM, Aprueban el TUPA de la SUNASS) (July/5/2006)

l) Act Nº 27293, Law that Creates the National System of Public Investment *(Ley Nº 27293, Ley que crea el Sistema Nacional de Inversión Pública)*, modified by Acts Nº 28522 and 28802 of May 25th of 2005 and July 21 of 2006 respectively and the Legislative Decree Nº 1005 of May 3th of 2008 and Nº 1091 of June 21st of 2008.

m) Supreme Decree Nº 102-2007- Regulations of the National System of Public Investment (*Decreto Supremo Nº 102-2007 - Reglamento del Sistema Nacional de Inversión Pública)*, of July 19th, 2007 and modified by the Supreme Decree Nº 038-2009-EF (February/15/2009).

n) Directive Resolution Nº 001-2011-EF/68.01, General Directive of the National System of Public Investment (*Resolución Directoral Nº 002-2009-EF/68.01, Directiva General del Sistema nacional de Inversión Pública)* (April 9th of 2011).

o) Directive Resolution Nº 003-2009-EF/68.01, Complementary Orders for the Investment Phase of the Project Cycle in the Framework of the National System of Pulic Investment (*Resolución Directoral Nº 003-2009-EF/68.01, Disposiciones complementarias para la fase de inversión del ciclo del proyecto en el marco del Sistema Nacional de Inversión Públic*a) (March/21/2009).

p) Act Nº 27972; Organic Law of Municipalities *(Ley Nº 27972: Ley Orgánica de Municipalidades.*

q) Ministerial Resolution 920-2008-VIVIENDA, Multi-Annual Strategic Sectoral Plan for *2008-2015* of the Ministry of Housing, Construction and Sanitation *(Resolución*

Ministerial 920-2008-VIVIENDA, Plan Estratégico Sectorial Multianual 2008-2015 del Ministerio de Vivienda, Construcción y Saneamiento) (December/31/2008).

r) Master Plan for the Water Supply and Sewerage System of Lima and Callao for 2009-2030 (*Plan Maestro de los Sistemas de Agua Potable y Alcantarillado de Lima y Callao* 2009-2030).

s) General Management Resolution 081-2008-SUNASS-GG, Regulations for the Rendering of Sanitation Services by SEDAPAL S.A *(Resolución de Gerencia General 081-2008-SUNASS-GG, Reglamento de Prestación de Servicios de Saneamiento de la Empresa SEDAPAL S.A.)* (August/18/2009)

t) Public Sector Indebtedness Law for 2010 Fiscal Year (*Ley de Endeudamiento del Sector Público para el Año Fiscal* 2011).

2.5 Diagnosis of Existing Situation

This section introduces and analyzes all variables for a reference framework in which the Study is carried out and operated. It also attempts to define the problem and to help set out objectives and solution to address the constraints.

2.5.1 Study Area

The Study area lies within the boundaries of the following districts: Comas, Carabayllo, Los Olivos, Puente Piedra, San Martin de Porres, Callao, and Ventanilla; the first five districts belong to the Lima Province while the last two belongs to the Callao Region, but all are the parts of northern Metropolitan Lima. The Study area is located within the operational jurisdiction of SEDAPAL North Services Management (GSN), and it is part of the area where water will be supplied by the under-construction Huachipa Potable Water Treatment Plant. As explained in Section 2.1 and 2.4, GSN divided its command area into four parts, namely Lima Norte I, II, III, and IV, and Lima Norte II is the Study Area. The Study Area is defined in the pre F/S (perfil) of this Project as "Area of Influence of the Huachipa Plant – Areas of Drainage of the Sewers: Oquendo, Sinchi Roca, Puente Piedra and Sectors 83, 84, 85 and 212".

Each district is divided by SEDAPAL into several distribution sectors. However, it is to be noted that all sectors of these 7 districts are not included in this Study Area. A total of 32 sectors are the subject area of this Study. General Location of the Study area with SEDAPAL's sector boundary is shown Figure 2.5.1-1.

The Study area is geographically located on the Pacific Coast, at 77º03' west longitude from the Greenwich Meridian, and at 11º55' south latitude from the Equator. The area is situated at 137 m above mean sea level. The Rimac River crosses the city following an east – west direction, and discharges at the north of the Callao port.

The nearest meteorological station near the Study area is located at the Jorge Chavez International Airport. The maximum monthly temperature registered there for the last 12 years never exceeded 32.9 °C, except for the December 1997 – 1998 period, because of the El Niño phenomenon. The maximum monthly temperatures during the winter months in 2007, 2008, and 2009 ranged between 19.4ºC (September, 2007) and 23.3ºC (July, 2007).

Long term average precipitation is around 40 mm / year, and gradually increases from May, and starts decreasing from November. The lowest peak is registered in April.

The relative humidity percentage in the Lima and Callao districts shows very high values during most of the year; relative humidity values registered at the Jorge Chavez International Airport's meteorological station show variations ranging between 73 % (July, 1997) and 91 % (September, 2001), as registered during the last decade, with small fluctuations throughout the year, and no seasonal differentiations.

The Project area limits with the following districts: at the north: Ventanilla and Puente de Piedra districts, at the south: Callao district, at the east: Comas, Carabaillo and Independencia

districts and at the west: the Pacific Ocean.

The Rímac river valley is the most important transport corridor that connects the metropolitan area with the central Andes region of Perú.

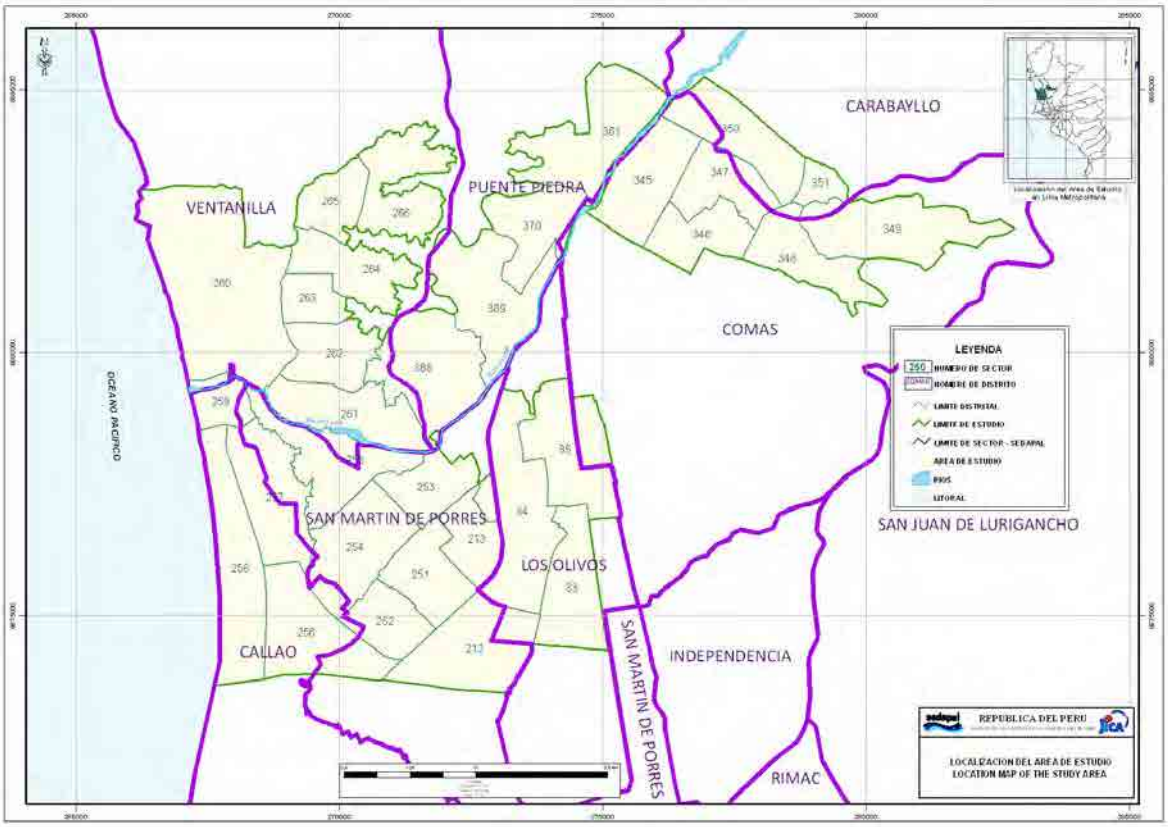

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Figure 2.5.1-1: Location of Study Area

Table 2.5.1-1 shows the cities and populated areas in all 7 districts that relates with the Study area. It is to be noted that the only Carabayllo district shows rural areas; and the sanitation services of these rural areas are not under SEDAPAL's scope.

Table 2.5.1-1: Populated Areas in the Districts related with the Study Area

District	Rural				Total Rural	Urban			Total Urban	Grand Total
	Housing association	Hamlet	Farming Cooperative	Others		City	Town	Others		
Callao						1			1	1
Ventanilla						1			1	1
Carabayllo	1	3	11	2	17		1	1	2	19
Comas							1		1	1
Los Olivos						1			1	1
Puente Piedra							1		1	1
San Martin de Porres						1			1	1
Total	**1**	**3**	**11**	**2**	**17**	**4**	**3**	**1**	**8**	**25**

Source: INEI – 2007 National Censuses: XI population census and VI housing census

The following is a description of the physical characteristics of the districts that relates to the Study area.

(1) Carabayllo

It is geographically located at the coordinates $11^0$51´06" south latitude and 77^0 02´11" west longitude. From this district, the sectors included in the Study Area are 350 and 351.

Carabayllo is the largest district in Metropolitan Lima, with an area of 346.88 km2 (34,688 Hectares), and it is mostly farmland. Carabayllo comprises 37. 3 % of the total area of the Lima Norte area, and it represents one of the lowest percentages of population. This district registers the largest growth rate in the last few years, and it is in the midst of an expansion in residential and agribusiness sectors. Carabayllo's urban growth is taking place at the expense of its farmland environment.

(2) Comas

It is geographically located at the coordinates 11°56'48" south latitude and 77°02'48" west longitude.

From this district, the sectors included in the Study Area are 345, 346, 347, 348, and 349.

The Comas district is located 8 kilometers north of Metropolitan Lima. It has an area of 48.75 Km2. It estimated population is 486,977 according to the 2007 population and housing census. Most of its area is already populated, even part of the hill slopes are populated. However, it still shows further growth but the growth rate is expected to gradually decline. Business is the major activity in the district.

(3) Los Olivos

It is geographically located at the coordinates 11°09'09" south latitude and 77°04'14" west longitude.

From this district, the sectors included in the Study Area are 83, 84, and 85.

The Los Olivos district has an area of 18.25 km2, and its estimated population is 318,140, according to the 2007 population and housing census. The district still shows a population growth.

(4) Puente Piedra.

It is geographically located at the coordinates 11°51'43" south latitude and 77°04'34" west longitude.

From this district, the sectors included in the Study Area are 361, 368, 369 and 370.

The Puente Piedra district has an area of 71.18 km2, and its estimated population is 233,602 in 2007. This district has shown a slower, though still high growth rate of 6.04%.

(5) San Martín de Porres

It is geographically located at the coordinates 12°01'40" south latitude and 77°02'36" west longitude.

From this district, the sectors included in the Study Area are 212, 213, 251, 252, 253, 254, 255, and 257.

Its area is 36.9 km2. This district has a population of 579,561 according to the 2007 population census. This district still shows population growth.

(6) Callao

It is geographically located at the coordinates 12°03'23" south latitude and 77°08'40" west longitude.

From this district, the sectors included in the Study Area are 256, 258, and 259.

The Callao district is one of the 6 districts that make up the Constitutional Province of Callao under Callao Region. Act 27867 of November 16th, 2002 turns this region as the only region having only one province. Its population is over 400,000, and its area is 45.65 km2.

(7) Ventanilla

It is geographically located at the coordinates 11°56'48" south latitude and 77°02'48" west longitude.

From this district, the sectors included in the Study Area are 260, 261, 262, 263, 264, 265, and 266.

Ventanilla is located north of the Constitutional Province of Callao, around 18 km north of the Callao district. Ventanilla is one of the most important population development poles in the northern area; it has a significant expansion area and a very low current density. Ventanilla's area is 73.52 km^2.

2.5.2 Demographic Characteristics

(1) Total Population and Gender Distribution

Urban population in the districts related to the Study area is 2,519,043, of which, 1,238,840 (49.2%) are men, and 1,283,203 (50.8 %) are women. Thus, men's percentage is slightly lower, i.e., there are 97 men for every 100 women (See Table 2.5.2-1.)

Table 2.5.2-1: 2007 Urban Population Structure by Gender

Location	Total	Men	Women
Region of Lima	8,275,823	4,047,671	4,228,152
Province of Lima	7,596,058	3,708,359	3,887,699
Province of Callao	876,877	430,582	446,295
Callao district	415,888	206,078	209,810
Ventanilla district	277,895	136,855	141,040
Carabayllo district	206,980	102,433	104,547
Comas district	486,977	239,665	247,312
Los Olivos district	318,140	153,963	164,177
Puente Piedra district	233,602	116,937	116,665
San Martín de Porres district	579,561	282,909	296,652
Total of 7 Districts	**2,519,043**	**1,238,840**	**1,280,203**
Gender distribution (%)	**100.00**	**49.20**	**50.80**

Source: INEI – 2007 National Censuses: XI population census and VI housing census

(2) Population by Age

According to INEI's 2007 census, the districts related to the Study area has 36.4 % of population under 20 years old, 35.4 % of population between 20 and 39 years old, and 3.6 % of population over 70 years old (See Table 2.5.2-2.)

Table 2.5.2-2: 2007 Urban Population Structure by Age

Location	Total	Age groups								
		0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80 +
Region of Lima	8,275,823	1,367,080	1,513,782	1,588,114	1,322,845	983,365	694,280	425,962	254,821	125,574
Prov. Lima	7,596,058	1,241,799	1,375,892	1,473,036	1,223,905	906,905	640,678	389,318	230,544	113,981
Prov. Callao	876,877	153,957	161,845	161,624	139,495	104,857	74,190	43,928	25,473	11,508
Callao district	415,888	67,548	73,799	80,098	65,532	49,250	39,240	22,660	12,171	5,590
Ventanilla district	277,895	59,906	59,296	51,625	44,561	31,801	17,287	7,708	4,131	1,580
Carabayllo district	206,980	40,415	41,693	39,068	33,894	23,407	14,693	8,214	3,950	1,646
Comas district	486,977	82,252	89,869	91,094	81,565	55,436	39,934	26,958	14,084	5,785
Los Olivos district	318,140	50,273	57,844	65,994	50,616	38,253	27,798	16,023	7,736	3,603
Puente Piedra district	233,602	46,190	49,526	47,562	36,830	26,090	14,925	7,209	3,639	1,631
S. M. de Porres district	579,561	93,707	105,177	109,553	92,772	75,559	50,015	27,281	16,978	8,519
Total of 7 Districts	**2,519,043**	**440,291**	**477,204**	**484,994**	**405,770**	**299,796**	**203,892**	**116,053**	**62,689**	**28,354**
Percentage (%)	**100.00**	**17.50**	**18.90**	**19.30**	**16.10**	**11.90**	**8.10**	**4.60**	**2.50**	**1.10**

Source: INEI – 2007 National Censuses: XI population census and VI housing census

(3) Population Growth

Since 1940, both the Region of Lima and the Province of Callao have shown high population growth rates. The annual average was around 4.89 % between the 1961 -1972 censuses period. After that, the growth was decreased to 2.04 % between the 1993 – 2007 censuses period. In addition, it is noted that population in the urban area has shown a different behavior from that of the rural area. Between the last two population censuses, the urban population has grown at

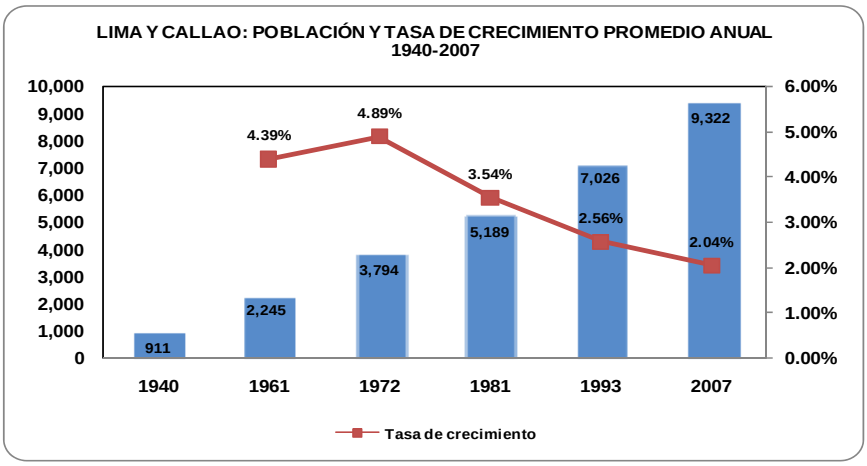
2.13 % annually, whereas the rural population has shrank at – 1.46 % annually. Table 2.5.2-3 shows populations, and growth rates.

Table 2.5.2-3: Nominally Registered Population in Censuses and Population Growth of Region of Lima and Callao in 1940 - 2007

Census	Total			Growth in Periods Between Census			Growth in Periods Between Census		
	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total
1940	711,441	199,144	910,585						
1961	1,957,267	287,324	2,244,591	1,245,826	88,180	1,334,006	4.94%	1.76%	4.39%
1972	3,554,367	239,428	3,793,795	1,597,100	-47,896	1,549,204	5.57%	-1.64%	4.89%
1981	4,983,357	205,933	5,189,290	1,428,990	-33,495	1,395,495	3.83%	-1.66%	3.54%
1993	6,818,052	207,985	7,026,037	1,834,695	2,052	1,836,747	2.65%	0.08%	2.56%
2007	9,152,700	169,388	9,322,088	2,334,648	-38,597	2,296,051	2.13%	-1.46%	2.04%

Source : INEI – 1972, 1981, 2007 population and housing censuses

Figure 2.5.2-1 shows annual average growth rate behavior between census periods, for the period 1940 – 2007. Between 1993 and 2007, population in these two regions increased to 2,296,051, that is, 164,004 per year. This meant 32.7 % increase compared to the 1993 population that was registered as 7,026,037.



Source: INEI – 1972, 1981, 2007 population and housing censuses

Figure 2.5.2-1: Population and Its Increase Ratio in Lima and Callao

Annual average growth rate of 2.04 % for the period 1993 – 2007 was lower than previous growth rates, and it is mainly due to a decrease in fertility levels.

According to the information from the 1993 and 2007 censuses supplied by INEI, districts related to the Study area had an urban population and household of 2,519,043 and 594,261 in 2007 resulting 4.22 persons per household (See Table 2.5.2-5). The annual average growth of 2.96 % for the urban areas is greater than the annual average growth value of 2.11% for Lima (See Table 2.5.2-4.)

Table 2.5.2-4: Population and Growth Rate in the Vicinity of the Study Area

Location	Period	Urban	Rural	Total
Region of Lima	1993	6,178,820	207,488	6,386,308
	2007	8,275,823	169,388	8,445,211
	1993-2007	2.11%	-1.44%	2.02%
Prov. Lima	1993	5,681,941	24,186	5,706,127
	2007	7,596,058	9,684	7,605,742
	1993-2007	2.10%	-6.33%	2.07%
Prov. Callao	1993	639,232	497	639,729
	2007	876,877	0	876,877
	1993-2007	2.28%	-100.0%	2.28%
Callao dist.	1993	369,412	356	369,768
	2007	415,888		415,888
	1993-2007	0.85%	-100.00%	0.84%
Ventanilla dist.	1993	94,356	141	94,497
	2007	277,895		277,895
	1993-2007	8.02%	-100.00%	8.01%
Carabayllo dist.	1993	98,492	8,051	106,543
	2007	206,980	6,406	213,386
	1993-2007	5.45%	-1.62%	5.09%
Comas dist.	1993	404,352	0	404,352
	2007	486,977		486,977
	1993-2007	1.34%		1.34%
Los Olivos dist.	1993	228,143		228,143
	2007	318,140		318,140
	1993-2007	2.40%		2.40%
Puente Piedra dist.	1993	101,568	1,240	102,808
	2007	233,602		233,602
	1993-2007	6.13%	-100.00%	6.04%
S.M. de Porres dist.	1993	378,353	2,031	380,384
	2007	579,561		579,561
	1993-2007	3.09%	-100.00%	3.05%
Districts in the area of influence	**1993**	**1,674,676**	**11,819**	**1,686,495**
	2007	**2,519,043**	**6,406**	**2,525,449**
	1993-2007	**2.96%**	**-4.28%**	**2.93%**

Source: INEI – 1993, 2007 population and housing censuses

Table 2.5.2-5: Urban Population and Household in the Vicinity of the Study Area

District	Population	Houses	Density	2003-2007 annual growth
Callao	415,888	94,931	4.38	0.84%
Ventanilla	277,895	81,388	3.41	8.01%
Comas	486,977	99,039	4.92	1.34%
Carabayllo	206,980	51,332	4.03	5.09%
Los Olivos	318,140	76,966	4.13	2.40%
Puente Piedra	233,602	58,453	4.00	6.04%
San Martín de Porres	579,561	132,152	4.39	3.05%
Total	**2,519,043**	**596,544**	**4.22**	**2.93**

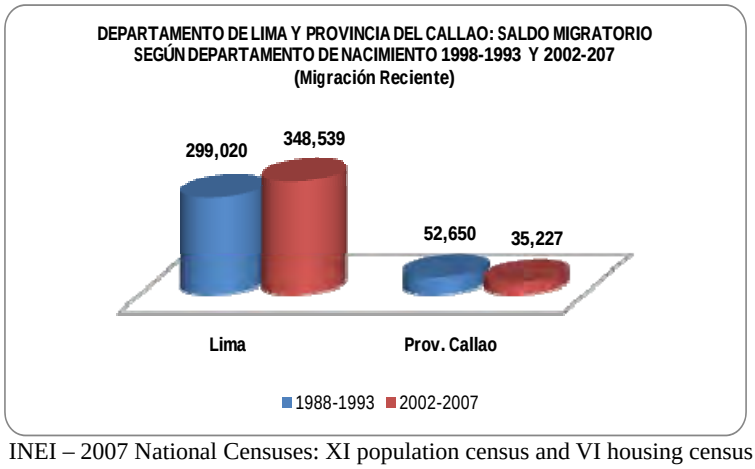
Source: INEI – 2007 National Censuses: XI population census and VI housing census

As mentioned before, the Study area comprises of -32 SEDAPAL sectors, which is only a small part of these 7 districts. The Study area population was 592,399 in 2007 (based on SEDAPAL information database) and person per household is 4.28. The Study area population is 23.52% of the total population of the 7 districts.

(4) Migration

The Region of Lima has been the major attraction pole for migration movements, as it absorbs over half the total number of people migrating out of their regions of origin.

Net population migration balance shows population increases or decreases at region level. According to the latest 2007 census, both the Region of Lima and the province of Callao showed a positive balance (net migration values of 348,539 and 35,227 respectively). (In 1993 also, a similar situation was observed as shown in Figure 2.5.2-2.



Source: INEI – 2007 National Censuses: XI population census and VI housing census

Figure 2.5.2-2: Number of Migration of Lima and Callao

(5) Other Population Indicators

1) Birth Rate

Birth rates are decreasing at a national level, from 27.3 in 1993, to 22.8 in 2003, for every one thousand inhabitants. This is the result of an intense National Family Planning Program that has been boosted in the last few years as a public policy. This program aims

at promoting changes in the population's reproductive behavior, and it is promoted by the Ministry of Health and ESSALUD, as the national Government public organizations. In the Lima Region, gross birth rates for the 1995 – 2015 period is expected to decrease, from 19.3 to 15.2.

2) Gross Mortality Rate

According to the INEI projections, this rate tends to increase for Lima Region, though not significantly, as it is expected to go from 4.1 to 5.2 in year 2015. However, this rate is below the national average estimated to be 6.2 in year 2005 having a tendency to decrease.

3) Life Expectancy at Birth

In Lima, life expectancy has increased from 76.8 years in 1995 to 78.4 years in 2005. According to INEI projections, life expectancy is to increase to 79.0 by 2015, as a result of better standard of living that is expected for the years to come. In addition, this indicator is well above the national average (for Perú) that is estimated to be 68.5 years.

According to the studies carried out by PNUD in 2005, the Callao district shows the highest life expectancy at birth (77.0 years), which is greater than the region and province average. The Puente Piedra district shows the shortest life expectancy of 75.2 years, below the region and provincial average (See Table 2.5.2-6.). This indicator can be used to understand the socioeconomic levels of the districts.

Table 2.5.2-6: Life Expectancy at Birth in 2005

Location	Population (inhab.)	Life Expectancy at Birth (years)
Department of Lima	7,819,436	75.8
Prov. Lima	7,007,388	76.0
Prov. Callao	810,568	76.5
Dist. Callao	389,579	77.0
Ventanilla dist.	243,526	75.4
Carabayllo dist.	188,764	75.6
Comas dist.	451,537	76.3
Los Olivos dist.	286,549	76.6
Puente Piedra dist.	203,473	75.2
San Martín de Porres dist.	559,367	76.2

Source: PNUD – 2006 Report on Human Development / Perú

Table 2.5.2-7 shows the major population indicators by 5 – year periods, according to the information from INEI. With regard to the mortality indicator, we see that child mortality rate is also expected to decrease from 19 to 14.

Table 2.5.2-7: Demographic Indicators in Region of Lima and Callao by Five–year Period

Indicator	1995-2000	2000-2005	2005-2010	2010-2015
Fertility				
Annual average births	138,014	138,179	138,524	138,126
Fertility rate (children per woman)	2.1	1.9	1.8	1.8
Gross birth rate (per one thousand)	19.3	17.7	16.4	15.2
Mortality				
Annual average deaths	29,553	34,769	40,713	47,300
Gross mortality rate (per one thousand)	4.1	4.5	4.8	5.2
Child mortality rate (for every one thousand born alive)	19.0	17.0	16.0	14.0
Life expectancy at birth	76.8	77.7	78.4	79.0

Source: INEI

2.5.3 Housing Characteristics

(1) Number of Dwellings

According to the 2007 census, the number of dwellings in the districts around the Study area is 594,261 units (See Table 2.5.3-1.)

Table 2.5.3-1: Number of Dwellings - Urban Area in 2007

District	Dwellings
Callao dist.	94,931
Ventanilla dist.	81,388
Comas dist.	99,039
Carabayllo dist.	51,332
Los Olivos dist.	76,966
Puente Piedra dist.	58,453
S.M Porres dist.	132,152
Total	**594,261**

Source: JICA Study Team

In the districts in the vicinity of the Study area, there are 8,986 blocks with 140,639 plots. Table 2.5.3-2 shows the plots and dwellings in each of the sectors within the Study area for 2007.

Table 2.5.3-2: Number of Blocks and Plots by Sectors in the Study Area (in units).

Sector	No. of blocks	No. of plots
83	540	9,204
84	615	14,102
85	409	7,414
212	421	9,510
213	287	4,915
251	339	7,477
252	171	3,765
253	291	5,277
254	413	6,599
255	112	1,023
256	509	9,160
257	118	1,174
258	33	75
259	200	3,371
260	35	175
261	81	735
262	33	154
263	32	127
264	49	271
265	30	253
266	35	403
345	205	3,191
346	312	6,267
347	198	3,453
348	292	3,776
349	795	9,144
350	525	7,700
351	184	1,666
361	240	3,919
368	706	7,991
369	487	7,112
370	199	1,236
Total	**8,896**	**140,639**

Source: INEI – 2007 National Censuses: XI population census and VI housing census

(2) Dwelling Tenure Regime

In the districts around the Study area, 21.6% of the dwellings are rented, 6.7 % are owned but not fully paid off, and 71.7 % are fully owned by the families. In the Ventanilla district, most of the dwellings (83.7 %) are totally paid; in Los Olivos, there is a larger portion of rented dwellings, and in the Carabayllo district, dwellings that are not fully paid shows a significant proportion.

Table 2.5.3-3: Dwelling Tenure Regime

District	Rented	Owned but not fully paid off	Fully owned and paid	Total
Callao	25.5%	5.4%	69.1%	100.0%
Ventanilla	8.1%	8.2%	83.7%	100.0%
Carabayllo	10.5%	12.5%	76.9%	100.0%
Comas	18.4%	4.1%	77.5%	100.0%
Los Olivos	32.6%	4.3%	63.1%	100.0%
Puente Piedra	11.7%	10.6%	77.7%	100.0%
S.M.P	28.1%	6.8%	65.1%	100.0%
Total	**21.6%**	**6.7%**	**71.7%**	**100.0%**

Source: INEI – 2007 National Censuses: XI population census and VI housing census

(3) Dwelling Construction Material

Table 2.5.3-4 shows major dwelling construction materials. It is noted that 77.5 % of the dwellings are made of brick or cement block, and San Martin de Porres is the district having the largest portion of this type of dwellings (92.9 %.).

Table 2.5.3-4: Dwelling Construction Materials

Type	Callao	Ventanilla	Carabayllo	Comas	Los Olivos	Puente Piedra	S.M.P	Total
Walls	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Brick or cement block	82.3%	37.2%	66.6%	88.8%	88.0%	61.6%	92.9%	77.5%
Wooden	9.8%	52.7%	13.4%	6.4%	1.5%	24.2%	3.6%	13.9%
Adobe or mud brick	3.5%	3.6%	12.7%	2.1%	8.5%	6.7%	2.2%	4.7%
Straw or bamboo mats	0.2%	4.5%	5.2%	1.4%	0.2%	4.7%	0.5%	1.9%
Other materials	4.2%	1.9%	2.1%	1.3%	1.9%	2.7%	0.8%	2.0%
Floors	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Cement	58.8%	54.1%	51.4%	62.4%	52.8%	52.6%	58.1%	56.6%
Tiles, terrazzo	24.5%	6.2%	10.3%	20.2%	27.0%	6.9%	26.0%	19.2%
Ground floor	9.1%	33.1%	35.4%	13.7%	10.3%	39.4%	9.0%	18.2%
Parquet o or polished wood	4.8%	0.7%	1.6%	2.0%	7.5%	0.3%	5.3%	3.6%
Other	2.9%	5.9%	1.4%	1.6%	2.5%	0.9%	1.5%	2.4%

Source: INEI – 2007 National Censuses: XI population census and VI housing census

(4) Utility Services

With regard to service availability, other than potable water and sewerage, in the districts around the Study area, it is noted that 94.5 % of the homes have electricity, and Los Olivos is the district having the largest number of dwellings with water supply (99.5 %). In most cases, homes connected to the water system seem to have more access to these services, in comparison to those homes without a water service.

With regard to the type of fuel used for cooking, most homes cook with gas (87.8 %), followed by kerosene (4.4 %), firewood (1.6 %), coal (1.3 %), electricity (1.8 %), and other types of fuel (3.1 %.)

Table 2.5.3-5: Utility Service Availability (%)

Service Availability	Callao	Ventanilla	Carabayllo	Comas	Los Olivos	Pte. Piedra	S.M.P	Total
Electricity	97.6	83.9	86.4	97.1	99.5	90.2	98.1	94.5
Land line telephone	55.2	32.1	37.0	51.9	55.6	33.3	54.5	48.2
Fuel type	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Gas	87.7	82.4	84.3	88.3	90.7	86.2	90.7	87.8
Firewood	0.6	4	3.7	0.9	0.6	3.5	0.6	1.6
Kerosene	5.4	7.1	5.8	4.7	2	4.7	2.6	4.4
Coal	0.5	2.3	2.6	1.8	0.8	1.9	0.6	1.3
Electricity	2.6	1.4	1.3	1.5	2	1	2.2	1.8
Other	3.2	2.8	2.3	2.8	3.9	2.7	3.3	3.1

Source: INEI – 2007 National Censuses: XI population census and VI housing census

2.5.4 Social Characteristics

(1) Health

1) Child Mortality Rate

Child mortality rate is an important indicator that allows for identifying the most vulnerable population groups on which suitable policy actions must be focused.

According to the WHO classification, under 1 (less than 1 year old) child mortality of 100 or more (death for every one thousand live births) is classified as very high child mortality level, while for the range between 60 and 99.9 is considered as high child mortality level. For medium and low child mortality level, the numbers should be between 30 and 59.9, and less than 30.

The 2004 – 2006 Health Survey results (ENDES)[1] show that during the 10 years prior to the survey, child mortality rates decreased in the urban area to 21 from 28 as reported in 2000 ENDES census. Child mortality in Metropolitan Lima is 14 (as noted in Table 2.5.4-1), and for the rest of the Coastal Perú, it is 22.

Table 2.5.4-1: Child mortality by Selected Characteristics in 2004-2006

Years before the survey	Infant mortality at birth (MN)	Infant mortality after birth (MPN)	Early Child mortality ($_1q_0$)	Post early Child mortality ($_4q1$)	Child mortality ($_5q_0$)
Metropolitan Lima	11.3	5.8	17.1	3.8	20.8

Source: 2004-2006 EDES.

2) Health Care Facilities

The Region of Lima has 680 health care facilities: 428 health care posts, 228 health care centers, and 24 hospitals. Districts around the Study area have 35 health care posts, 80 health care centers, and 4 hospitals that report to the Ministry of Health. The Callao and Comas districts show the largest number of healthcare facilities (See Table 2.5.4-2.)

[1] INEI:2000 Demographic and Family Health Survey - INEI /USAD/PROGRAMA MEASURE DHS, August, 2007

Table 2.5.4-2: Hospitals, Health Care Centers and Health Care Posts in 2008

Location	Health Care Post	Health Care Center	Hospital	Total
Department of Lima	428	228	24	680
Prov. Lima	171	175	17	363
Prov. Callao	2	51	3	56
Callao Dist.	1	31		32
Ventanilla Dist.	1	14	1	16
Carabayllo Dist.	7	4		11
Comas Dist.	10	13	1	24
Dist. Los Olivos	6	5		11
Dist. Puente Piedra	1	6	1	8
Dist. San Martin de Porres	9	7	1	17

Source: MINSA

3) Health Practitioners

With regard to health practitioners, the Region of Lima has 30,632 health practitioners that include 12,071 professionals (39.4 %), 11,725 technicians, auxiliary staff and assistants (38. 3 %), and 6,836 administrative and general service staff. (22.3 %). (See Table 2.5.4-3). Districts in the vicinity of the Study area have 1,997 practitioners that represent 16.5 % of the total practitioner population in the department. In addition, there are 1,758 (15.0 %) technicians, auxiliary staff and assistants, and 1,274 (18.6 %) administrative and general service staff.

Table 2.5.4-3: Ministry of Health Staff in the Health Care Facilities in 2007

Staff	Dept.	Prov.	Prov.	District						
	Lima	Lima	Callao	Callao	Ventanilla	Carabayllo	Comas	Los Olivos	Puente Piedra	S.M de Porres
Physicians	4,731	3,993	579	80	84	19	209	44	90	248
Nurses	3,517	3,017	408	36	31	22	87	32	45	245
Dentists	608	497	73	27	15	7	23	22	13	27
Obstetricians	1,306	1,076	146	42	38	17	54	35	38	42
Psychologists	313	306	57	11	4	1	9	15	5	31
Nutritionists	159	118	20	3	3	1	4	3	1	7
Pharmaceutical chemist	191	177	23	5	1	0	3	6	3	10
Other practitioners	1,246	1,147	271	38	14	0	48	11	17	71
Total Practitioners	12,071	10,331	1,577	242	190	67	437	168	212	681
Total Technicians, auxiliary staff, and assistants	11,725	10,368	617	186	94	74	431	100	144	729
Others	6,836	5,738	1,481	126	32	37	413	63	155	448
Grand Total	30,632	26,437	3,675	554	316	178	1,281	331	511	1,858

Source: Statistical Almanac of MINSA - 2007

4) Epidemiological Profile

According to the epidemiological information registered for years 2007 and 2008 by the Lima City Health Authority for the Carabayllo, Comas, Los Olivos, Puente Piedra, and San Martin de Porras districts and by the Callao Regional Health Authority for the Callao and Ventanilla districts, it is noted that the major morbidity causes registered in the districts around the Study area include severe respiratory infections, followed by mouth infections, intestinal infections, and other severe lower respiratory infections, chronic lower respiratory diseases, and other diseases, as shown in Table 2.5.4-4 and Table 2.5.4-5.

Table 2.5.4-4: Major Groups of Diseases that Cause Morbidity, as Registered by External Care in 2007 and 2008 (Carabayllo, Los Olivos, Puente Piedra, San Martín, and Comas)

Item	Morbidity Causes	2007	%	2008	%
1.	Severe respiratory infections	251,936	17.3%	270,805	18.1%
2.	Osteomuscular system and conjunctive tissue diseases	90,203	6.2%	101,546	6.8%
3.	Skin and subcutaneous diseases	94,473	6.5%	100,633	6.7%
4.	Diseases affecting other parts of the digestive system	82,369	5.6%	92,532	6.2%
5.	Teeth and periodontal diseases	107,492	7.4%	89,292	6.0%
6.	Other respiratory diseases	67,563	4.6%	75,239	5.0%
7.	Female genital organ diseases	60,621	4.2%	64,565	4.3%
8.	Mental and behavior disorders	64,680	4.4%	58,604	3.9%
9.	Intestinal infection diseases	52,390	3.6%	55,327	3.7%
10.	Urinary tract diseases	48,796	3.3%	54,617	3.7%
11.	Other causes	538,729	36.9%	529,771	35.5%
	Total	**1,459,252**	**100.0%**	**1,492,931**	**100.0%**

Source: Lima City V Health Authority, Epidemiology Office, May, 2010

Table 2.5.4-5: Major Groups of Diseases that Cause Morbidity, as Registered by External Care in 2007 and 2008 (Callao and Ventanilla)

Ítem	Morbidity Causes	2007	%	2008	%
1.	Severe respiratory infections	143,018	33.8%	137,810	32.2%
2.	Mouth infections	67,801	16.0%	75,800	17.7%
3.	Chronic respiratory infections	20,032	4.7%	18,398	4.3%
4.	Other severe respiratory infections	19,730	4.7%	18,109	4.2%
5.	Intestinal infections	27,016	6.4%	14,722	3.4%
6.	Other urinary tract diseases	8,307	2.0%	10,930	2.6%
7.	Dermatitis and eczema	7,339	1.7%	7,862	1.8%
8.	Other causes	129,940	30.7%	144,229	33.7%
	Total	**423,183**	**100%**	**427,860**	**100%**

Source: Callao Regional Health Authority, Epidemiology Office, May, 2010

Deficient or unavailable water and sanitation services are the major cause of intestinal infections. Percentages of intestinal infections are around 4% for the districts in the province of Lima within the Study scope, but the percentages for the districts of Callao and Ventanilla was higher, 6.4 % for 2007 and 3.4 % for 2008.

Severe diarrheic diseases can cause morbidity among children under 5 years old, and the most important cause is deficient water and sanitation service. Table 2.5.4-6 shows the diarrheic diseases in the districts around the Study area. It is noted that the occurrence rates for every one thousand inhabitants are lower in the districts around the Study area than what is noted at national level for 2008, except for the Callao Region that shows a rate of 301.2 for every one thousand inhabitants, as shown in Table 2.5.4-6.

Table 2.5.4-6: Children < 5 YEARS OLD – Case tendencies and Influence Rate (per 1,000 persons)

Districts	2007		2008	
	Case	TIA (influence rate)	Case	TIA (influence rate)
Carabayllo	3,780	206.9	4,014	212.1
Comas	6,526	155.3	6,371	151.7
Los Olivos	5,663	215.5	4,747	179.5
Puente Piedra	3,260	162.7	2,780	132.8
San Martin de Porras	6,787	138.9	6,088	122.8
Callao and Ventanilla1/	22,676		16,466	301.2
National		**449.7**		**251.6**

1/ It is at regional level.

Source: Lima City V Health Authority and Callao Health Regional Authority, Epidemiology Offices, May, 2010

At present, the health sector policy in the districts around the Study area is population health oriented, mainly to child and maternal health. The health sector faces several limitations, such as scarce medical equipment, little maintenance budget and little timely transportation for an optimum care.

(2) Education.

1) Illiteracy Rate

In order to measure the extent of educational development, the illiteracy rate is analyzed. The illiteracy rate in the Lima Region (according to INEI) in 2005 represents 3.2 %, which is less than the national average of 8.1 %; this means that, in average, there are less illiterate people.

According to the INEI projections, it is expected that by year 2015, the illiteracy rate in the Region of Lima will decrease from 3.2 % to 2.4 % (See Table 2.5.4-7.)

Table 2.5.4-7: Illiteracy Rate in Lima Region in 1995-2015

Censuses		Country	Lima	%
1995	Illiterate people	1,679,061	172,824	10.3
	Illiteracy rate	11.1	3.6	
2000	Illiterate people	1,581,947	171,873	10.9
	Illiteracy rate	9.3	3.2	
2005	Illiterate people	1,550,779	171,400	11.1
	Illiteracy rate	8.1	3.2	
2010	Illiterate people	1,563,854	171,422	11.0
	Illiteracy rate	7.3	2.6	
2015	Illiterate people	1,606,050	172,832	10.8
	Illiteracy rate	6.9	2.4	

Source: INEI – 2007 National Censuses: XI population census and VI housing census

According to the 2007 XI National Population Census and the VI National Housing Census, the districts in the vicinity of the Study area show an illiteracy average rate of 6.8 %, with Ventanilla having the largest rate of 8.6 %, and Los Olivos, the lowest rate of 5.8 % (See Table 2.5.4-8).

Table 2.5.4-8: Literacy Condition in the Districts in the vicinity of the Study Area

Location	Illiteracy rate (%)	Total	Age groups (years)							
			3 to 4	5 to 9	10 to 14	15 to 19	20 to 29	30 to 39	40 to 64	65 +
Callao		**395,154**	**14,544**	**32,270**	**36,228**	**37,571**	**80,098**	**65,532**	**101,536**	**27,375**
Can read and write		369,742		26,477	35,995	37,381	79,724	65,191	99,717	25,257
Cannot read or write	**6.4**	25,412	14,544	5,793	233	190	374	341	1,819	2,118
Ventanilla		**259,522**	**12,715**	**28,818**	**31,026**	**28,270**	**51,625**	**44,561**	**53,532**	**8,975**
Can read and write		237,317		23,432	30,799	28,139	51,309	44,123	51,810	7,705
Cannot read or write	**8.6**	22,205	12,715	5,386	227	131	316	438	1,722	1,270
Carabayllo		**201,009**	**8,711**	**20,629**	**21,918**	**21,123**	**40,252**	**34,850**	**44,137**	**9,389**
Can read and write		184,746		17,291	21,789	21,008	39,976	34,454	42,464	7,764
Cannot read or write	**8.1**	16,263	8,711	3,338	129	115	276	396	1,673	1,625
Comas		**462,396**	**17,269**	**40,402**	**44,582**	**45,287**	**91,094**	**81,565**	**110,699**	**31,498**
Can read and write		431,481		33,943	44,363	45,067	90,710	81,123	108,308	27,967
Cannot read or write	**6.7**	30,915	17,269	6,459	219	220	384	442	2,391	3,531
Los Olivos		**302,442**	**10,521**	**24,054**	**26,665**	**31,179**	**65,994**	**50,616**	**75,526**	**17,887**
Can read and write		284,780		20,350	26,515	31,044	65,745	50,387	74,350	16,389
Cannot read or write	**5.8**	17,662	10,521	3,704	150	135	249	229	1,176	1,498
Puente Piedra		**219,471**	**9,720**	**22,339**	**24,303**	**25,223**	**47,562**	**36,830**	**45,191**	**8,303**
Can read and write		201,335		18,696	24,145	25,107	47,265	36,447	43,210	6,465
Cannot read or write	**8.3**	18,136	9,720	3,643	158	116	297	383	1,981	1,838
San Martin de Porres		**551,526**	**19,493**	**46,179**	**50,575**	**54,602**	**109,553**	**92,772**	**140,973**	**37,379**
Can read and write		518,704		39,030	50,323	54,337	109,147	92,280	139,004	34,583
Cannot read or write	**6.0**	32,822	19,493	7,149	252	265	406	492	1,969	2,796
Total		**2,391,520**	**92,973**	**214,691**	**235,297**	**243,255**	**486,178**	**406,726**	**571,594**	**140,806**
Can read and write		2,228,105		179,219	233,929	242,083	483,876	404,005	558,863	126,130
Cannot read or write	**6.8**	163,415	92,973	35,472	1,368	1,172	2,302	2,721	12,731	14,676

Source: INEI – 2007 National Censuses: XI population census and VI housing census

2) Attendance Rate

Another way to measure the degree of educational development is by looking at the percentage of school children attending regular school, that is, the attendance rates.

School age population includes children between ages 3 and 24. By law, population between ages 3 and 5 must attend preschool, population between ages 6 and 11 must attend elementary school, population between 12 and 16 must attend high school, and population between ages 17 to 24 should attend some type of higher education. According to the 2007 Census results, in the Region of Lima, 2,380,755 people with ages ranging from 3 to 24 attend to some type of regular school. From the population attending schools, 12.4 % are between 3 and 5 years old, 34.2 % are between 6 and 11 years old, 29.3 % are between 12 and 16 years old, and 24.1 % are between 17 and 24 years old.

In the province of Callao, the 2007 Census registered 248,618 people with ages ranging from 3 to 24 who attend some type of schools. 13.6 % are between 3 and 5 years old,

35.4 % are between 6 and 11 years old, 30.0 % are between 12 and 16 years old, and 21.0 % are between 17 and 24 years old.

3) School Dropout Rate

School dropout rate is defined as the "portion of students, who abandon school activities for a year or more, before completing the academic grade they were studying the previous year." At national level, this indicator in 2002 was 4 %, both for men and women.

Dropout rate for 2007 in the Lima Region was 5.3 %, the rate was 5.4 % for the province of Lima, and 5.2 % for the province of Callao.

4) Educational Infrastructure

The Region of Lima has 18,658 schools: out of which 7,192 schools (42.4 %) depend on the Ministry of Education, and 10,746 schools (57.6 %) are private schools. Schools in the area of influence represent 29.7 % of the total educational infrastructure in the Region of Lima (See Table 2.5.4-9.)

Number of enrolled students and teachers in year 2008 were 2,364,840 and 140,713 (ratio is 17 students per teacher). These students are distributed in 105,369 classes on an average.

5) Academic Level, Teachers, Students, and Classes

According to educational statistics, there are 24 schools (4 %) for children with special needs, 2,717 (49.0 %) preschools, 1,703 (30.7 %) elementary schools, 953 (17.2 %) high schools, 114 (2.1 %) trade schools, and 37 (0.7 %) higher education schools.

In the districts in the vicinity of the Study area, educational infrastructure in year 2008 was 5,548, 35.6 % of which depend on the Ministry of Education, and 65.4 % are private schools (See Table 2.5.4-9).

Table 2.5.4-9: Educational Institutes in 2008*

District	Ministry of Education	%	Private	%	Total
Region of Lima	7,912	42.4	10,746	57.6	18,658
Prov. Callao	648	37.2	1,094	62.8	1,742
Callao	273	36.2	481	63.8	754
Ventanilla	303	48.6	321	51.4	624
Prov. Lima	5,523	35.3	10,127	64.7	15,650
Carabayllo	218	41.9	302	58.1	520
Comas	371	35.5	674	64.5	1,045
Los Olivos	193	26.7	530	73.3	723
Puente Piedra	274	45.8	324	54.2	598
S.M.P	290	22.6	994	77.4	1,284
Total of 7 Districts	**1,922**	**34.6**	**3,626**	**65.4**	**5,548**

Source: Ministry of Education – Scale / * Preliminary Educational Statistics

Number of enrolled students and teachers in the 7 districts during year 2008 was 653,454 and 37,114, respectively. The average student teacher ratio was 18, while it was 7 for children with special needs and 22 for the trade schools.

Table 2.5.4-10: Schools, Classes, Students and Teachers in 2008*

Lugar	For children with special needs				Preschool				Trade				Elementary			
	Schools	Classes	Students	Teachers	Schools	Classes	Students	Teachers	Schools	Classes	Students	Teachers	Schools	Classes	Students	Teachers
Region of Lima	129	816	9,305	1,493	8927	19130	381,028	20,664	685	4231	118,195	5,922	5416	45964	928,014	51,107
Prov. Lima	105	648	8,253	1,363	7554	16820	336,030	18,761	575	3666	105,729	5,159	4417	38500	816,064	44,534
Comas dist.	3	20	443	59	507	1100	21056	1047	36	124	2957	183	322	2672	52782	2788
Carabayllo dist.	2	10	154	28	276	493	10113	448	6	24	500	28	150	1253	25302	1249
Los Olivos dist.	3	35	452	55	327	758	14673	849	24	143	5777	224	218	1833	37555	2081
Puente Piedra dist.	4	69	163	28	321	537	10728	477	7	18	1179	52	168	1391	30106	1424
S.M. de Porres dist.	4	27	302	50	579	1427	23331	1478	15	153	3720	214	442	3204	55410	3501
Province of Callao	12	123	1,327	205	878	2072	42,196	2232	31	240	8,566	312	522	4590	98,401	5158
Callao	3	22	160	29	372	956	19536	1041	18	173	6013	210	220	1942	41446	2202
Ventanilla	5	30	183	24	335	603	14315	590	8	32	1052	52	183	1666	36924	1803
Districts of influence area	**24**	**213**	**1,857**	**273**	**2717**	**5874**	**113,752**	**5930**	**114**	**667**	**21,198**	**963**	**1703**	**13961**	**279,525**	**15048**

Source: Ministry of Education – Scale / * Preliminary Educational Statistics

Schools, Classes, Students, and Teachers in 2008 (Continuation)

Location	High school				Higher education				Total			
	Schools	Classes	Students	Teachers	Schools	Classes	Students	Teachers	Schools	Classes	Students	Teachers
Region of Lima	3236	30126	781,758	51,721	265	5102	146,540	9,806	18658	105369	2,364,840	140,713
Prov. Lima	2766	26243	691,309	44,696	233	4876	140,877	9,244	15650	90753	2,098,262	123,757
Comas dist.	172	1779	49257	2872	5	93	1894	171	1045	5788	128389	7120
Carabayllo dist.	84	682	17388	1041	2	14	322	27	520	2476	53779	2821
Los Olivos dist.	142	1362	37306	2187	9	106	3412	257	723	4237	99175	5653
Puente Piedra dist.	95	852	22923	1264	3	30	392	37	598	2897	65491	3282
S.M. de Porres dist.	236	1832	42483	3076	8	87	2846	196	1284	6730	128092	8515
Province of Callao	299	2837	76,306	4940		94			1742	9956	226,796	12847
Callao	135	1208	31766	2113	6	33	841	102	754	4334	99762	5697
Ventanilla	89	894	25937	1511	4	10	355	46	624	3235	78766	4026
Districts of influence area	**953**	**8609**	**227,060**	**14064**	**37**	**373**	**10,062**	**836**	**5548**	**29697**	**653,454**	**37114**

Source: Ministry of Education – Scale / * Preliminary Educational Statistics

The number of classes to serve the student population is 29,697, that means, there are 22 students per class (See Table 2.5.4-11.)

Table 2.5.4-11: Schools, Classes, Students, and Teachers in 2008*

Level / Type	Schools	Classes	Students	Teachers	Student /Teacher	Students /Class
Total (7 districts)	5,548	29,697	653,454	37,114	18	22
Education for children with special needs	24	213	1,857	273	7	9
Preschool	2,717	5,874	113,752	5,930	19	19
Trade school	114	667	21,198	963	22	32
Elementary school	1,703	13,961	279,525	15,048	19	20
High school	953	8,609	227,060	14,064	16	26
Higher non-university education	37	373	10,062	836	12	27

Source: Ministry of Education – School Education Statistics / * Preliminary

(3) Poverty

The 2007 Poverty Technical Report by the National Institute of Statistics and IT (INEI)[2], develops the poverty map focused on basic needs and the expenditures per capita of the population living in each of the 1,832 districts of Perú. This information is submitted at provincial, regional, and national level.

The poverty map combines information from the 2007 Population and Housing Census with the data from the 2007 National Household Survey (ENAHO), in order to determine a greater number of indicators that explain reasons for poverty in a specific geographic area. According to the definition of poverty, people living in private homes and having per capita expenditures less than the poverty line or in another measure, who do not secure the minimum necessary food and non food needs, are deemed to be poor. In addition, other data sources, such as the 2007 National Municipality Register RENAMU, and the 2005 School Children Height Measurement Census were also used. According to the results at regional, provincial, and district levels, four (4) or five (5) groups can be made up, based on their poverty levels, with Group 1 being the poorest.

The poverty line is determined by the minimum expenditures needed in order to survive. For urban area, this value is S/. 445.8 per month. People having expenditures below this values will be deemed to be living in a state of poverty, as shown in Table 2.5.4-12.

[2] Source: "Poverty in Perú in year 2009" Technical Report – INEI

Table 2.5.4-12: Average per Capita Monthly Expenditures in 2007
(Constant soles at Metropolitan Lima prices)

Geographic scopes	2007 Annual (S/.)	2007* Annual (S/.)	Percentage Validation 2007*/2007
National	**352.2**	**352.6**	**0.1**
Urban	445.3	445.8	0.1
Rural	178.8	178.8	0.0
Scopes			
Metropolitan Lima	523.4	526.6	0.6
Rest of urban area	382.6	380.9	-0.5
Rural	178.8	178.8	0.0
Regions			
Urban coast	404.8	396.6	-2.0
Rural coast	251.9	252.0	0.1
Urban Andes region	381.3	384.2	0.8
Rural Andes region	160.5	160.5	0.0
Urban jungle	321.4	328.7	2.3
Rural jungle	185.8	185.9	0.1
Metropolitan Lima	523.4	526.6	0.6

* New blocks and urbanizations with no chances at all to be selected by ENAHO, from 2001 to 2006, are not included .

Source: Based on INEI – 2007 National Household Survey – ENAHO.

For the case of Metropolitan Lima, average expenditure is S/. 526.90. With regard to the 7 districts in the vicinity of the Study area, average population of poor people is 22.4 %, with 1.0 % of them living in extreme poverty conditions. Carabayllo (2.5 %) and Puente Piedra (2.0 %) are the districts showing the largest percentages of extreme poor in comparison to the other districts (See Table 2.5.4-13.).

Table 2.5.4-13: Poverty Map at District Level in 2007

District	Population	Poor %			Non-Poor	Poverty Ranking
		Total Poor	Extreme	Non Extreme		
Callao	422,532	16.4	0.2	16.2	83.6	1,762
Ventanilla	282,335	29.2	0.6	28.6	70.8	1,577
Carabayllo	215,065	29.7	2.5	27.2	70.3	1,567
Comas	490,809	19.3	0.7	18.6	80.7	1,733
Los Olivos	320,643	15.9	0.7	15.2	84.1	1,769
Puente Piedra	235,441	31.1	2.0	29.1	68.9	1,532
San Martín de Porres	584,123	15.1	0.5	14.6	84.9	1,776
Total of 7 Districts	**2,550,948**	**22.4**	**1.0**	**21.4**	**77.6**	

Source: INEI – Technical Demographic and Social Indicator Office, Feb., 2009

(4) Accessibility and Means of Transportation

Districts in the vicinity of the Study area are peripheral districts, and many people commute for work, study, and other purposes to central Lima. On average it takes over 40 minutes for one way travel.

Most used means of transportation for commuting is public transportation (over 80 %). At present, the existing road infrastructure is basically used to access the two major destinations: Lima downtown, and the west area of the city including Argentina Av and the Coast line (via freeway).

There are only two road axis connecting the 7 districts with the rest of the city: the Panamericana Norte, and Túpac Amaru. Thus, existing facilities are insufficient for a suitable "urban mobilization." The localized transportation within the district areas basically renders a service to residential areas with the rest of the city. There is no significant traffic congestion at district level.

There is an east west interrelation problem as these roads lack continuity. There are 4 roads (over 20 meters wide) that stop 100 meters before reaching Av. Túpac Amaru (De La Puente, Carabayllo, Honduras, and Mexico.) There are no direct road links between the high part, the middle part, and the Chacracerro sector. The high areas have road capacity problems, as the roads are no wider than 14 meters, causing limited urban activity.

Short range public transportation is basically carried out in 2 ways: three wheel auto-rickshaws and the collective taxis. Pedestrian walkway is either non-existent or neglected; especially in the high parts and in the chacracerro sector. Pedestrians have to walk on roads or on dusty road shoulders, with all the potential danger associated with this. Already poorly constructed sidewalks are further disrupted by street vendors, and utility services posts.

Pavement conditions are another critical issue that leads to congestion and sometimes accidents. Most critical pavement problems involve potholes and the lack of asphalt layer.

Unplanned stops by vehicles, particularly buses are also critical, as they cause road congestion. For example, capacity of a 2 lane road decreases up to 30% due to unplanned road side vehicle stoppage. Thus, capacity reduction of a 2 lane road, having a rated capacity of 3,000 vehicle/hour, is 900 vehicle/hour.

The "Metropolitan" is a new integrated public transportation system for Lima, with large capacity articulated buses that run on exclusive corridors or "bus lane", under the BRT (Bus Rapid Transit) scheme. The first of the Metropolitan route connects the south of Lima with the northern Lima, as it crosses 16 districts in the city of Lima, from Chorrillos to Comas, thus benefiting around 1 million users per day.

The objective of this modern system is to enhance living standard, by reducing the commuting time and offering improved service. This also offers better environmental protection and user safety. More inter-connections to Northern Lima are planned in the future.

(5) Civil Society Organizations

The major civil society organizations in the vicinity of the Study area include:

- The community groups including women's organizations (Glass of Milk committees, soup kitchens, wawa wasis [day care centers]), youth organizations, neighbors' organizations (shanty town, housing association, housing cooperative, urbanization, block committee representatives), and civil committees for parks and gardens.
- The private sector. It includes the organized micro businessmen, and trader organizations.
- Non Government Organizations (NGOs), schools, the Lawyers Association, the Biologists Association, the Church, the Civil Ombudsman's office, the transportation organizations, the local media, the National University of Callao, the San Marcos University, and the Villarreal University, the Frente Único de Dirigentes y Vecinos en Beneficio del distrito de SMP (the Leaders and Neighbors Single Front on Behalf of the San Martin de Porres District - FUDIVUBD-SMP.)

2.5.5 Economic Characteristics

(1) Working Population and Employment Situation

Working age population in the Region of Lima for year 2007 was 3,744,947; 96.4 % of them (3,611,300) were employed, and 3.6 % (133,647) were unemployed. Employment ratio for the province of Lima was 96.4 % (3,274,973), and that for the province of Callao was 95.6 % (350,505). For the 7 districts in the vicinity of the Study area, this ratio was 96.0 % (1,032,684).

Table 2.5.5-1: Working Population Distribution in 2007 of the 7 Districts

Location	Employed	Unemployed	Total
Department of Lima	3,611,300	133,647	3,744,947
Prov. Lima	3,274,973	120,969	3,395,942
Prov. Callao	350,505	16,201	366,706
Callao dist.	168,708	7,932	176,640
Ventanilla dist.	106,754	4,893	111,647
Carabayllo dist.	85,346	3,371	88,717
Comas dist.	199,057	7,588	206,645
Los Olivos dist.	138,538	5,341	143,879
Puente Piedra dist.	91,647	3,522	95,169
San Martín de Porres dist.	242,634	10,424	253,058
Total of 7 Districts	**1,032,684**	**43,071**	**1,075,755**

Source: INEI – 2007 National Censuses: XI population census and VI housing census

The type of employment in the 7 districts in the vicinity of the Study area is shown in the Table 2.5.5-2.

Table 2.5.5-2: Employment Category among the Population in the of the 7 Districts in 2007

Category	People	%
Employee	419,056	40.6
Worker	189,163	18.3
Self – employed	345,434	33.5
Employer	17,026	1.6
Non-paid family member, worker or employee	21,481	2.1
Domestic worker	40,524	3.9
Total	**1,032,684**	**100.0**

Source: INEI – 2007 National Censuses: XI population census and VI housing census

(2) Economic and Productive Activity

Economic activities in the 7 districts are driven by medium and large companies, small and medium businesses (Pymes), and the informal sector. The medium and large companies are mostly devoted to industrial and service activities. However, small and medium businesses are the major employer in the area.

The main primary sector activities include cattle-raising, hunting, forestry, and mining. In the 7 districts, for year 2007, primary sector employed 1.7 % of the workforce, and this was as high as 4.8 % for the district of Carabayllo.

The secondary sector includes activities in the manufacturing and construction industries; and for the 7 districts, 21.1 % of the work force are devoted to this sector. Puente Piedra district shows the highest proportion (25.9 %) of employment for this sector.

The tertiary sector is made up of commerce and services, and it involves the largest percentage (77. 2 %) of the work force. Callao is the district having the largest proportion (80.0 %.)

Table 2.5.5-3: Employment by Sector in 2007

Location	Primary Sector	%	Secondary Sector	%	Tertiary Sector	%	Total
Department of Lima	166,525	4.6	691,379	19.1	2,753,396	76.2	3,611,300
Prov. Lima	48,732	1.5	652,174	19.9	2,574,067	78.6	3,274,973
Prov. Callao	6,402	1.8	67,994	19.4	276,109	78.8	350,505
Callao dist.	3,291	2.0	30,452	18.1	134,965	80.0	168,708
Ventanilla dist.	2,048	1.9	26,696	25.0	78,010	73.1	106,754
Carabayllo dist.	4,138	4.8	19,295	22.6	61,913	72.5	85,346
Comas dist.	1,888	0.9	44,138	22.2	153,031	76.9	199,057
Los Olivos dist.	1,301	0.9	26,976	19.5	110,261	79.6	138,538
Puente Piedra dist.	2,276	2.5	23,715	25.9	65,656	71.6	91,647
San Martín de Porres dist.	2,618	1.1	46,584	19.2	193,432	79.7	242,634
Total of 7 Districts	**17,560**	**1.7**	**217,856**	**21.1**	**797,268**	**77.2**	**1,032,684**

Source: INEI – 2007 National Censuses: XI population census and VI housing census

(3) Income Levels

Gross average monthly household income is 1,159 Nuevos Soles in the Northern Lima which is less than the average income for Metropolitan Lima. Around 78 % of the Northern Lima households show a family income of less than 1,890 Nuevos Soles / month, as shown in Table 2.5.5-4.

Table 2.5.5-4: Gross Family Income Levels

Description	Total Lima	North Lima
	%	%
Up to189 Nuevos soles	0	0
From 189 to 567 Nuevos soles	16	19
From 567 to 945 Nuevos soles	28	27
From 946 to 1,890 Nuevos soles	29	32
From 1,890 to 3,780 Nuevos soles	11	11
From 3,780 to 9,450 Nuevos soles	4	1
Over 9,450 Nuevos soles	2	0
Not declared	10	10
Total	**100**	**100**
Average (Nuevos Soles)	**1,761**	**1,159**

Note: Exchange rate taken into account: S/ 3.15 per 1 USD
Source: Apoyo Opinión y Mercado – MAPINSE 2007

Table 2.5.5-5 shows that average monthly per capita income is 296 Nuevos Soles in the North Lima, which is also significantly less than the average monthly per capita income for Metropolitan Lima.

Table 2.5.5-5: Monthly per Capital Income Levels

Description	Total Lima	North Lima
	%	%
Up to189 Nuevos soles	32	36
From 189 to 567 Nuevos soles	38	42
From 567 to 945 Nuevos soles	11	10
From 946 to 1,890 Nuevos soles	5	2
From 1,890 to 3,780 Nuevos soles	2	0
From 3,780 to 9,450 Nuevos soles	1	0
Over 9,450 Nuevos soles	0	0
Not declared	11	10
TOTAL	**100**	**100**
Average (Nuevos Soles)	**517**	**296**

Note: Exchange rate taken into account: S/ 3.15 per 1 USD
Source: Apoyo Opinión y Mercado – MAPINSE 2007

(4) Public Services

1) Electricity

The seven relevant districts have 24-hour electricity supply service offered by EDELNOR. Power supply service coverage is 94.5 %.

2) Water Service

Potable water service in the 7 districts is supplied by SEDAPAL, through its North Service Management and the Commercial Units of Comas and Callao.

According to the 2007 Census, there are 447,620 dwellings with potable water service in the 7 districts, 85.7 % of them have an indoors connection, 6.4 % of them have an outdoors connection, and 7.9 % of them are supplied by sinks.

Table 2.5.5-6: Dwellings with Potable Water Supply – Urban Area

District	Total	Public Network	Public network Outdoors	Sink
Callao	79,374	71,915	6,537	922
Ventanilla	40,067	25,008	1,542	13,517
Comas	86,902	79,095	4,806	3,001
Carabayllo	29,036	22,908	1,673	4,455
Los Olivos	72,299	67,802	3,966	531
Puente Piedra	31,199	17,889	2,380	10,930
San Martín de Porres	108,743	99,174	7,768	1,801
Total	**447,620**	**383,791**	**28,672**	**35,157**
Share (%)	**100.0**	**85.7**	**6.4**	**7.9**

Source: INEI – 2007 National Censuses: XI population census and VI housing census

According to SEDAPAL's commercial statistics as of December, 2009, the 7 districts had 336,876 total potable water connections. This number represents 27.4 % of the total water connections with regard to the total number of connections in all the districts within SEDAPAL's scope (See Table 2.5.5-7.).

Table 2.5.5-7: Potable Water Connections of the 7 Districts in 2009

District	Total Connections
Callao	51,966
Ventanilla	37,023
Carabayllo	26,398
Comas	59,089
Los Olivos	46,524
Puente Piedra	31,160
San Martín de Porres	84,716
Total	**336,876**

Source: SEDAPAL Tariff Study, April, 2010, SUNASS

3) Sewerage Service

This service is also managed by SEDAPAL. According to the 2007 census, there are 414,055 dwellings in the 7 districts (urban area) that are benefited with the sewerage service; 92.7 % of them have indoors connections to the public network, and 7.3 % have outdoors connections to the public network.

Table 2.5.5-8: Dwellings with Sewerage Service – District Urban Area in 2009

Location	Total	Public Network	Public Network Outdoors
Dist. Callao	79,902	72,997	6,905
Dist. Ventanilla	27,129	25,465	1,664
Dist. Comas	85,162	79,895	5,267
Dist. Carabayllo	24,082	22,647	1,435
Dist. Los Olivos	72,087	67,467	4,620
Dist. Puente Piedra	17,933	15,991	1,942
Dist. San Martin de Porres	107,760	99,161	8,599
Total	**414,055**	**383,623**	**30,432**
Share (%)	**100.0**	**92.7**	**7.3**

Source: INEI – 2007 National Censuses: XI population census and VI housing census

According to SEDAPAL's commercial statistics as of December, 2009, the 7 districts had 308,088 total sewerage connections. This number represents 27.5 % of the total sewerage with regard to the total number of connections in all the districts within SEDAPAL's scope (See Table 2.5.5-9.)

Table 2.5.5-9: Sewerage Connections of the 7 Districts

District	Total Connections
Callao	47,438
Ventanilla	33,995
Carabayllo	24,207
Comas	54,226
Los Olivos	42,722
Puente Piedra	27,825
San Martín de Porres	77,675
Total	**308,088**

Source: SEDAPAL Tariff Study, April, 2010, SUNASS

4) Telecommunications

The 7 districts in the vicinity of the Study area are covered with most of the current services and technologies, such as telephone, mobile, radio, cable TV, Internet, etc. i

5) Transportation

With regard to transportation mode, Table 2.5.5-10 shows that 64 % of the population in Lima North has no vehicle of their own. Sports bicycles are the most prominent transport mode in the north Lima area.

Table 2.5.5-10: Transportation Means per Household, Owned by the Family (*)

Description	Total Lima	Lima North
	%	%
None	**62**	**64**
Has some kind of vehicle (*)	**36**	**32**
· Sports bicycle	21	23
· Automobile / pick up truck	18	11
· Automobile / private 4-wheel drive vehicle	14	8
· Automobile / pick up truck for work	5	4
· Bicycle for work	3	4
· Tricycle for work	2	3
· Three wheel auto rickshaw	1	0
· Motorbike	1	0
· Truck for work	0	0
Not specified	**2**	**4**

(*) Some use two or more types of services.

Source: APOYO Opinión y Mercado - MAPINSE 2007

(5) Tourism

The 7 districts in the vicinity of the Study area have a wide range of tourism resources that are being promoted by their respective municipalities.

In order to turn Comas into an ecotourism oriented district, the Comas municipality is working on starting a circuit that will combine visits to cultural spaces, botanical parks, as well as archaeological sites. A boulevard was built to pay homage to Peruvian folk music and in memory of the Néctar folk music band. Likewise, a botanic park is being set up that not only will display a great variety of plant and flower species, but will also have trees pruned in animal shapes. Another park, the Sinchi Roca Park, has been designed for family entertainment. The tourist circuit will also include the Culture Boulevard, where the International Outdoors Drama Festival (Fiteca) will take place.

Other tourist sites in the Study area of influence include the Ventanilla Swamps, in the central western area of the Ventanilla district, just beside the Costa Azul beach. The swamps have a surface of 366 Hectares, and they are surrounded by low hills at the Ventanilla Pampa and the Salinas and Los Perros Hills. This is a wildlife heaven for many flora species, such as the totora reed, rush, seashore grass, glasswort, wild cane, etc. At least 54 bird species have been registered in the Swamps, including both resident and migrating birds. The most significant include the big white heron, the small white heron, the blue heron, the “perrito cigüeñela” (a kind of small stork – an endangered species), the “huerequeque” (Peruvian thick-knee), the “zarapito trinador” (whimbrel), the “turtupilin” (vermilion flycatcher), the red-breast bird, the “saltapalito” (blue black grassquit), etc.

The Pampa de los Perros archaeological site is located in the southern part of the Ventanilla district, and due to its importance, the Andean Archaeology Research Center (CIARA) took on the initiative to revalue it, as it is one of the oldest monumental architecture in Lima.

According to some researches, this site was developed at least 4,500 years ago, even before the development of pottery.

Another archaeological tourist attraction in the Ventanilla district is the “Chivateros Complex”. This site was discovered and studied by Edward Lanning, and it is located on the Chillón River mouth. Hundreds of stone artifacts of different shaped and quality, as well as stone debris were found in the site. The oldest remains in this site are estimated to date back to 10,000 b.C., and the most recent remains are estimated to date back to 7,000 b.C.

Other significant archaeological sites are “Cerro Culebra”, “Cerro Trinidad”, Puente Piedra, Media Luna, La Uva, and Playa Grande on the Chillón River basin within the Ventanilla, Puente Piedra, and San Martin districts. “Cerro Culebra” is one of the best-known archaeological sites located on the northern banks of this river. According to data from “Pre-hispanic Perú”, it has a trapezoid-shaped building and a domestic area in its surroundings with dwellings that were built out of “quincha” (bamboo canes and mud) and boulders. In addition, Media Luna is another important archaeological site that is worth mentioning. It is located 1 km northwest of Cerro Culebra, and it is maybe even older that Cerro Culebra.

The 8 km long Ventanilla beach is one of the most important tourist attractions in the area. This beach is the largest along the southern Pacific.

2.5.6 Results of Socioeconomic Study

(1) SEDAPAL Service in the Study Area

The geographic area of the Study is included in the districts of Los Olivos, San Martín de Porres, Callao, Comas, Carabayllo, Ventanilla and Puente Piedra. As explained before, SEDAPAL divided each district into several sectors. A total of 32 sectors are included in the Study area. The sectors that have households with SEDAPAL water connections are: sectors 83, 84 and 85 in Los Olivos; sectors 212 and 213 in San Martín de Porres; sectors 345, 346, 347, 348 and 349 in Comas; sectors 350 and 351 in Carabayllo; sectors 368 and 369 in Puente Piedra; and sector 259 in Callao. The sectors within the Study area without SEDAPAL water service networks are: sectors 251, 252, 253, 254 and 255 in San Martín de Porres; sectors 256, 257, 258 in Callao sectors 260, 261, 262 and 263 in Ventanilla and sectors 361 and 370 in Puente Piedra. Further, sectors 264, 265 and 266 are also without SEDAPAL water services, but the populations of these sectors are very low. The number of households within the Study area is composed of 105,590 households with SEDAPAL water and sanitation services and 41,245 households without SEDAPAL service.

(2) Survey Methodology

The objective of the socio-economic study by sample survey was to obtain primary information about the households with and without SEDAPAL services regarding income and willingness to pay for the water and sanitation services, and the impact of improvement of household connections that will be a direct result of the project.

Two types of questionnaires were prepared for “with” and “without” SEDAPAL services, the method of questioning varies regarding to the service facilities. The questionnaire for each case is attached in Appendix A7.

Before the actual field survey, training of the surveyors was carried out (for 1 day) and a pilot survey (pre-testing) was applied (for 1 day) in order to improve the questions so that the surveyors can get the result properly.

Source: JICA Study Team

Picture 2.5.6-1: Training of Surveyors

Source: JICA Study Team

Picture 2.5.6-2: Pilot Survey in Callao

The survey sample size was 388 households chosen randomly on the basis of a proportional distribution of each SEDAPAL sectors. The sample size[1] has an acceptable error of d=+/- 5 %, associated to a level of confidence of 95% (t), and in the conditions of heterogeneity the prior informative probability of 0.5 (p=0.5 and q=0.5). The sample has been distributed proportionally to the quantity of SEDAPAL service connection in each sector. . Table 2.5.6-1 shows the sample distribution.

Table 2.5.6-1: Samples of survey by districts and sectors

District	Sector	Population with service	Quantity of houses	(%)	Quantity of samples
Los Olivos	83	46,550	11,271	10.3%	39
	84	61,202	14,819	13.5%	52
	85	37,517	9,084	8.3%	32
S.M.de Porres	212	44,046	10,196	9.7%	37
	213	17,414	4,031	3.8%	15
Callao/Ventanilla	259	12,020	2,751	2.7%	16
Comas -1	345	10,528	2,340	2.3%	9
	346	33,892	7,532	7.5%	29
	347	21,235	4,719	4.7%	18
Carabayllo	350	39,680	9,293	8.8%	33
	351	6,266	1,467	1.4%	5
Comas -2	348	18,961	4,214	4.2%	16
	349	44,094	9,799	9.7%	37
Puente Piedra	368	32,316	7,622	7.1%	27
	369	27,367	6,454	6.0%	23
Total		**453,088**	**105,590**	**100%**	**388** [1/]

[1/] 1% of houses has been added
Source: JICA Study Team, 2010

Furthermore, a sample of 82 households was surveyed in sectors without SEDAPAL service. The purpose of applying the survey in these areas was to investigate the economic situation of the families and of other services. The accuracy of results from these areas is less than that of the households with service. The minimum sample number was decided as four (4) samples for each sector. However, no samples were taken from sectors 260, 264, 265 or 266, because the populations of these sectors are very low (for example, only 147 for sector 265).

Table 2.5.6-2 shows the sample distribution by district, and sectors with and without SEDAPAL water service networks.

[1] Formula used, $n=t^2.p.q/(d^2)$, t= 1.96, without finite correction

Table 2.5.6-2: Survey Samples by Sectors and Supply Type

District	Sector	Population	Number of Samples	SEDAPAL Service	Hours of Service (h)	Type of Alternative Service
Los Olivos	83	46,550	39	Yes	24	
	84	61,202	52	Yes	24	
	85	37,517	32	Yes	24	
S.M.de Porres	212	44,046	37	Yes	24	
	213	17,414	15	Yes	24	
	251	32,835	12	No	...	Tank truck
	252	18,972	7	No	…	Well/Tank Truck
	253	17,414	6	No	…	Well/Tank Truck
	254	29,036	10	No	…	Well/Tank Truck
	255	4,501	4	No	…	Well/Tank Truck
Callao/Ventanilla	256	40,304	14	No	…	Well/Tank Truck
	257	5,166	4	No	…	Well/Tank Truck
	258	170	4	No	…	Well/Tank Truck
	259	12,020	16	Yes	12	
	261	3370	4	No	…	Tank truck
	262	375	4	No	…	Well
	263	309	4	No	…	Tank truck
Comas -1 1/	345	10,528	9	Yes	24	
	346	33892	29	Yes	24	
	347	21,235	18	Yes	24	
Comas -2 2/	348	18,961	16	Yes	5 a 7	
	349	44,094	37	Yes	3	
Carabayllo	350	39,680	33	Yes	24	
	351	6,266	5	Yes	24	
Puente Piedra	361	13,631	5	No	…	Well
	368	32,316	27	Yes	24	
	369	27,367	23	Yes	24	
	370	5,572	4	No	…	Well
Total			**470**			

1/Has water supply 24 hours a day; 2/ water service around 3 to 7 hours a day.
Source: JICA Study Team

Two standardized questionnaires were designed with both open- and close-ended questions to be asked in a face-to-face interview. In both questionnaires, five (05) replies were printed for willingness to pay with different values, with the goal of estimating the willingness to pay for improvement in services as a direct effect of the project.

Source: JICA Study Team

Picture 2.5.6-3: Area with SEDAPAL Service (Los Olivos)

Source: JICA Study Team

Picture 2.5.6-4: Area with SEDAPAL Service (Los Olivos)

Picture 2.5.6-5: Area without SEDAPAL Service

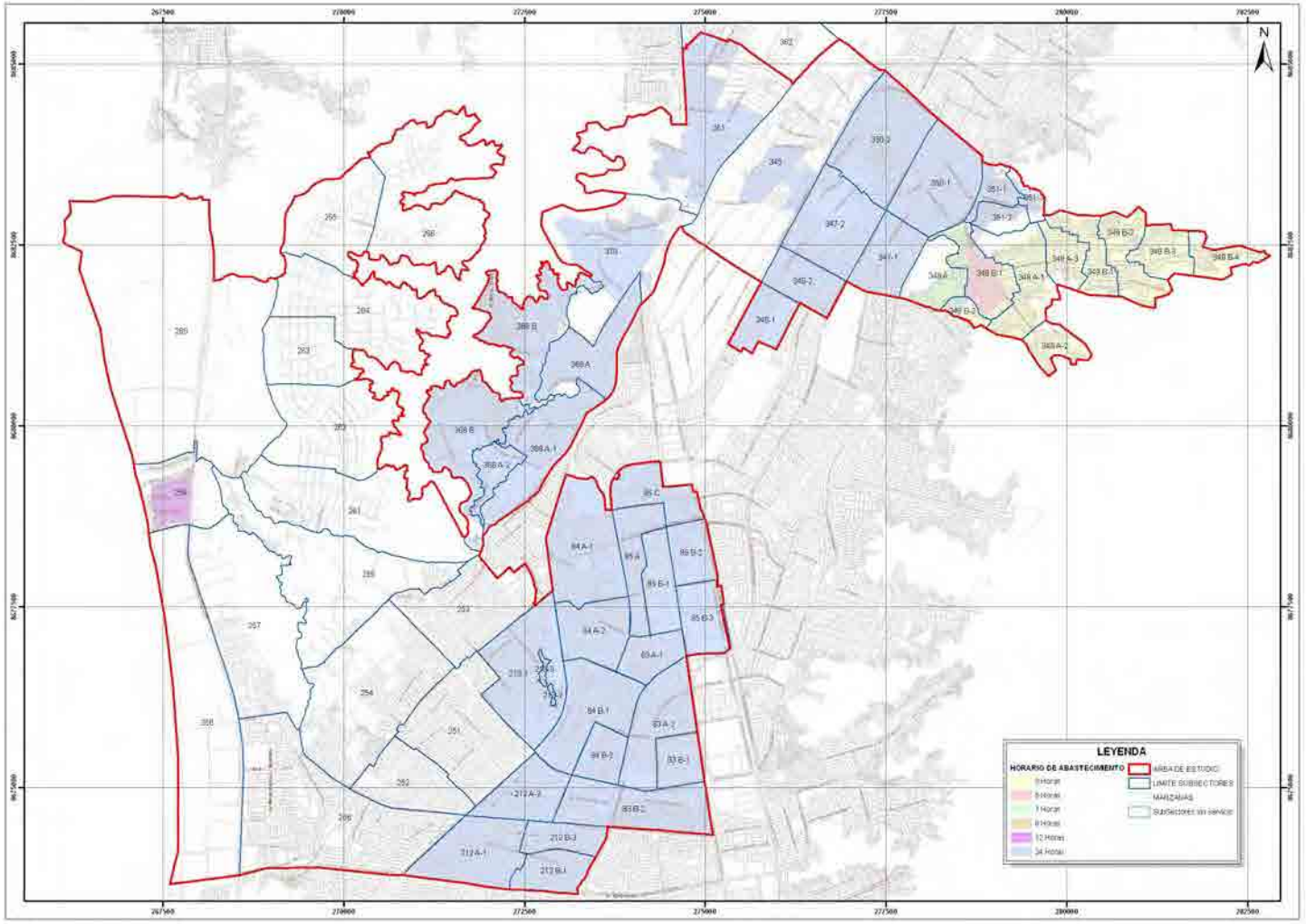


Figure 2.5.6-1: Sectors with and without SEDAPAL Service – Survey Coverage

(3) Survey Results

1) Family Size

The average number of persons per family is 4.2 for the sectors with SEDAPAL service, with the lowest value being 3.6 persons per household (sector 354, Comas) and the highest value being 4.9 persons per household (sector 369, Puente Piedra), as can be observed in Table 2.5.6-3.

2) Family Income and Expenditures

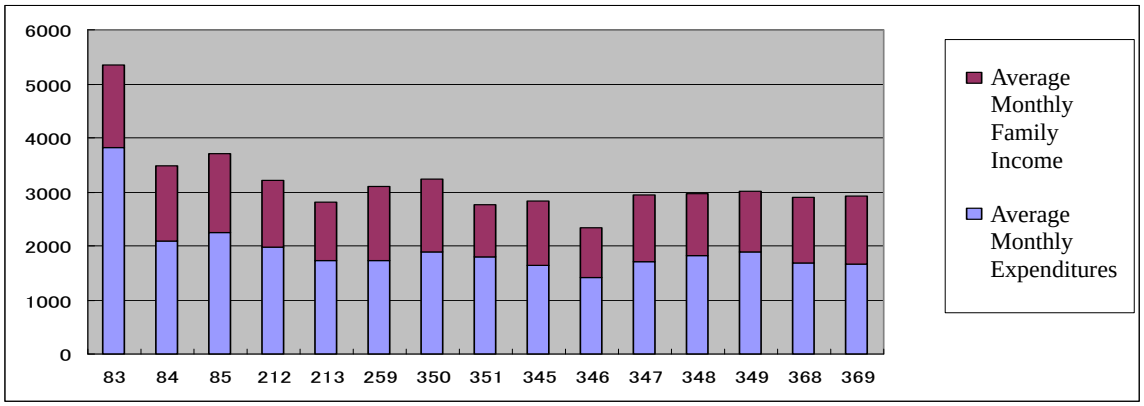
The results of the total monthly incomes and expenditures for each sector (with and without SEDAPAL service) are shown in Table 2.5.6-3 and Table 2.5.6-4. The income was calculated from the number of working people and the quantity of income for each working family member in the household. The expenditure was calculated by adding all types of expenses (such as electricity, water and sewerage, telephone, gas, rent, food, education, clothing, transportation and others). The average family incomes for the households connected to the SEDAPAL network vary between S/. 1,410 and S/. 3,826, with an average of S/. 2,058; while for the households not connected to the SEDAPAL network, the family incomes were less, varying between S/. 585 and S/. 2,721 (S/. 1,534 average).

It is to be noted that small differences can occur due to sampling error, considering that the families surveyed sometimes declare greater expenditures and lesser incomes than the actual values. For that reason, the household expenditures are sometimes better indicators of approximate household income.

Table 2.5.6-3: Monthly Family Incomes and Expenditures by Sector with SEDAPAL Water Service

District	Sector	Frequency	Average Number Living in Household	Average Monthly Family Income (S/.)	Average Monthly Expenditures (S/.)	Income, from OMP: "Apoyo Opinión y Mercado" 2005
Los Olivos	83	39	3,9	3,826	1,523	1,425
	84	50	4,1	2,083	1,409	
	85	32	4,2	2,238	1,471	
San Martín de Porres	212	37	4,5	1,988	1,225	1,165
	213	15	4,2	1,734	1,086	
Callao	259	16	4,4	1,731	1,370	1,174
Carabayllo	350	33	4,3	1,887	1,351	868
	351	5	4,7	1,795	972	
Comas- 1	345	8	3,6	1,650	1,186	1,060
	346	27	4,0	1,410	930	
	347	18	4,2	1,709	1,231	
Comas-2	348	16	4,6	1,817	1,147	
	349	36	4,1	1,886	1,134	
Carabayllo	350	33	4,3	1,887	1,351	868
	351	5	4,7	1,795	972	
Puente Piedra	368	27	4,3	1,684	1,219	708
	369	23	4,9	1,659	1,257	
Total Average		**382**	**4,2**	**2,058**	**1,275**	

Source: JICA Study Team



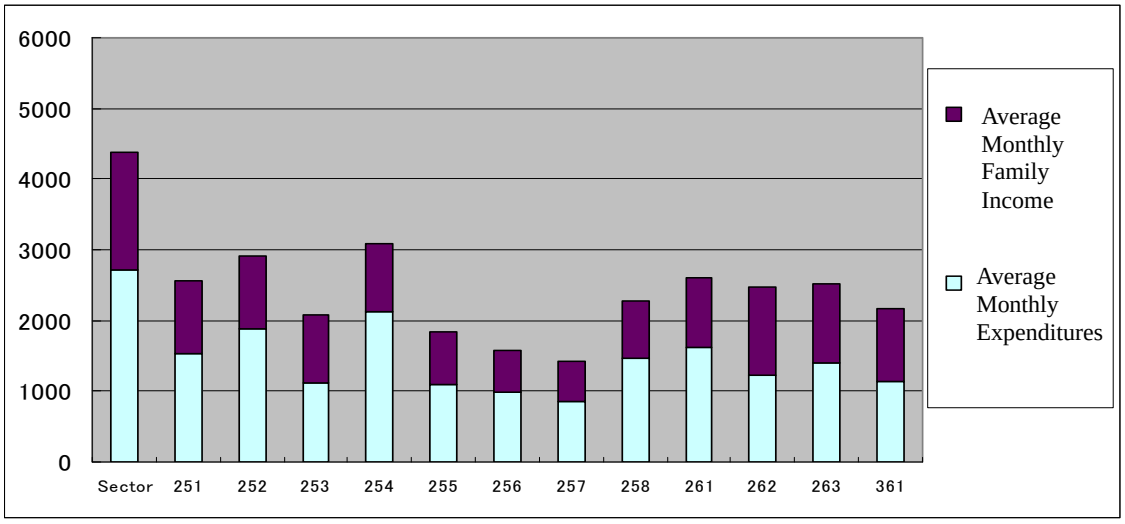
Source: JICA Study Team

Figure 2.5.6-2: Monthly Family Incomes and Expenditures by Sector with SEDAPAL Water Service

Table 2.5.6-4: Monthly Family Incomes and Expenditures by Sector without SEDAPAL Water Service

District	Sector	Frequency	Average Number Living in Household	Average Monthly Family Income	Average Expenditures	Income, from OMP: "Apoyo Opinión y Mercado" 2005
San Martín de Porres	251	12	5,4	2,721	1,651	1,165
	252	7	5,5	1,530	1,024	
	253	6	4,0	1,883	1,027	
	254	10	4,6	1,108	962	
	255	4	3,6	2,125	954	
Callao	256	14	3,6	1,097	744	1,174
	257	4	4,8	995	585	
	258	4	7,3	850	582	
	261	4	4,0	1,475	805	
	262	4	4,3	1,615	987	
	263	4	3,8	1,225	1,248	
Puente Piedra	361	5	5,0	1,400	1,115	708
	370	4	3,8	1,138	1,030	
Total Average		**82**	**4,6**	**1,534**	**1,019**	

Source: JICA Study Team



Source: JICA Study Team

Figure 2.5.6-3: Monthly Family Incomes and Expenditures by Sector without SEDAPAL Water Service

3) Influence of Water Borne Diseases

Table 2.5.6-5 and Table 2.5.6-6 show the results of illnesses affecting some family members in the previous twelve (12) months because of poor water and sewerage services.

Table 2.5.6-5: Illness Related to Poor Water and Sewerage Service in Areas with SEDAPAL Service

Illness	Sector								Total (388 samples)
	83	84	85	212	259	350	349	369	
Diarrhea	1	4	2	0	2	0	2	0	11 (2.8%)
Skin	0	0	0	1	0	2	1	1	5 (1.7%)
Conjunctivitis	1	3	0	0	0	1	0	0	5 (1.7%)
Parasitosis	0	0	0	0	0	0	1	0	1 (0.3%)
Other sickness	0	1	0	0	0	0	0	0	1 (0.3%)
Total	2	8	2	1	2	3	4	1	23 (5.9 %)

Source: JICA Study Team

Table 2.5.6-6: Illness Related to Poor Water and Sewerage Service in Areas without SEDAPAL Service

Illness	District			Total (82 samples)
	San Martín de Porres	Callao	Puente Piedra	
Diarrhea	16	3	3	22 (26.7%)
Cholera	3	0	0	3 (3.7%)
Skin	1	1	0	2 (2.4%)
Parasitosis	1	0	0	1 (1.2%)
Typhoid	0	1	0	1 (1.2%)
Total	21	5	3	29 (35.4%)

Source: JICA Study Team

The rate of incidence of diarrheal illnesses indicates a high incidence in the zone without SEDAPAL service in comparison with the area that has SEDAPAL service. Therefore, the benefit of reducing illnesses by supplying SEDAPAL water is considered high.

4) Water Supply Information

(a) With SEDAPAL Service: Facility and Water Supply Problems

i) Average monthly water consumption

The average monthly water consumption is 17.9 m3. The monthly consumption in each sector and district is indicated in Table 2.5.6-7.

The verification of the average consumption in each case was carried out by reading the SEDAPAL invoices; however, many users had difficulty finding their last invoice, as well as the previous ones, and it is possible that some were delinquent accounts.

ii) Payment for water service

Table 2.5.6-7 shows the average monthly payments for water consumption by sector.

The average monthly payment for water consumption is S/. 42.89 nuevos soles. The values for the districts of Los Olivos and S.M. de Porres are above the mean and that for the Puente Piedra is the lowest. Many users complain about their high consumption bills, and others maintain that their consumption does not correspond to the amount of the invoice, as they have been wrongly considered a residential sector.

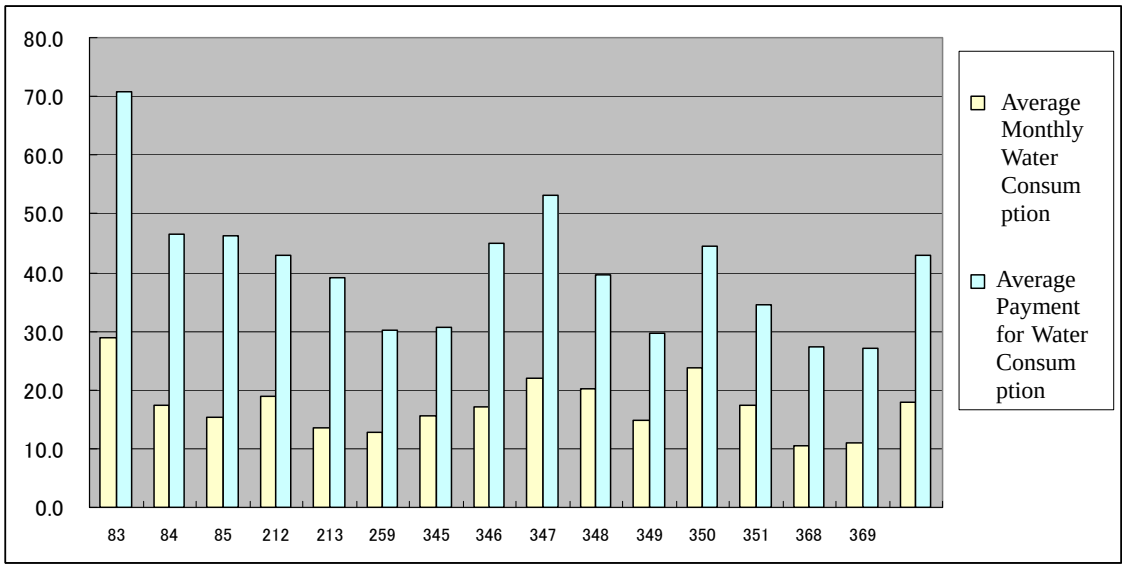
In the sectors where water is rationed to 12 hours a day, as in sector 259 in Callao, the households pay around S/. 30.13. In sector 348 in Comas, where the water is rationed to 5 to 7 hours per day, the households pay S/. 39.56; sector 349 receives water only 3 hours a day and pays a sum of S/. 29.68.

If the values indicated in the Optimized Master Plan (OMP), 2009-2013 are compared with the survey results, it is observed that the payment amounts for monthly service consumption are higher in the survey results. According to the OMP, on average, the households with SEDAPAL service pay S/. 37.0 per month; whereas in the survey the payment was S/. 42.89. However, one reason for this difference may be the natural increase in income, as the OMP information is four (4) years old.

Table 2.5.6-7: Average Monthly Water Consumption and Payments in Areas with SEDAPAL Service

District	Sector	Sample Size	Hours of Service	Average Monthly Water Consumption (m^3/Household)	Monthly Payment for Water Consumption (S/./Household)	Payment/ Consumption (S/./ m^3)
Los Olivos	83	39	24	28.8	70.9	2.46
	84	52	24	17.4	46.6	2.68
	85	29	24	15.3	46.3	3.03
San Martín de Porres	212	27	24	19.0	43.0	2.26
	213	15	24	13.6	39.1	2.88
Callao	259	16	12	12.7	30.1	2.37
Comas 1	345	9	24	15.7	30.7	1.96
	346	20	24	17.2	45.1	2.62
Comas 2	347	18	24	22.1	53.2	2.41
	348	15	**5 a 7**	20.1	39.6	1.97
	349	37	**3**	14.7	29.7	2.02
Carabayllo	350	32	24	23.8	44.5	1.87
	351	3	24	17.4	34.4	1.98
Puente Piedra	368	27	24	10.5	27.4	2.61
	369	22	24	11.0	27.1	2.46
Total		**361**		**17.9**	**42.9**	**2.40**

Source: JICA Study Team



Source: JICA Study Team

Figure 2.5.6-4: Average Monthly Water Consumption and Payment by Sector in Areas with SEDAPAL Service

The average Price for water and sewerage is S/. 2.40 soles/m³. The 2009 Statistical Almanac report, which is an official SEDAPAL report, indicates that the mean price for water and sewerage is S/. 2.16 soles/m³ (in all areas), so the result obtained in the survey is reliable.

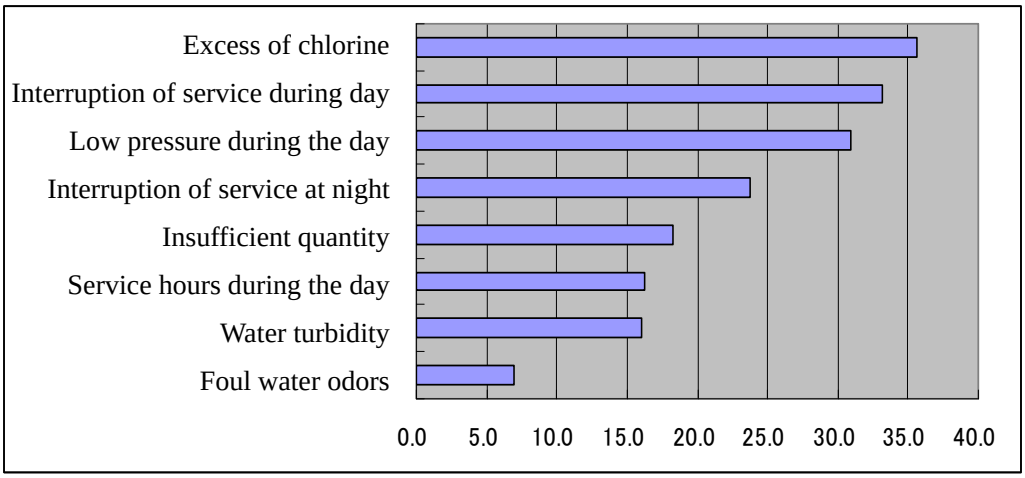
iii) Household water problems

The frequency of all water service problems is summarized, and the most mentioned problems quoted are “excess of chlorine”, “interruption of service during the day”, and “low pressure during the day”. As it is easy to recognize, Callao and Comas-2 have different tendencies than other areas. The families in Comas-2 complain about the lack of water in the day and night, and the families in Callao complain about the interruption of water service at night and the excess of chlorine in the water. Table 2.5.6-8 shows the problems perceived by families in each district.

Table 2.5.6-8: Problems with Water Service for Household by District in Areas with SEDAPAL Service

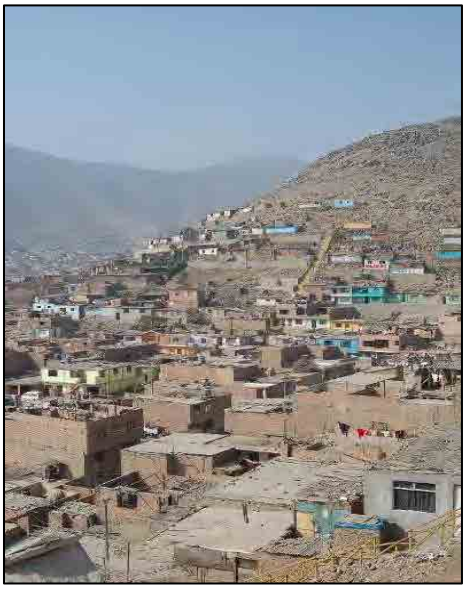
Perceived Problems	District							Average all Districts
	Los Olivos	San Martín de Porres	Callao	Carabayllo	Comas 1	Comas 2	Puente Piedra	
Excess of chlorine	42.3%	26.9%	**50.0**%	34.2%	41.1%	26.4%	28.0%	**35.6**%
Interruption of service during the day	21.1%	9.6%	37.5%	15.8%	33.9%	**96.2**%	32.0%	**33.2**%
Low pressure during the day	37.4%	32.7%	25.0%	42.1%	16.1%	45.3%	8.0%	**30.9**%
Interruption of service at night	6.5%	3.8%	**87.5**%	13.2%	12.5%	**98.1**%	8.0%	**23.7**%
Insufficient quantity	17.1%	5.8%	12.5%	18.4%	7.1%	**60.4**%	4.0%	**18.3**%
Service hours during the day	4.1%	0.0%	0.0%	2.6%	3.6%	**100.0**%	4.0%	**16.2**%
Water turbidity	30.1%	19.2%	6.3%	5.3%	8.9%	5.7%	8.0%	**16.0**%
Foul water odors	10.6%	5.8%	0.0%	7.9%	8.9%	0.0%	6.0%	**7.0**%

Source: JICA Study Team



Source: JICA Study Team

Figure 2.5.6-5: Main Perceived Water Service Problems in Areas with SEDAPAL Service



Source: JICA Study Team

Picture 2.5.6-6: Comas 2

Source: JICA Study Team

Picture 2.5.6-7: Basins

The hours of water service in the Comas and Callao sectors is currently restricted. Continuous supply shall be obtained through implementation of the Project.

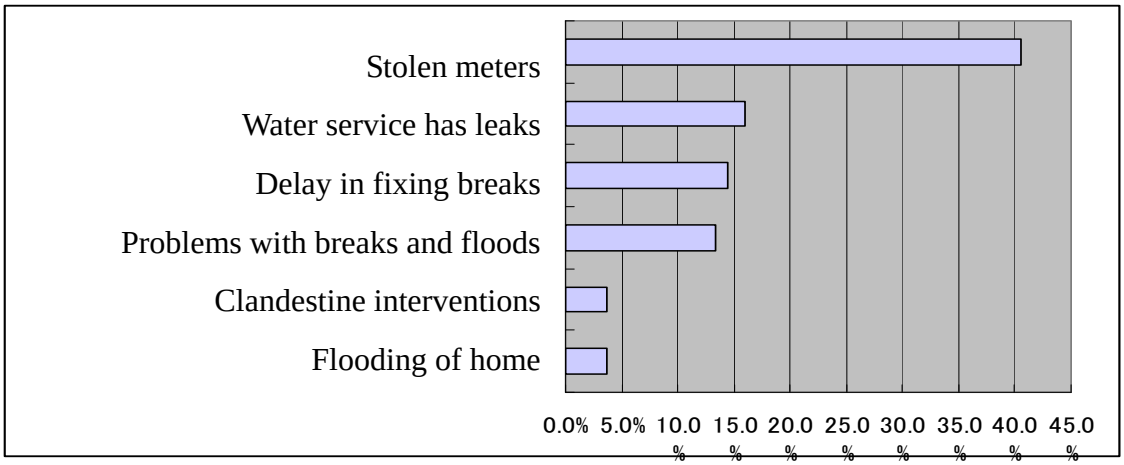
iv) Water problems outside the home

The problems outside of homes are shown in Table 2.5.6-9; "stolen meters" are the main problem, and the frequency of other problems is low. In Callao, there are more water service problems regarding the frequent occurrence of leaks, breaks, and floods. According to the study interview, the reason for this was said to be the poor work performed during pipe installation in this area. (See Table 2.5.6-9).

Table 2.5.6-9: Service Problems Observed Outside the Home in Areas with SEDAPAL Service

Problems Outside the Home	District							Avergae all Districts
	Los Olivos	San Martin de Porres	Callao	Caraba yllo	Comas 1	Comas 2	Puente Piedra	
Stolen meters	**57.7%**	30.8%	**62.5%**	44.7%	45.5%	1.9%	34.0%	40.6%
Water service has leaks	19.7%	7.7%	**37.5%**	13.2%	21.4%	9.4%	12.0%	16.0%
Delay in fixing breaks	22.8%	3.8%	13.3%	13.2%	23.2%	5.7%	6.0%	14.5%
Problems with breaks and floods	16.3%	7.7%	**25.0%**	15.8%	16.1%	7.5%	10.0%	13.4%
Clandestine interventions	4.1%	2.0%	6.3%	0.0%	0.0%	11.3%	2.0%	3.6%
Flooding of home	4.9%	5.8%	0.0%	0.0%	5.4%	1.9%	2.0%	3.6%

Source: JICA Study Team



Source: JICA Study Team

Figure 2.5.6-6: Water Service Problems Observed Outside the Home in Areas with SEDAPAL Service

v) Use of electric water pump

According to the survey result, the number of household pumps (electric pumps for elevated water tanks) installed is limited or minimal (only 1.6% of households). The average installation cost for the cistern, pump and tank is S/. 933.3 nuevos soles, and the average monthly maintenance cost for the electric pump is S/. 27.5 nuevos soles. (See Table 2.5.6-10).

Table 2.5.6-10: Use of Electric Pump to Propel Water to an Elevated Tank in Areas with SEDAPAL Service

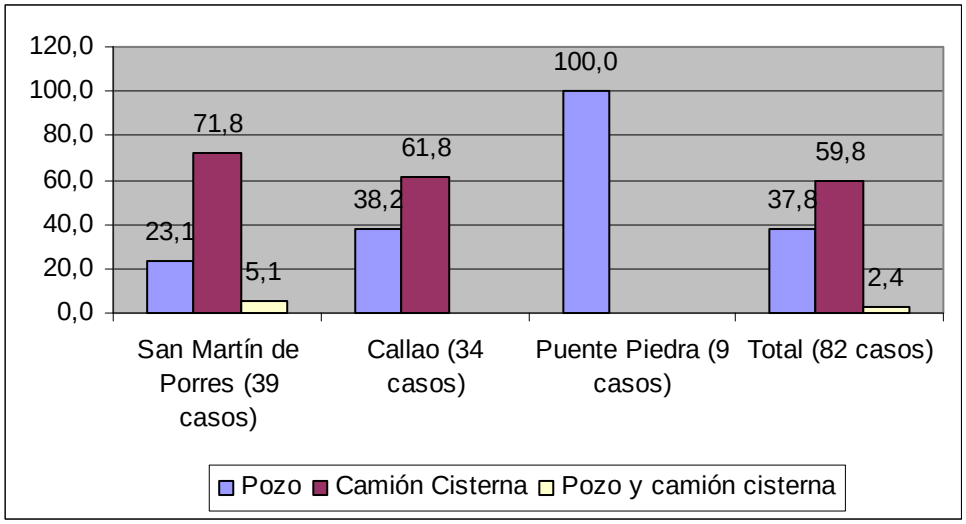
Response	District							Total Sample
	Los Olivos	San Martín de Porres	Callao	Carabayllo	Comas 1	Comas 2	Puente Piedra	
Yes	1	1	0	1	1	1	1	6 (1.6%)
No	119	51	10	36	52	51	44	363 (98.4%)
Total	120	52	10	37	53	52	45	369 (100%)

Source: JICA Study Team

(b) Without SEDAPAL Service

i) Household water source

Of the households surveyed, regarding the water source, 59.8% are served by a tank truck, 37.8% are served by wells, and 2.4% are served by both wells and tank trucks.



Source: JICA Study Team

Figure 2.5.6-7: Household Water Supply Source by District in Areas with SEDAPAL Service

Source: JICA Study Team

Picture 2.5.6- 8: Water Tank Truck

Source: JICA Study Team

Picture 2.5.6-9: Typical Installation of Water Tank in Front of Home

ii) Average monthly water consumption

The average monthly water consumption is 5.0 m^3. The mean consumption quantity in sectors without SEDAPAL service is only 28% of the mean quantity in the SEDAPAL service area, as can be observed in Table 2.5.6-11.

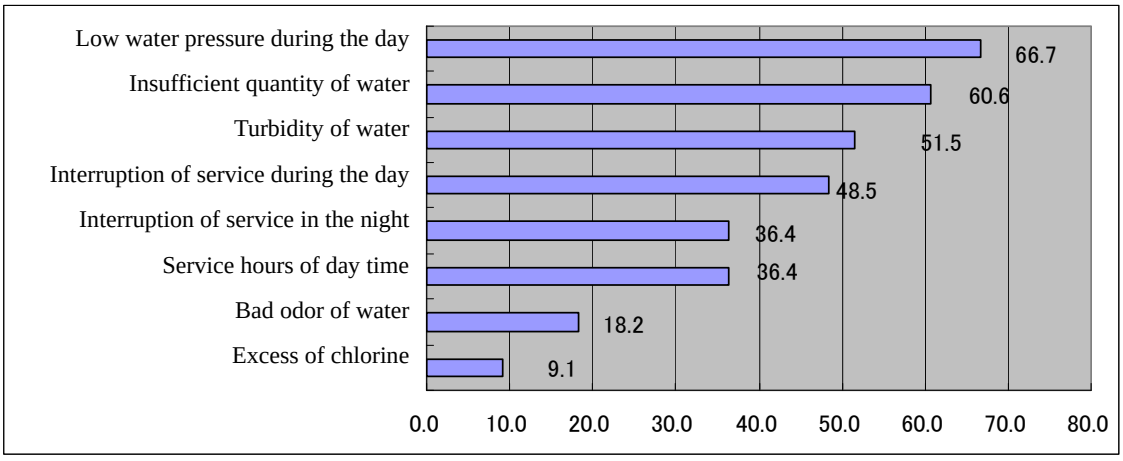
Table 2.5.6-11: Average Monthly Water Consumption and Payment in Areas without SEDAPAL Service

District	Sector	Sample Size	Type of Service	Average Monthly Water Consumption (m^3/Household)	Monthly Payment for Water Consumption (S/.)
San Martín de Porres	251	12	Tank truck	5.8	61.9
	252	7	Well/Tank truck	1.2	74.6
	253	6	Well/Tank truck	3.9	63.1
	254	10	Well/Tank truck	4.0	47.9
	255	4	Well/Tank truck	5.5	53.5
Callao/Ventanilla	256	14	Well/Tank truck	3.3	25.8
	257	4	Well/Tank truck	2.0	18.8
	258	4	Well/Tank truck	1.0	29.3
	261	4	Tank truck	5.5	61.3
	262	4	Well	10.3	27.5
	263	4	Tank truck	7.5	78.8
Puente Piedra	361	5	Well	12.8	0.0
	370	4	Well	7.6	7.0
Total		**82**		**5.0**	**44.1**

Source: JICA Study Team

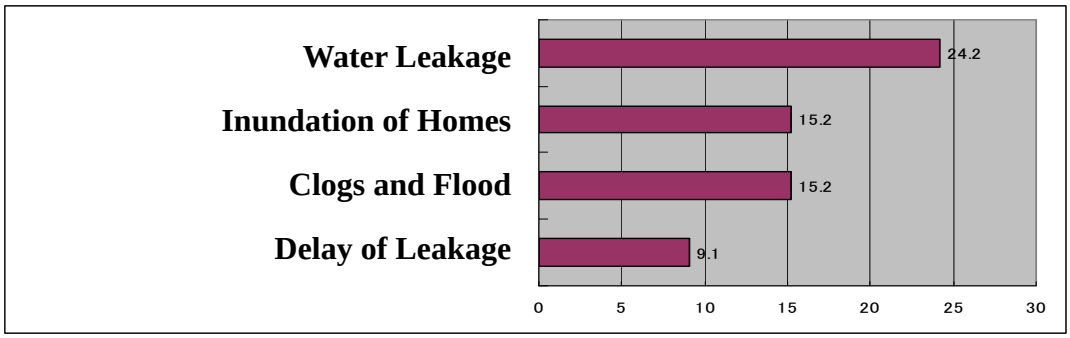
iii) Principal water supply problems in the home

The homes have four types of problems: insufficient quantity of water in the home, turbidity of water, interruption of service and low water pressure during the day. The rest of the problems are less significant for the majority of households. These identified problems are due to the fact that the homes that have a water tap or well do not have an adequate water supply. Regarding problems outside of the home, the greatest problem is the presence of water leaks or floods.



Source: JICA Study Team

Figure 2.5.6-8: Water Service Problems Observed in the Home in Areas without SEDAPAL Service



Source: JICA Study Team

Figure 2.5.6-9: Water Service Problems Observed Outside the Home in Areas without SEDAPAL Service

v) Use of electric water pumps

Of the households without SEDAPAL service, 12.1% use electric water pumps to lift the water to an elevated tank.

Table 2.5-6-12: Use of Electric Pumps to Lift Water to an Elevated Tank

Response	District			Total
	San Martín de Porres	Callao	Puente Piedra	
Yes	0	0	4	4 (12.1%)
No	11	13	5	29 (87.9%)
Total	11	13	9	33 (100%)

Source: JICA Study Team

5) Existing Water Service Level

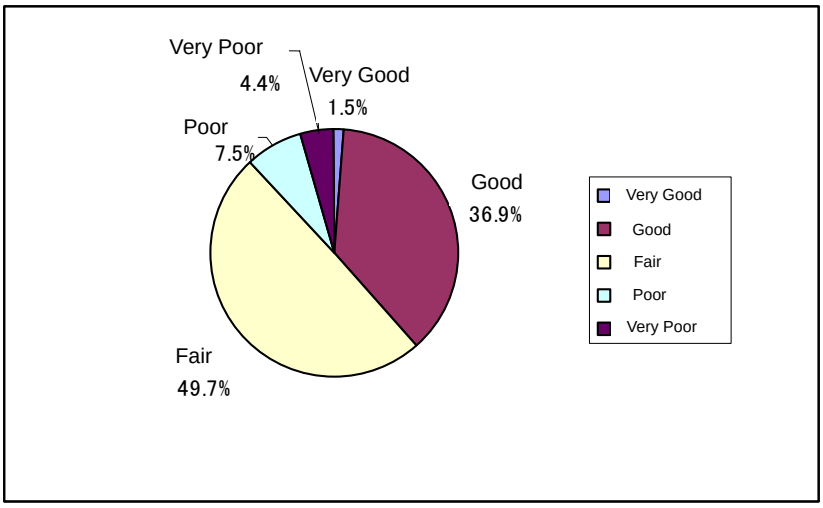
(a) With SEDAPAL Water Service

Table 2.5.6-13 shows the perception of SEDAPAL water service. In general, 49.7% qualify the service as fair, 36.9% as good, 7.5% as poor, 4.4% as very bad, and only 1.5% as very good. The users of SEDAPAL service are mainly satisfied with the service quality according to the result.

Table 2.5.6-13: Perception of SEDAPAL Service

Response	District							Total (%)
	Los Olivos	San Martín de Porres	Callao	Carabayllo	Comas 1	Comas 2	Puente Piedra	
Very good	1.6 %	0.0	0.0	2.6%	1.8%	1.9%	2.0%	1.5
Good	33.3%	53.8%	68.8	28.9%	39.3%	18.9%	40.0%	36.9
Fair	52.0%	34.6%	18.8	57.9%	50.0%	58.5%	54.0%	49.7
Poor	10.6%	5.8%	0.0	5.3%	5.4%	**15.1%**	0.0	7.5
Very poor	2.4%	5.8%	**12.5**	5.3%	3.6%	5.7%	4.0%	4.4
Total frequencies	**123**	**52**	**16**	**38**	**56**	**53**	**50**	**388**

Source: JICA Study Team



Source: JICA Study Team

Figure 2.5.6-10: Perception of SEDAPAL Service

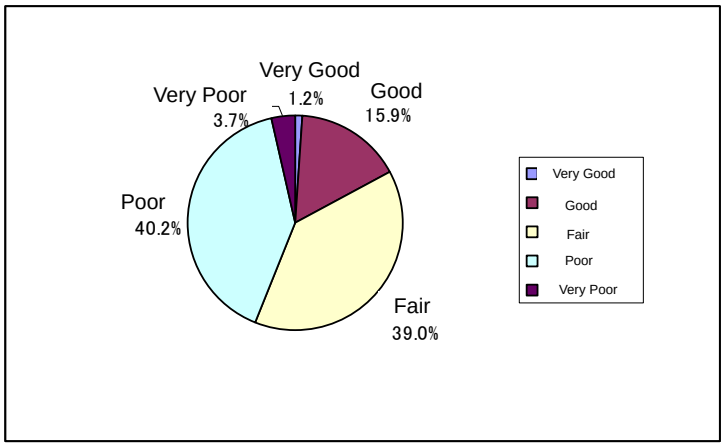
(b) Without SEDAPAL Service

As shown in Table 2.5.6-14, 40.2% described the quality of service as poor, 39.0% as fair, 15.9% as good, and 3.7% as very poor.

Table 2.5.6-14: Perception of Water Service Supplied (Tap, Well, or Tank Truck)

Response	District			Total (%)
	San Martín de Porres	Callao	Puente Piedra	
Very good	0.0%	2.9%	0.0%	1.2
Good	7.7%	26.5%	11.1%	15.9
Fair	28.2%	44.1%	66.7%	39.0
Poor	56.4%	26.5%	22.2%	40.2
Very poor	7.7%	0.0%	0.0%	3.7
Total frequencies	**39**	**34**	**9**	**82**

Source: JICA Study Team



Source: JICA Study Team

Figure 2.5.6-11: Perception of Service Quality of Water Supplied (Tap, Well, or Tank Truck)

6) Sewerage Service Situation

(a) With SEDAPAL Service Area: Facilities and Sewerage Service Problems

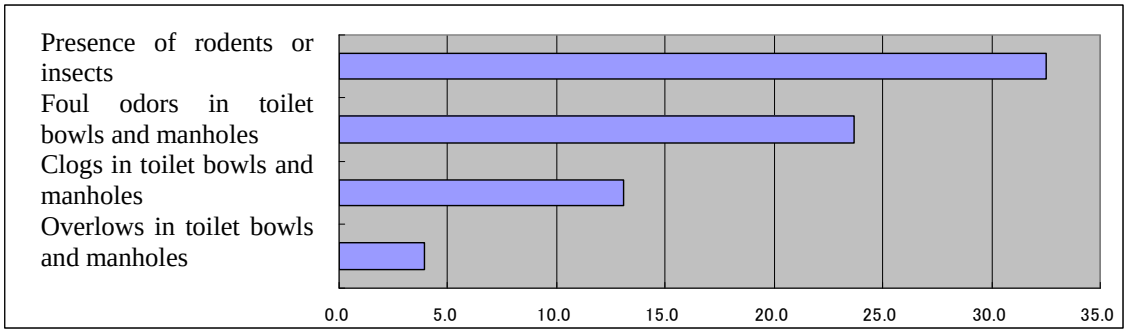
i) Perception of sewerage service problems within the home

In terms of SEDAPAL´s strategy, the water and sewerage services for each household are connected at the same time. Therefore, the service areas for water supply and sewerage basically correspond. The survey results regarding problems recognized in the SEDAPAL service area show that the “presence of rodents and insects” and “foul odors in the toilet bowl or manhole” were the main problems. The population in Comas-2 had more complaints than other areas.

Table 2.5.6-15: Problems with Household Sewer Pipes in Areas with SEDAPAL Service

Problems	District							Average of all Districts
	Los Olivos	San Martín de Porres	Callao	Carabayllo	Comas 1	Comas 2	Puente Piedra	
Presence of rodents or insects	**36.6%**	26.9%	25.0%	25.0%	28.3%	**42.1%**	36.0%	**32.5%**
Foul odors in toilet bowls and manholes	26.8%	19.2%	25.0%	10.7%	24.5%	**31.6%**	28.0%	**23.7%**
Clogs in toilet bowls and manholes	13.0%	15.4%	6.3%	5.4%	15.1%	15.8%	18.0%	**13.1%**
Overlows in toilet bowls and manholes	4.1 %	0.0%	0.0%	1.8%	3.8%	13.2 %	4.0 %	**3.9%**

Source: JICA Study Team



Source: JICA Study Team

Figure 2.5.6-12: Problems with Household Sewer Pipes in Areas with SEDAPAL Service

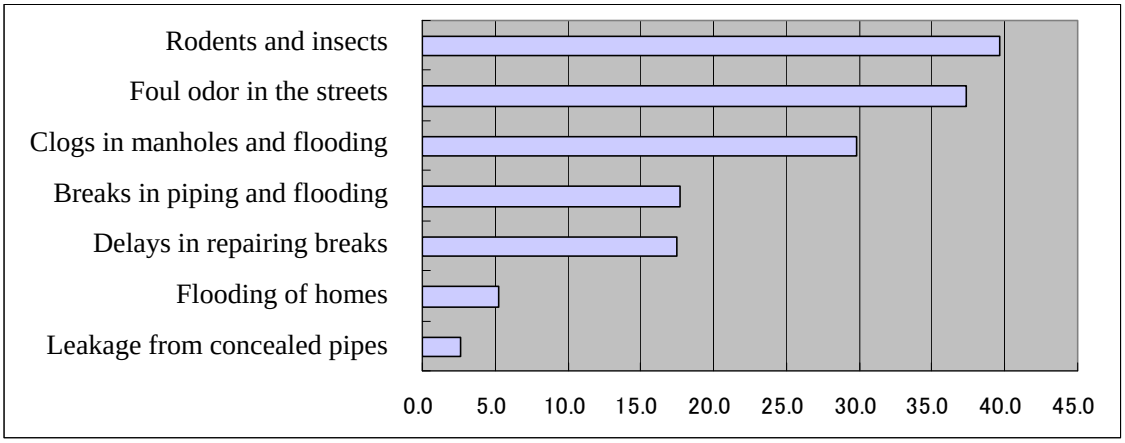
ii) Perception of sewerage service problems outside the home

The majority of homes do not have sewerage service problems outside the home. The main sewerage problems outside the home originated from the customs of throwing trash in the manholes and stealing the lids of the manholes. In Callao, the foul odors are not only from the sewer manholes, but also from the wastes of marine species. The foul odors in the streets are also a result of the trash that the neighbors drop on the corners and vacant lots. The problems with the presence of rodents and insects, the foul odors in the streets, the clogging of manholes and flooding are not only because of the sewerage networks. According to the survey responses, the neighbors´ concealed installations and flooding in the homes are the least problematic. (See Table 2.5-6-16.)

Table 2.5.6-16: Sewerage Service Problems Outside the Home in Areas with SEDAPAL Service

Perceived Problems	District							Total (%)
	Los Olivos	San Martin de Porres	Callao	Comas 1	Comas 2	Caraba yllo	Puente Piedra	
Rodents and insects	38.0%	34.6%	**50.0%**	40.0%	34.6%	**60.5%**	34.7%	**39.7**
Foul odor in the streets	30.6%	40.4%	**62.5%**	43.6%	45.3%	43.2%	22.4%	**37.3**
Clogs in manholes and flooding	31.1%	21.2%	**68.8%**	25.5%	30.2%	36.8%	22.4%	**29.9**
Breaks in piping and flooding	18.9%	17.3%	31.3%	16.4%	20.8%	7.9%	16.3%	**17.7**
Delays in repairing breaks	22.3%	9.6%	37.5%	25.5%	15.4%	0.0	14.3%	**17.5**
Flooding of homes	1.7%	7.7%	6.3%	12.7%	5.8%	2.6%	4.1%	**5.2**
Leakage from concealed pipes	5.7%	0.0	0.0	1.9%	3.8%	0.0	0.0	**2.6**

Source: JICA Study Team



Source: JICA Study Team

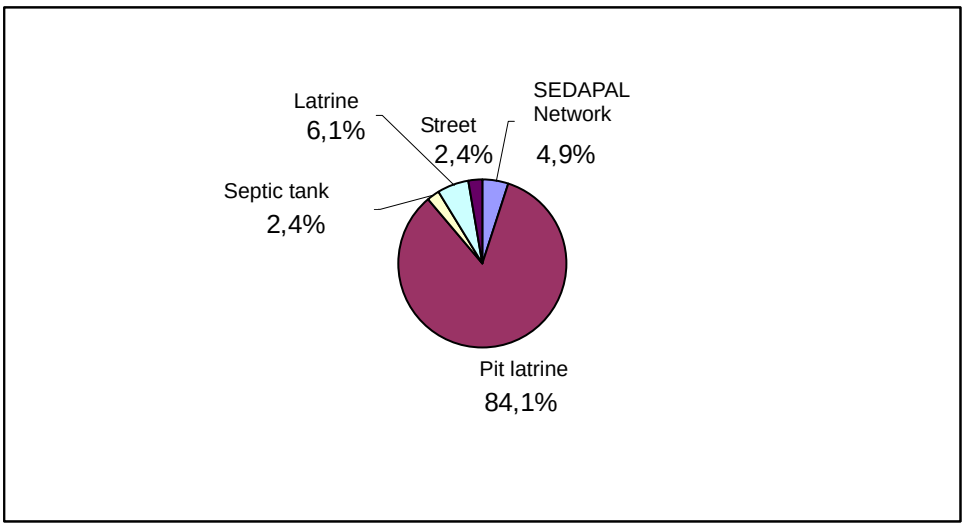
Figure 2.5.6-13: Sewage Service Problems Outside the Home in Areas with SEDAPAL Service

(b) Without SEDAPAL Service

i) Systems for household waste disposal

For excreta disposal, currently, 84.1% of households use the vault system, 6.1% pit latrines, 4.9% through the (unauthorized hook up with) SEDAPAL network, 2.4% septic tank, and the rest 2.4% use open defecation.

The final disposal of waste is a problem of great importance if the current situation is not reversed. The percentage of open defecation is extremely serious, and the vault latrines are not treated correctly because the population has not received proper training to clean the sludge, and because the lots are so small that there is hardly any space to dig simple wells to deposit the sludge.

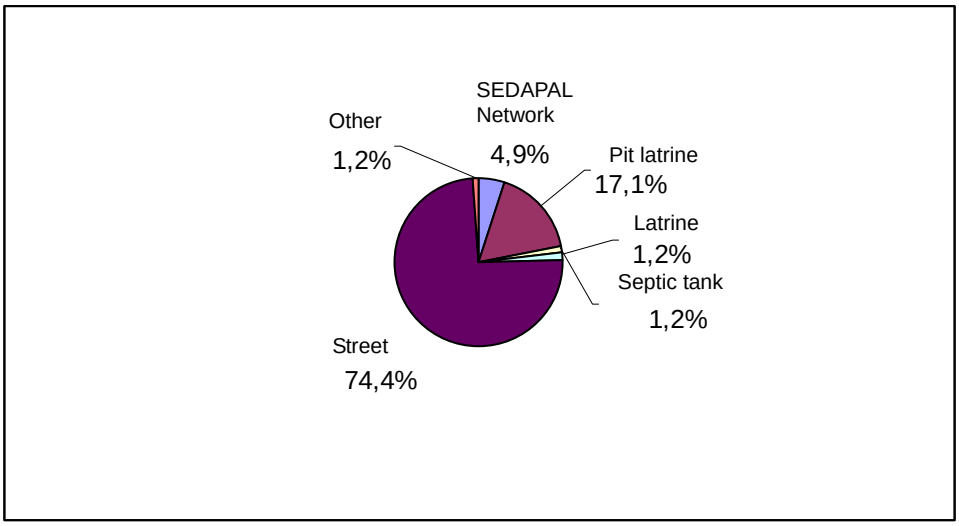


Source: JICA Study Team

Figure 2.5.6-14: Elimination of Excreta in Areas without SEDAPAL Service

With respect to the elimination of grey water from kitchen and bathroom, etc., 74.4% cases, these waters are disposed of in the street, 17.1% in the vault latrine, and 4.9% through the (unauthorized hook up with) SEDAPAL network. (See Figure 2.5.6-15.)

Since many neighborhoods disposed of their waste water in the streets, a proper sewerage system in these areas will improve the situation a lot. The new system will not only eliminate disposal of grey waters in the streets, but also urine and excreta.



Source: JICA Study Team

Figure 2.5.6-15: Elimination of Waste Water in Areas without SEDAPAL Service

ii) Perception of problems of waste disposal system within the home

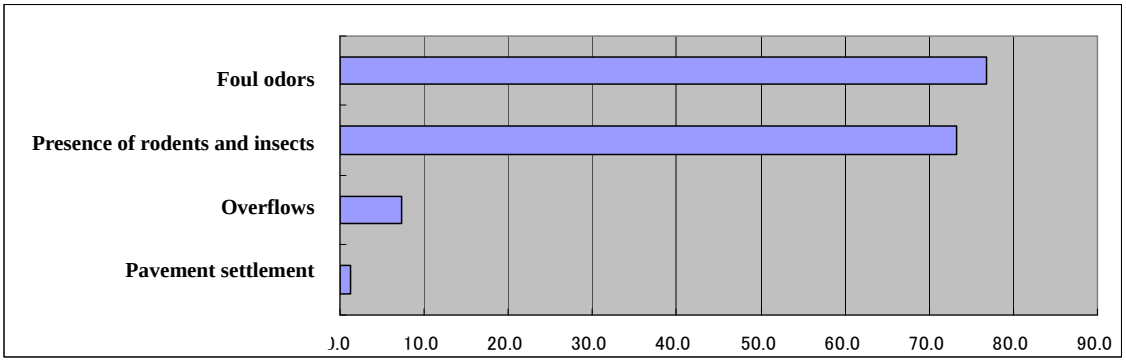
Out of all those interviewed, 76.8% express that there are problems with foul odors in the waste disposal system in their home; 73.2% express problems with the presence of rodents and insects, 7.3% express problems with overflows, and 1.2% express problems with pavement settlement.

The rudimentary systems of excreta disposal in vaults, pits, or septic tanks that keep the excreta inside the home longer can be dangerous for health if there is a lack of adequate maintenance systems.

Table 2.5.6-17: Problems with the Excreta Disposal Systemin Areas without SEDAPAL Service

Perceived Problems	District			Total (%)
	San Martín de Porres	Callao	Puente Piedra	
Foul odors	**70.2%**	**84.6%**	**88.9%**	**76.8**
Presence of rodents and insects	**70.2%**	**80.8%**	**66.7%**	**73.2**
Overflows	6.4%	3.8%	22.2%	7.3
Pavement settlement	2.1%	0.0	0.0	1.2
Total Number of Samples (Frequency)	39	34	9	82

Source: JICA Study Team



Source: JICA Study Team

Figure 2.5.6-16: Problems with the Waste Disposal System in Areas without SEDAPAL Service

iii) Household costs for maintenance and cleaning of the waste disposal system

The average monthly maintenance cost of the systems (with lime, disinfectant, cleaning materials, etc.) is S/. 9.9 nuevos soles (See Table 2.5-6-18.).

Table 2.5.6.-18: Maintenance Cost for Waste Management System

District	Total Frequencies	Average Monthly Cost for System Maintenance (S/.)
San Martín de Porres	47	12.7
Callao	26	5.3
Puente Piedra	9	9.2
Total	82	9.9

Source: JICA Study Team

(c) Existing Service Level

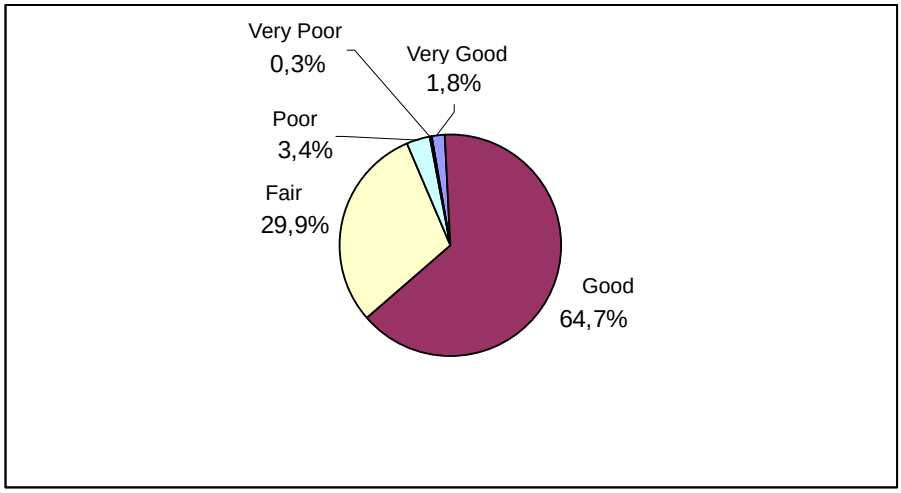
i) With SEDAPAL service

Another inconsistency among the survey responses with reference to the sewerage networks is evident in Table 2.5.6-19: more than 95% think that the service is between good and fair, and on the other hand, there were a high percentage of complaints of rodents, insects, foul odors, clogs, flooding, etc.

Table 2.5.6-19: Perception of Sewerage Service (provided by SEDAPAL)

Description	District							Total (%)
	Los Olivos	San Martín de Porres	Callao	Carabayllo	Comas 1	Comas 2	Puente Piedra	
Very good	3.3%	3.8%	0	0	1.8%	0	0	1.8
Good	60.2%	69.2%	75.0%	63.2%	76.4%	49.1%	72.9%	64.7
Fair	32.5%	25.0%	18.8%	34.2%	18.2%	49.1%	20.8%	29.9
Poor	4.1%	1.9%	6.3%	0	3.6%	1.9%	6.3%	3.4
Very por	0	0	0	2.6%	0	0	0	0.3
Total frequency	123	52	16	38	55	53	48	385

Source: JICA Study Team



Source: JICA Study Team

Figure 2.5.6-17: Perception of Sewerage Service Provided by SEDAPAL

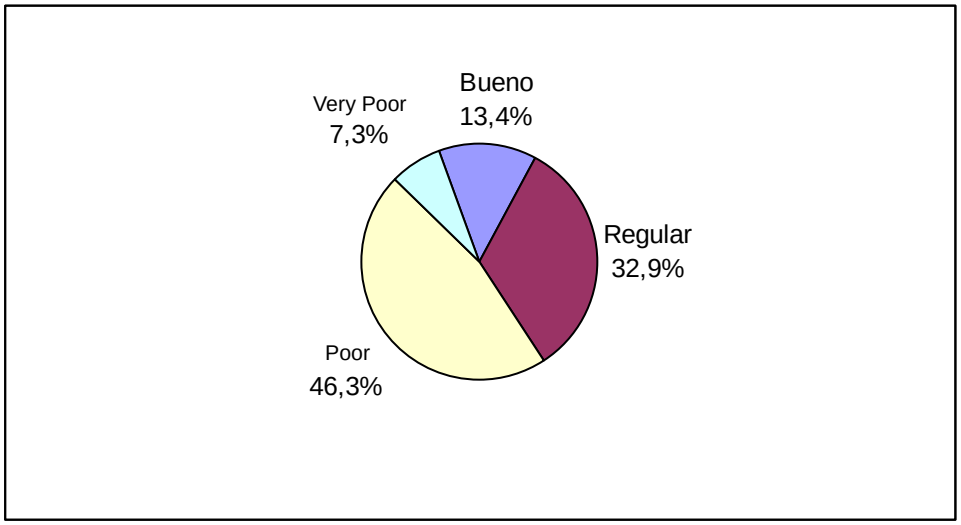
ii) Without SEDAPAL service

Among the respondents, 46.3% rate the sewerage system as poor, 32.9% rate it as fair, 13.4% rate it as good, and 7.3% rate it as very poor. There is limited knowledge about the change in lifestyle that can result from the use of a toilet connected to the sewerage system; this knowledge should be more widely circulated. When a high percentage gives a "fair" rating to the use of vault latrine or septic tank, it is evident that they are clearly unfamiliar with the significance of the sewerage networks. (See Table 2.5.6-20.)

Table 2.5.6-20: Perception of Sewerage System provided by SEDAPAL

Description	District			Total (%)
	San Martín de Porres	Callao	Puente Piedra	
Very good	0.0	0.0	0.0	0.0
Good	7.7%	14.7%	33.3%	13.4
Fair	12.8%	47.1%	66.7%	32.9
Poor	69.2%	32.4%	0.0	46.3
Very por	10.3%	5.9%	0.0	7.3
Total frequencies	**39**	**34**	**9**	**82**

Source: JICA Study Team



Source: JICA Study Team

Figure 2.5.6-18: General Perception of Sewerage System provided by SEDAPAL

7) Tariff and Service Payments

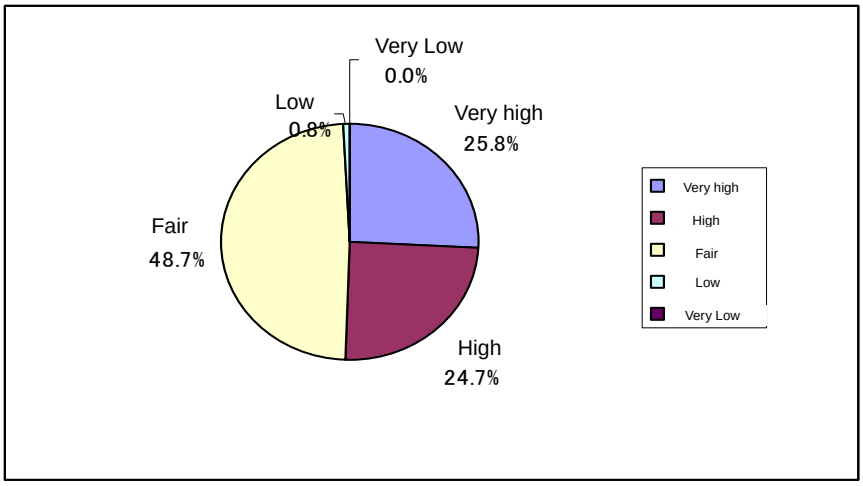
(a) Water and Sewerage and/or Sanitation Service Costs

Table 2.5.6-7 shows the average monthly costs incurred by users of SEDAPAL water and sewerage services, which is a payment of S/. 42.9. Table 2.5.6-11 and Table 2.5.6-18 indicate that the users without SEDAPAL services pay a monthly total of S/. 44.10 for water and S/. 9.9 for sanitation maintenance. It can be observed that the families that do not have water and sewerage service on the SEDAPAL network incur a greater cost.

(b) Perception of Payment for Water and Sewerage (and/or Sanitation) Services

i) With SEDAPAL service

Regarding the total payment for water and sewerage services paid by the families, half of the users have the opinion that it is high, and the other half think it as reasonable.

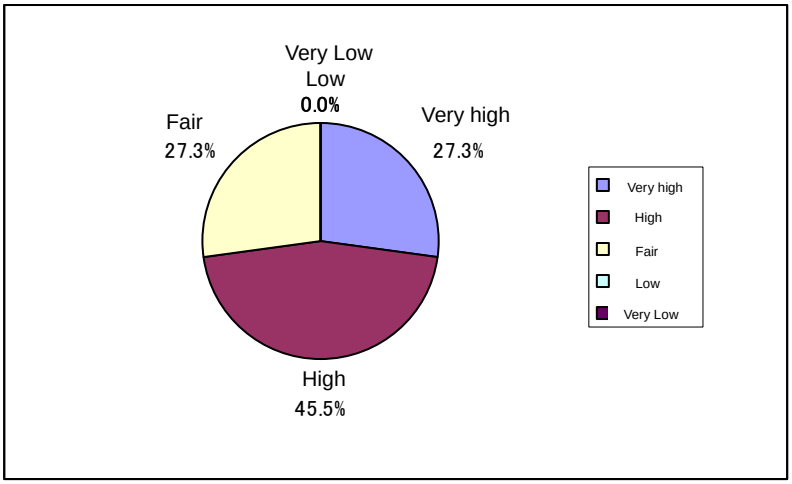


Source: JICA Study Team

Figure 2.5.6-19: Opinion about Payment for Water and Sewerage Service

ii) Without SEDAPAL service

In general, 45.5% think that the amount paid for existing water services is high, 27.3% express that it is very high, and another 27.3% think that it is normal. There is not much difference in this tendency among the sectors.



Source: JICA Study Team

Figure 2.5.6-20: General Opinion about the Amount Paid for Existing Water Service

8) Payment Affordability

The total incomes and expenditures in a household and the average payment for water and sewerage services are summarized below. On average, the monthly payment for sanitation services represents 2.08% of the household income with SEDAPAL service, and 3.53% for households without SEDAPAL service. Generally, the maximum percentage of this

indicator is 5.0%, according to the recommendations by the World Bank and other international organizations. See Table 2.5.6-21 and Table 2.5.6-22.

Table 2.5.6-21: Payment Affordability in SEDAPAL Service Area

District	Sector	Average Monthly Income	Average Monthly Expenditures	Monthly Water / sewerage Payment	Payment / Income	Payment / Expenditures
Los Olivos	83	3,826	1,523	70.9	1.85%	4.66%
	84	2,083	1,409	46.6	2.24%	3.31%
	85	2,238	1,471	46.3	2.07%	3.15%
San Martín de Porres	212	1,988	1,225	43.0	2.16%	3.51%
	213	1,734	1,086	39.1	2.25%	3.60%
Callao	259	1,731	1,370	30.1	1.74%	2.20%
Comas 1	345	1,650	1,186	30.7	1.86%	2.59%
	346	1,410	930	45.1	3.20%	4.85%
	347	1,709	1,231	53.2	3.11%	4.32%
Comas 2	348	1,817	1,147	39.6	2.18%	3.45%
	349	1,886	1,134	29.7	1.57%	2.62%
Carabayllo	350	1,887	1,351	44.5	2.36%	3.29%
	351	1,795	972	34.4	1.92%	3.54%
Puente Piedra	368	1,684	1,219	27.4	1.63%	2.25%
	369	1,659	1,257	27.1	1.63%	2.16%
Total Average		**2,058**	**1,275**	**42.9**	**2.08%**	**3.36%**

Source: JICA Study Team

Table 2.5.6-22: Payment Affordability in Area without SEDAPAL Service

District	Sector	Average Income	Average Expenditures	Monthly Water Payment	Monthly Sanitation Payment	Payment / Income	Payment / Expenditures
San Martin de Porres	251	2721	1651	61.9	9.3	2.62%	4.31%
	252	1530	1024	74.6	12.1	5.67%	8.47%
	253	1883	1027	63.1	9.7	3.87%	7.09%
	254	1108	962	47.9	28.5	6.90%	7.94%
	255	2125	954	53.5	7.5	2.87%	6.39%
Callao	256	1097	744	25.8	7.4	3.03%	4.46%
	257	995	585	18.8	4.6	2.35%	4.00%
	258	850	582	29.3	2.0	3.68%	5.38%
	261	1475	805	61.3	3.3	4.38%	8.02%
	262	1615	987	27.5	5.0	2.01%	3.29%
	263	1225	1248	78.8	0.0	6.43%	6.31%
Puente Piedra	361	1400	1115	0.0	9.6	0.69%	0.86%
	370	1138	1030	7.0	8.8	1.39%	1.53%
Total		**1534**	**1019**	**44.1**	**10.0**	**3.53%**	**5.31%**

Source: JICA Study Team

9) Willingness to Pay (WTP)

(a) With SEDAPAL Service

i) Willingness to pay for better water and sewerage service

For the analysis of the maximum willingness to pay, the Contingent Valuation methodology is one of the methods available to measure the benefits and costs related to the policies that affect the stock or characteristics of the public service or the environment.

It is a direct, non-market method. This means that it is not based on market information, but rather on a hypothetical market for the public service or for the environment. Parameters for this market are defined, and individuals are asked for their willingness to pay for a change in the characteristics of the water and sewerage services. Among these advantages, it stands out that this method involves an exact measurement in the change in well-being anticipated, and it does not depend on the order of the changes in the attributes when there are multiple changes.

The application of this method is based on the following assumptions: the individual interviewed is involved in the effect of Project execution on improving water and sewerage service, and therefore, given their available income, will maximize its utility; the behavior of the individual in the hypothetical market is equivalent to their behavior in the real market; the individual has complete information about the benefits that an efficient water and sewerage service will generate for him or her.

The double entry method of dichotomous election (that is, asking the questions of two alternative answers for 2 times) of contingent valuation is applied in the investigation. The procedure was processed in the following way: at first, price of additional payments at the current rate was shown to the individual interviewed, and they were asked if they could accept or not. Then, it was indicated whether or not they would accept the second price. The second, higher price becomes the first rate if the people respond “Yes” to the first question, and it becomes less if they respond “No” to the first question. The result of the entire questionnaire is summarized and evaluated through the prediction of how it approaches an average number. Five (5) payment prices were formulated, as shown in the Table 2.5.6-23 and Table 2.5.6-24, and the used questionnaire is chosen randomly before doing interview, so that the result has less bias of indicated number influence.

The Logit-linear model (which is a generalized linear model used for binomial regression for the prediction of probability), was used in order to process the information regarding willingness to pay (WTP), and the results are shown in the Tables corresponding to each case (with and without SEDAPAL water and sewerage service).

Substantial differences can be observed in the maximum willingness to pay according to the type of access to water service. In that sense, there is an inverse relationship between having water and sewerage and the maximum willingness to pay for the project; in other words, those that have continuous water and sewerage service through the SEDAPAL network (24 hour continuity) are the ones who are willing to pay less for the improvement and optimization of the water and sewerage service; on the other hand, the households that do not have continuous service (that is service with interruptions) are willing to pay more

for the improvement of water and sewerage service that will be a direct effect of the project.

In that sense, of the households that have water service 24 hours a day, the median willingness to pay is S/. 4.49 per month; in other words, 50% of those surveyed are only willing to pay up to this amount. The average willingness to pay is S/. 8.18 monthly. However, the families that have water service rationed by hours are willing to pay more than the families that have water 24 hours a day. In fact, the median is S/. 8.54 per month and the average is S/. 13.57 per month, as can be observed in Table 2.5.6-23.

Table 2.5.6-23: Willingness to Pay for Better Water and Sewerage Service

Type of Household	Median (S/. per month)	Average (S/. per month)
Households with service 24 hours a day	4.49	8.18
Households with service less than 24 hours a day	8.54	13.57

Source: JICA Study Team

Table 2.5.6-24: Maximum Willingness to Pay (WTP) in Areas with 24-Hour SEDAPAL Service [1/]

Type	First Question	Second Question	YY	YN	NY	NN	Total
1	S/. 3.00 / month	S/. 1.50 / month or S/. 5.00 / month	17	27	10	19	73
2	S/. 5.00 / month	S/. 3.00 / month or S/. 10.00 / month	6	23	7	33	69
3	S/. 10.00 / month	S/. 5.00 / month or S/. 20.00 / month	2	23	13	33	71
4	S/. 20.00 / month	S/. 10.00 / month or S/. 30.00 / month	0	14	12	42	68
5	S/. 30.00 / month	S/. 20.00 / month or S/. 45.00 / month	0	6	9	40	55
			25	93	51	167	**336**

1/ except in Comas-2

Note: If the answer of first question is Y, second question is for the higher ceiling and vice versa.

Where the results are:

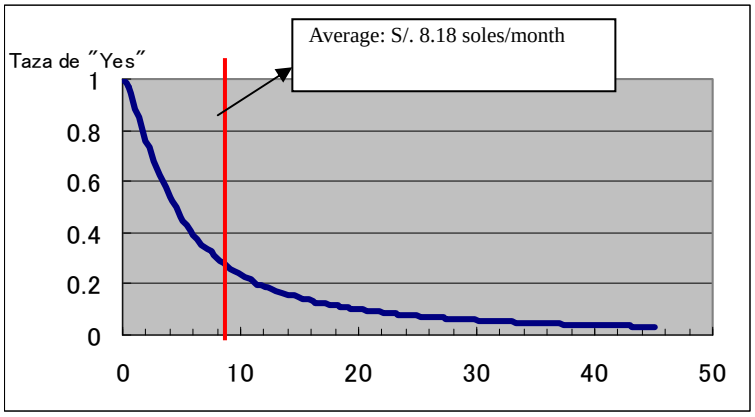
YY: Yes to the first price and yes to the second price

YN: Yes to the first price and no to the second price

NY: No to the first price and yes to the second price

NN. No to the first price and no to the second price

Source: JICA Study Team



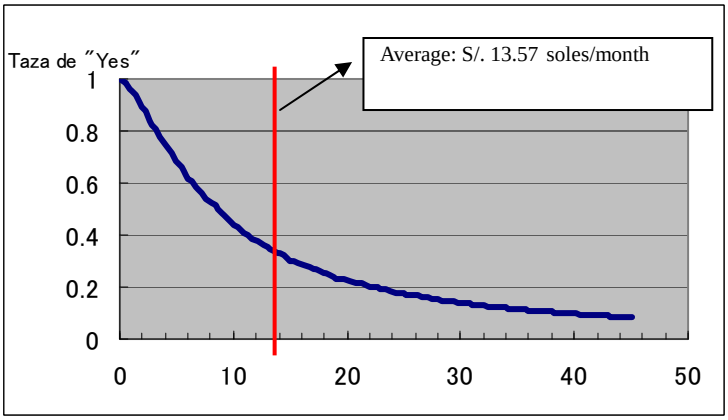
Source: JICA Study Team

Figure 2.5.6-21: Accumulation of Additional WTP for Better Service

Table 2.5.6-25: Result of WTP Questions in Areas with Less than 24 Hour Service (Comas-2)

Type	First Question	Second Question	YY	YN	NY	NN	Total
1	S/. 3.00 / month	S/. 1.50 / month or S/. 5.00 / month	4	4	1	4	13
2	S/. 5.00 / month	S/. 3.00 / month or S/. 10.00 / month	3	6	0	2	11
3	S/. 10.00 / month	S/. 5.00 / month or S/. 20.00 / month	1	6	2	2	11
4	S/. 20.00 / month	S/. 10.00 / month or S/. 30.00 / month	1	6	1	3	11
5	S/. 30.00 / month	S/. 20.00 / month or S/. 45.00 / month	0	1	2	4	7
			9	23	6	15	**53**

Source: JICA Study Team



Source: JICA Study Team

Figure 2.5.6-22: Accumulation of Additional WTP for Better Service (Comas 2)

The results for greatest willingness to pay (WTP) shall be utilized for the Project´s economic evaluation.

(b) Without SEDAPAL Service

i) Willingness to pay for SEDAPAL water and sewerage service

The households that do not have water service and are supplied by well, tap, or tank trunk are willing to pay more for improved water service. The median willingness to pay is S/. 17.28 per month; in other words, 50% of those surveyed are willing to pay up to this amount. The average willingness to pay is S/. 21.46 per month. In conclusion, those who are lacking water most would willing to pay a higher sum to optimize water and sewerage service.

Table 2.5.6-26: Willingness to Pay for the Project According to Type of Household (In S/.)

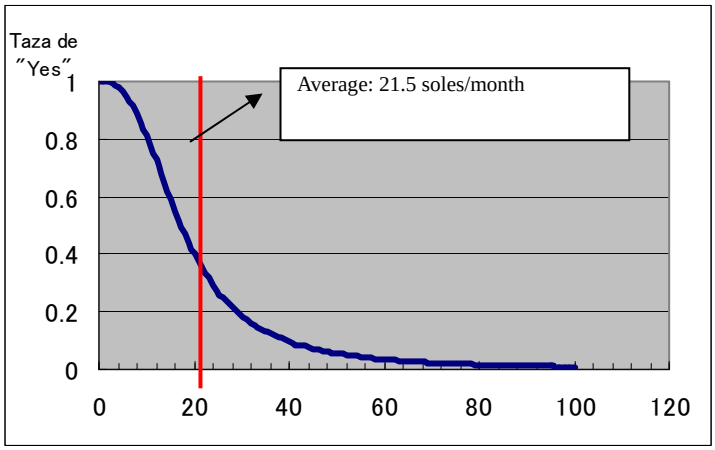
Type of Household	Median (S/. per month)	Average (S/.per month)
Households without SEDAPAL service	17.28	21.46

Source: JICA Study Team

Table 2.5.6-27: Result of WTP Questions in Areas without SEDAPAL Service (Comas-2)

Type	First Question	Second Question	YY	YN	NY	NN	Total
1	S/. 10.00 / month	S/. 5.00 / month or S/. 15.00 / month	4	12	1	1	18
2	S/. 15.00 / month	S/. 10.00 / month or S/. 30.00 / month	1	7	6	1	15
3	S/. 30.00 / month	S/. 15.00 / month or S/. 45.00 / month	2	3	5	6	16
4	S/. 45.00 / month	S/. 30.00 / month or S/. 65.00 / month	1	1	4	9	15
5	S/. 65.00 / month	S/. 45.00 / month or S/. 100.00 / month	0	1	1	11	13
			8	24	17	28	**77**

Source: JICA Study Team



Source: JICA Study Team

Figure 2.5.6-23: Accumulation of Additional WTP for Better Service (Comas 2)

The average WTP of the inhabitants in the areas without SEDAPAL service for the better service alternative is almost the same as the current water service payment of S/. 19.4 per month. In general, the willingness to pay in the poorer service area, tends to exceed the current payment, because of the additional benefits of an alternative water supply source coming from SEDAPAL.

The reason for which the WTP is not higher could be that the inhabitants´ lack of understanding or ability to imagine the situation with better service. In reality, the number of samples in the zone without SEDAPAL service is limited to 82 samples. It is proposed to study with more depth and a greater sample size, if SEDAPAL would like to investigate the most accurate WTP value.

2.5.7 Topographic and Geotechnical Characteristics

(1) Topographic Characteristics

1) Background

The main objective of topographic survey is to investigate location, elevation and slope in and around a proposed or planned construction site. In this Study, it is included that the topographic survey should be carried out for any new construction.

2) Location

The Study area is located between UTM coordinates 274,930.482 and 8,685,434.462 in the north; 267,601.314 and 8,673,667.189 in the south; 282,805.503 and 8,682,343.127 in the east; and 266,216.240 and 8,683,112.935 in the west. The highest elevation is registered in the Collique area in the district of Comas at 550 m.a.s.l. The spurs of the Andes Mountain Range´s western branch start near the Study area's eastern limit. The Chillón River and the Lurín River valleys limit the study area's extension to the north and south, respectively. The distance between both the river mouths, along the Coast, is about 65 Km. The western boundary of the Study area is the Pacific Ocean.

3) Topography

The described area covers a predominantly flat area with a slight gradient at an average 4 – 5 % in a NE-SW direction. The Rímac River crosses the area's urban settings, following an east-west direction, and discharges to the north of the Callao port. The Rímac River valley makes up the major access to connect the metropolitan area to the central Andean region of Peru.

4) Field Work

For the new pipe construction proposed in the Study, a topographic survey is carried out for route survey as well as transverse profiles at every 20 m. In addition, elevation bench marks are measured for other infrastructures like reservoirs, pumping stations, etc. Details can be found in Appendix A1.

5) Validation of SEDAPAL Topographic Data

In order to contrast topographic elevations with the data managed by SEDAPAL's mappings, samples were taken from 12 of the field work points. Average topographic elevation mismatch is 0.64 m, ranging from a maximum of 2.82 m to a minimum of 0.15m. Biggest mismatches were found in the hill areas.

In that sense, it is deemed that the same mismatches will be found in the areas where no topographic survey was made.

Table 2.5.7-1: Validation of SEDAPAL Data

Differences between elevation of SEDAPAL data and topographic survey						
Section	Points	Coordinates		Elevation		
		East	North	SEDAPAL	Field	Difference
1	1	274,084.436	8,677,541.998	80	77.69	2.32
	2	274,235.737	8,677,286.941	77.5	77.29	0.21
2	3	274,580.613	8,676,807.824	75	74.73	0.27
	4	274,390.152	8,676,567.701	72.5	73.43	-0.93
	5	274,602.520	8,676,014.247	67.5	69.03	-1.53
3	6	274,676.253	8,675,098.591	62.5	62.65	-0.15
	7	274,328.342	8,674,745.646	57.5	58.45	-0.95
4	8	273,425.350	8,674,459.793	47.5	49.29	-1.79
	9	273,408.774	8,674,145.320	42.5	44.56	-2.06
5	10	273,803.457	8,676,602.232	70	70.16	-0.16
	11	273,289.489	8,676,799.118	70	69.79	0.21
6	12	273,670.950	8,676,398.349	65	67.31	-2.31
	13	273,196.017	8,675,811.341	85	85.40	-0.40
7	14	273,641.162	8,675,863.514	60	61.69	-1.69
	15	273,669.629	8,675,074.771	52.5	54.38	-1.88
	16	274,028.799	8,675,334.515	57.5	59.02	-1.52
8	17	272,644.118	8,674,941.213	45	46.82	-1.82
	18	272,191.584	8,673,834.571	35	36.63	-1.63
	19	272,614.601	8,674,556.299	42.5	45.32	-2.82
9	20	273,211.372	8,677,425.833	75	74.49	0.51
	21	273,932.072	8,677,624.915	80	79.80	0.20
10	22	273,152.768	8,678,579.283	80	79.05	0.95
	23	273,747.124	8,678,870.482	90	89.02	0.98
11	24	280,642.176	8,682,206.693	320	321.22	-1.22
	25	281,390.671	8,682,456.425	388	390.45	-2.45
12	26	279,452.723	8,681,870.164	238	235.10	2.90
Average Value of Comparison						-0.64

Source: JICA Study Team

(2) Geotechnical Characteristics

The JICA Study Team conducted a soil and geotechnical survey to understand the general soil condition of the Study area. Details can be found in Appendix A2. A brief explanation is given below.

1) Diagnosis

Basically the Study area is an undulating area. The Chillón River flows through the Study area, dividing the districts of Puente Piedra and Los Olivos. An old alluvial fan can also be found forming the river bed, just before the river flows into the Pacific Ocean.

The study area is covered mainly by deposits of old fluvial-alluvial, as well as recent fluvial alluvial of Quaternary age. Intrusive rocks can also be found in some specific areas. Thus, most of the water and sewerage pipes are expected to be placed in the old alluvial deposits. Within the top layer of the soil, up to 1.5m to 3.0m deep, the soil consists of sandy silt, sandy loam, silty clay and / or clay. This layer is followed by a loose to medium compacted layer of sandy-gravel of various gradations, mixed with rounded and partially rounded pebbles of maximum diameter of 0.50m. The water level in the subsoil is generally found at lower than 10m of depth.

This configuration corresponds to a typical calm water alluvial deposit formed by horizontal and sub-horizontal strata of sand, silt, clay and lean and loose sandy-gravels. Fine materials are always found on top and the coarse ones deeper. It is necessary to point out that in these areas there are deposits of anthropogenic origin due to the explosive urban growth of the Northern Lima during the last two decades.

Since most of the populated areas within the Study area are located far from the main river channel of Chillón, flooding, bed erosion, marginal erosion, etc. are less likely to affect the construction activities of the Project.

In some isolated areas, such as Collique, Nueva Patria Reservoir area and Olives Pro R-1 Reservoir area in Los Olives District, and Márquez R-522 Reservoir area in Ventanilla District, any future construction works should preferably be placed over an outcrop of Diorite type intrusive rocks originating in the Super Drive Santa Rosa or Patapo (Gabrodiorita). It is possible to find such rocks only in small, isolated areas, in a highly fractured and altered form, between 0.10m and 0.50m of depth.

As the geological profile of the Study area is basically rigid soil consisting of sandy gravel, it is estimated that the values of the shear wave speed is between 750m/s to 1000m/s, and the periods of natural soil vibration are less than 0.40 seconds. It is also estimated that there is a slight possibility of local seismic amplification effects, and its value is estimated to be between 1.00 and 1.15 times the rock acceleration.

It is estimated that the depth of the sandy-gravel alluvial of medium to high compactness reaches more than 20.0m. The seismic response of the soil is governed by the characteristics of this deposit.

It is recommended that the water and sewer pipes should be placed around 3.0 m deep over silty clay, silt, sand, or sandy-silt. If the required depth is greater, the pipes should be placed over slightly wet sandy gravels, but without the presence of water level. When the soil compactness is between loose and medium and bearing capacity is between 1.00 Kg/cm2 and 2.00 Kg/cm2, it is easily excavated by manual or mechanical means; however, this type of soil shows instability of the vertical surface for excavations more than 2.50 m.

In many cases, the soils excavated for the installation of pipes, cannot be re-used to refill the trenches, due to some physical and mechanical characteristics. For example, some soil shows varied levels of chemical aggression towards concrete and ductile iron. In such cases, borrowed filling materials are required. A clear example of this phenomenon can be found near the Reservoir RP-2 Cerro Oquendo up to Reservoir R-522 Márquez in Ventanilla, where borrowed filling material has to be used for the filling of the trenches. Depending on the chemically aggressive soil property, enhanced protection is required for ductile iron pipe, like Type V cement and PE covering. There is a risk of this chemical attack in approximately 60% (estimated value) of the Study area.

2) Conclusions

Based on the assessment of soil characteristics, the following are the conclusions that should be taken into consideration during planning and designing future construction activities in the Project.

a) Ninety-five percent of the materials to be excavated for the trenches are expected to be dry and loose material like clays, silts and gravels. They are generally easy to excavate, either by manual or mechanical procedures. Difficulties are expected only in some isolated sectors due to the presence of altered and deeply fractured rock.

b) Excavation of the trenches may be carried out without any lateral support up to a depth of 2.50m. Support measures should be taken for deeper trenches, like dampening the vertical surface, plastering the vertical surface with cement-sand mortar, or others specific to the needs.

c) The foundation soil for pipe support is not expected to suffer any serious problems due to the presence of the high water table, loose soils, or soils of very low bearing capacity. Hence it requires no other treatment of the foundation prior to mechanical compaction, with the exception of those cases where material is anthropogenic and/or all the material up to the depth of influence will have to be removed.

d) In the preliminary design, it is recommended to use a load capacity of 1.00 Kg/cm2 for fine soils with foundations at a minimal depth of 1.50m, and a value of 2.00 Kg/cm2 in case of the sandy gravel soils (Reference values).

e) It is estimated that fifty percent of the excavated materials can be reused for backfill. Soils with low resistivity, high salt and sulfate content, high plasticity, high organic material content, or high waste material content cannot be used as backfill material, and suitable backfill material should be arranged from elsewhere.

f) It is estimated that 60% of the soil within the Study area has a strong presence of chemicals aggressive to the foundation soil and to the concrete and ductile iron pipes. In such cases, it is required to use Type V Cement and /or PE protection. In the case of the PVC pipes, no protection is required, because it is an inert material to chemical aggression.

g) During the water and sewer pipe replacement works, if the current backfill materials are considered to be inappropriate, new suitable material should be used as backfill.

h) Minimum coverage should be 1.2m and backfill should be properly compacted.

2.5.8 Diagnosis of Existing Infrastructure – Water Supply

(1) Restructuring of "Sector" and Setting of Sub-sector

"Sector" is the current operational unit of existing water supply system of SEDAPAL. From the initial assessment, it is found that some of the sectors have a large number of connections which is not suitable for effective sectorization, NRW management and system optimization. In the Study, thus, some of the current sectors are proposed to be divided into two or three sectors. Moreover, each sector is also divided into a number of sub-sectors, which in principle have their own reservoirs, and inflow volume and pressure measurement, to be operated independently as smallest operational units. The concepts of restructuring "sectors" and setting of sub-sectors are explained in Sections 3.4.2 and 3.4.3.

In this section of diagnosis of the existing infrastructure, a "sector" signifies the proposed restructured one in principle, and the current sector is expressed as "original sector". The following table presents correspondence of original sectors, proposed sectors and proposed sub sectors. Number of proposed sectors is 41, which corresponds to 32 original sectors. Number of proposed sub-sectors is 63.

Table 2.5.8-1: Correspondence of Proposed Sectors and Sub-sectors with Original Sectors in the study area

District	Original Sector	Sector	Sub-sector
Los Olivos	83	83 A	83A-1, 83A-2
		83 B	83B-1, 83B-2
	84	84 A	84A-1, 84A-2
		84 B	84B-1, 84B-2
	85	85 A	85 A
		85 B	85B-1, 85B-2, 85B-3
		85 C	85 C
S.M. de Porres	212	212 A	212A-1, 212A-2
		212 B	212B-1, 212B-2
	213	213	213-1, 213-2, 213-3
	251	251	251
	252	252	252
	253	253	253
	254	254	254
	255	255	255
Callao	256	256	256
	257	257	257
	258	258	258
	259	259	259
Ventanilla	260	260	260
	261	261	261
	262	262	262
	263	263	263
	264	264	264
	265	265	265
	266	266	266
Comas	345	345	345
	346	346	346-1, 346-2
	347	347	347-1, 347-2
	348	348 A	348 A
		348 B	348B-1, 348B-2
	349	349 A	349A-1, 349A-2, 349A-3
		349 B	349B-1, 349B-2, 349B-3, 349B-4
Carabayllo	350	350	350-1, 350-2
	351	351	351-1, 351-2, 351-3
Puente Piedra	361	361	361
	368	368 A	368A-1, 368A-2
		368 B	368 B
	369	369 A	369 A
		369 B	369 B
	370	370	370
Number	32	41	63

Source: JICA Study Team

(2) Water Supply System

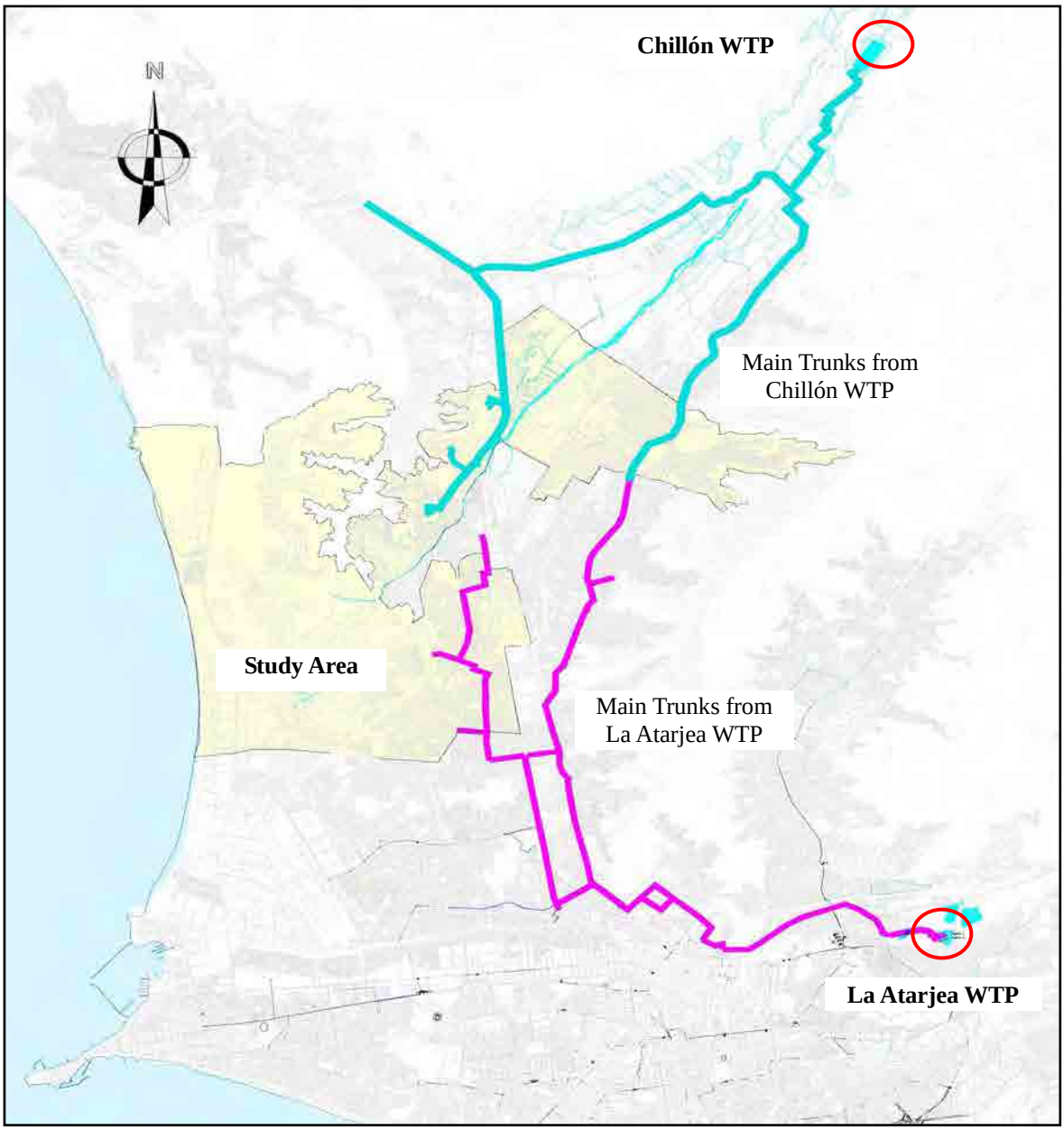
1) General Description of Current Water Supply System

SEDAPAL has two water treatment plants, which are the La Atarjea Water Treatment Plant (La Atarjea WTP) and the Chillón Water Treatment Plant (Chillón WTP).

At present, the area with existing network within the Study Area is receiving water supply from the two WTPs mentioned above and also from wells. Water distribution system from La Atarjea WTP is mainly supplying water to center and southern part of the Study area, which includes the districts of Callao, Los Olivos and San Martín de Porres. The water distribution system from Chillón WTP, on the other hand, is mainly supplying water to the northern part of the Study area, which includes the districts of Comas, Carabayllo and Puente Piedra.

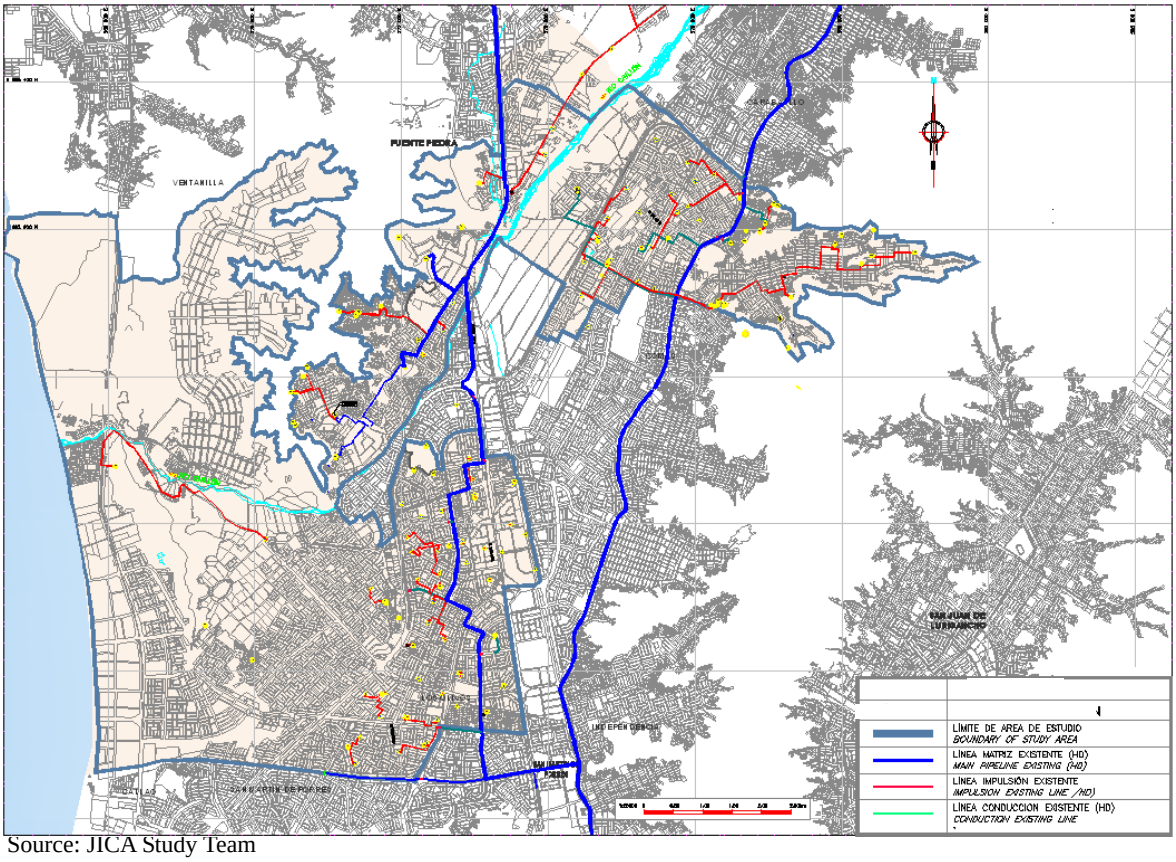
In addition, the two distribution networks are connected with each other so that they can compensate the other's production when it is not enough.

Figure 2.5.8-1 shows locations of the two WTPs in relation to the Study Area; Figure 2.5.8-2 illustrates the coverage of water supply systems in the Study Area, and Figure 2.5.8-3 presents the configuration of the water supply system.



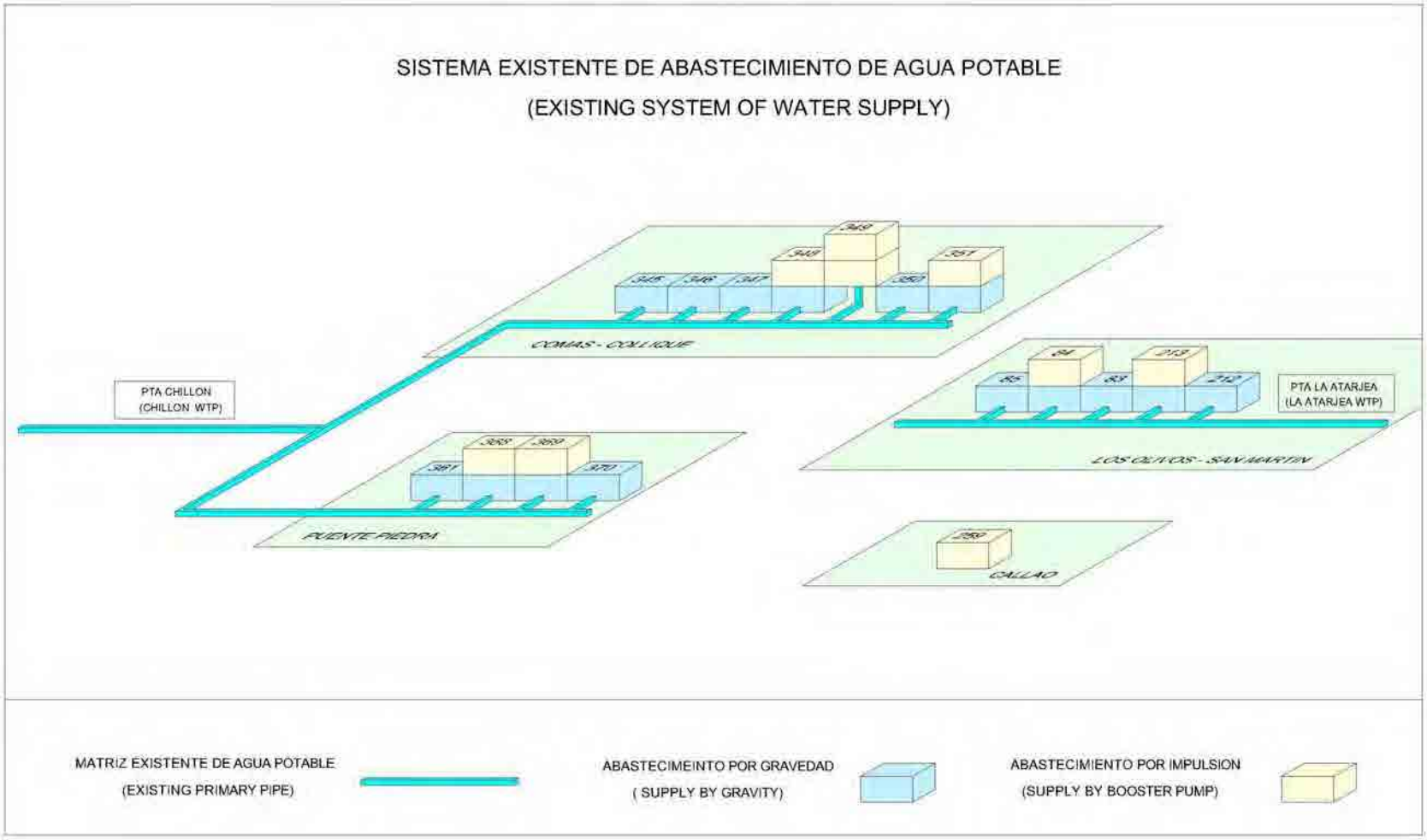
Source: JICA Study Team

Figure 2.5.8-1: Location of Water Treatment Plants in relation to the Study Area



Source: JICA Study Team

Figure 2.5.8-2: Water Supply System in the Study Area



Source: JICA Study Team

Figure 2.5.8-3: Configuration of Current Water Supply System in the Study Area

2) Sectorization

(a) Current Situation

In the water supply engineering, "sectorization" means ability to operate a sector in isolation, installation of micrometer for each user, and provision of inlet pressure and flow measurement. With this kind of operation mode, it is possible to identify water loss.

In the Study Area, only eleven original sectors are physically sectored, and each sector is equipped with a valve pit with a micrometer, a pressure control valve, and pressure sensors at their entrance of the sector, as presented in Table 2.5.8-2. Other original sectors cannot be supervised or controlled independently. In addition, only five ogirinal sectors (83, 84, 85, 212 and 213) of the eleven can automatically control the valve and store the data of measured water flow and pressure. This situation makes it difficult for SEDAPAL to grasp exact conditions of water distribution, such as the non-revenue water (NRW) ratio, and to control the distribution to suit the geographic condition of each area.

It is necessary to improve the primary network in the Project so that it is possible to implement sectorization for each sector in order to optimize the water supply system.

Table 2.5.8-2: Original Sectors in the Study Area with Valve Pits at Their Entrance

District	Original Sector
Los Olivos	83*
	84*
	85*
San Martín de Porres	212*
	213*
Comas	350
	345 – 346
	347 – 346
Pte. Piedra	361
	368
	369

*: Original sectors which can be controlled and monitored automatically.
Source: JICA Study Team

(b) Problems of Sectorization

As explained above, sectorization is not completed in the Study Area, so that NRW can not be monitored exactly.

(3) Operational Conditions

As only some sectors can be operated and monitored automatically, available data regarding operational conditions such as water flow and pressure are significantly limited. Observing the overall water supply system in the Study Area and the limited monitored operational information, operational conditions in the Study Area can be described as below;

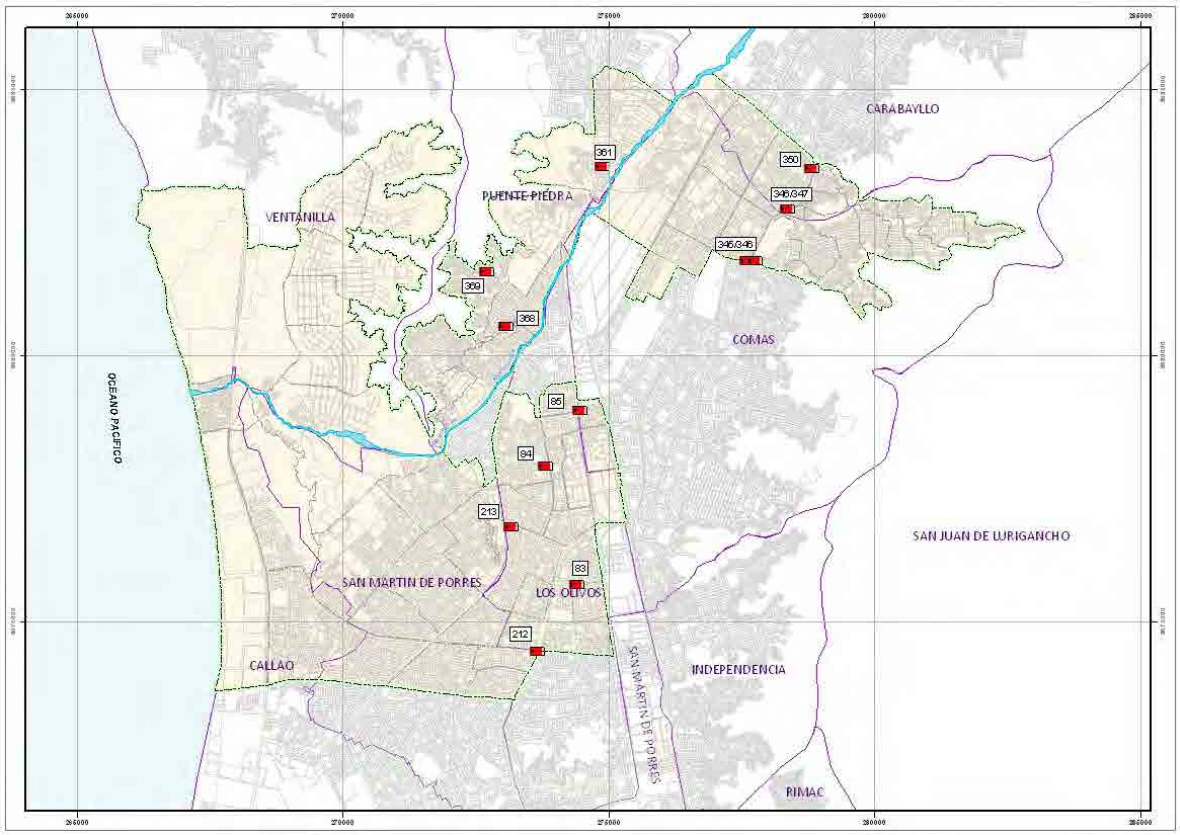
1) Water Flow

Figure 2.5.8-4 illustrates locations of the valve pits which are monitoring and controlling the inflow to the sectors, and Figure 2.5.8-5 presents monitored water flow in the former sectors 83, 84, 85, 212 and 213. Data recorded in autumn (from 8th to 14th June 2009) is presented, when water consumption shows the typical trend in a year.

Because the original sectors 83, 84, 85, 212 and 213 are supplying water directly to the households without any buffer storage, water flows shown in the figure are mostly presenting the water consumption in each original sector. Water flow in the original sector 213, which shows a convexity curve, can not present the exact actual consumption because it has a pumping station to serve a high-elevation area in the sector.

Generally, all the sectors have the same consumption tendency in a sense that water flow is large in the daytime and small in the nighttime, which is derived from the typical life pattern of inhabitants. Original sector 85, however, has a slightly different trend, where high consumption continues until 11 P.M, due to large scale industrial users in the sectors.

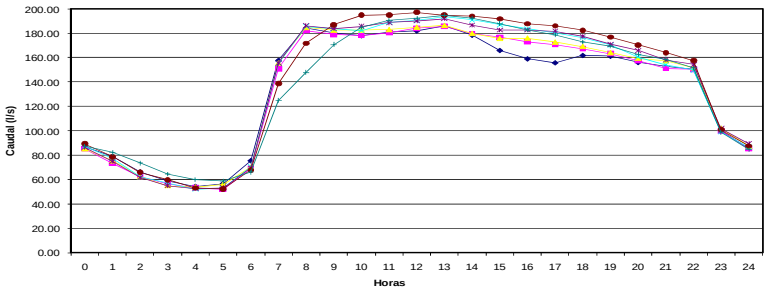
Regarding the original sector 213, the pump operation period results drastic increase in the water flow.



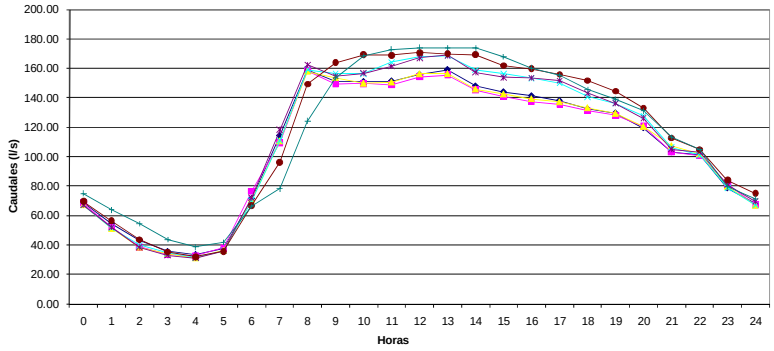
Source: JICA Study Team

Figure 2.5.8-4: Locations of the Valve Pits at the Entrances of the Monitored Sectors

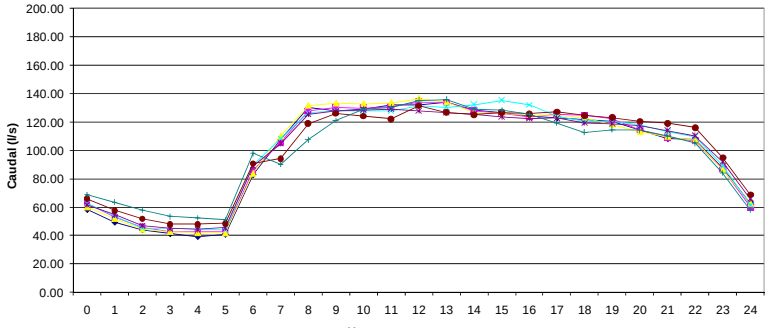
Sector 83



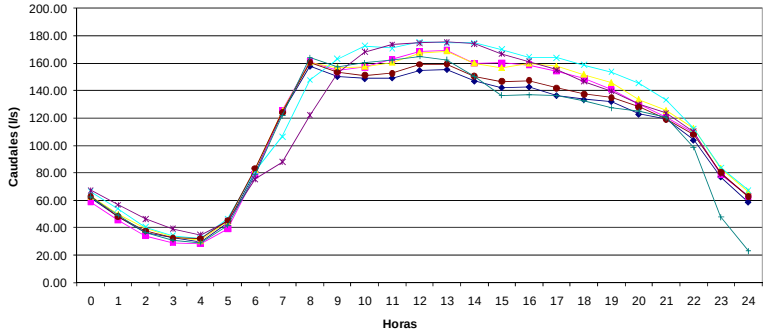
Sector 84



Sector 85



Sector 212



Sector 213

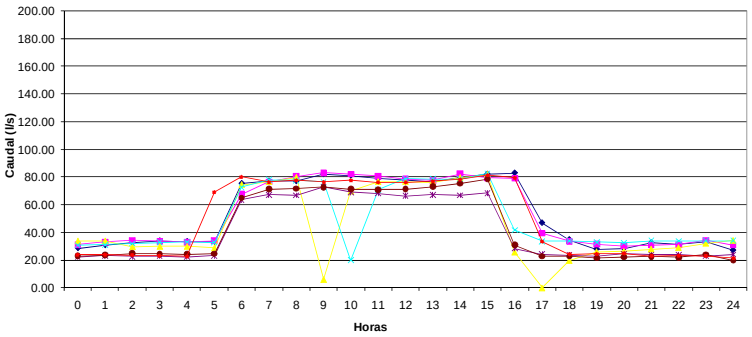


Figure 2.5.8-5: Water Flow at Entrances of Monitored Sectors

2) Water Pressure

Figure 2.5.8-6 presents monitored water pressure before it is controlled by valves in the former sectors 83, 84, 85, 212 and 213, which are located in Los Olivos and San Martín de Porres. Figure 2.5.8-7 also presents the monitored pressures at the sectors, but after they are regulated by the valves. In addition, Figure 2.5.8-8 presents water pressure measured by pressure sensor and monitored manually in the secondary networks. Presented data are those which were recorded in autumn (from 8th to 14th June 2009), when water consumption shows typical trend in a year.

(a) Water Pressure in Primary Network

The pressure of the water before it is controlled at the valve represents water pressure in primary networks, which are the networks that convey water from the WTPs to the sectors. (In the case of the former sectors above, the primary network is transferring water from the La Atarja WTP.)

Water pressures ranges between 30 m.c.a and 150 m.c.a., and at the entrances of original sectors 83, 212 and 213, the pressures are continuously higher than 80 m.c.a.

(b) Water Pressure in Secondary Network

The pressure of the water after it is controlled at the valve represents the conditions of water pressure in secondary networks, which are the networks that receive water from primary networks and distribute it throughout in the distribution area. Except for original sector 213, which has a pumping station, the inflows to the sectors are distributed directly to the households.

In original sectors 83, 84 and 212, water pressures are constantly around 36 m.c.a., 25 m.c.a., and 27 m.c.a., respectively. The constant pressure after the pressure control in the original sectors 83, 84 and 212 suggests that the pressure control is being successfully carried out.

In original sector 85, on the other hand, water pressure lowers by about 5 m.c.a. at peak time of water consumption.

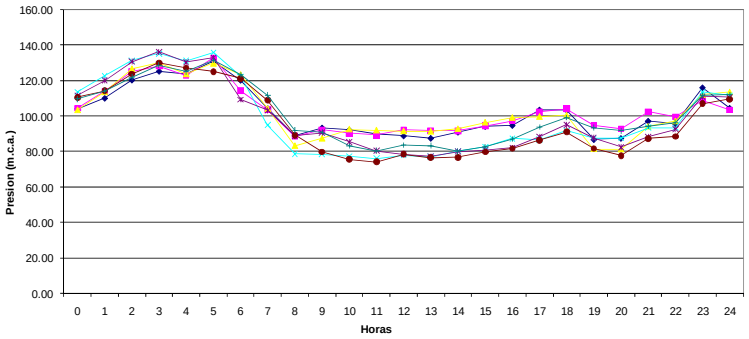
(c) Problems of Water Pressure Control

Observing the dynamic trend of water pressure at the entrance of the monitored sectors, current problems of water pressure control can be summarized as follows;

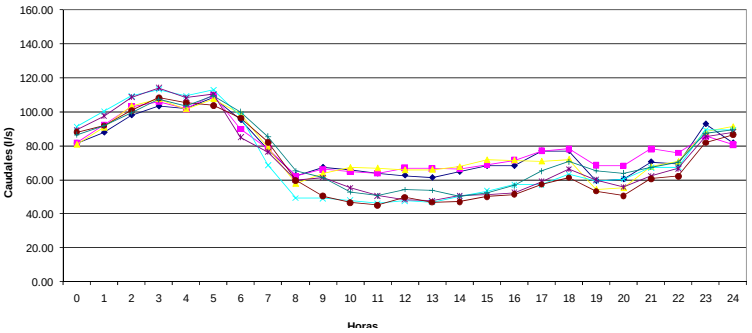
- In view point of conservation of the pipeline, the constant pressure (80 m.c.a.) and the maximum pressure (150 m.c.a.) are so high that breakage and water leakage from pipe joints might be a concern. It is necessary to control them as much as possible to be lower than 75 m.c.a.
- In addition, reduction of the pressure is also necessary in order to avoid cavitation at the pressure control valve.
- The water pressure after pressure control in original sector 83 (constantly 36 m.c.a.) is significantly high, and like the primary network, breakage and water loss at pipe joints are a concern. It is necessary to lower the pressure of the inflow to the sector.
- As observed in the original sector 85, there might be some other areas, where the

water pressure at end users is low during the peak hours around lunch time. It is necessary to consider an operational or infrastructural corrective measure in order to optimize the distribution pressure.

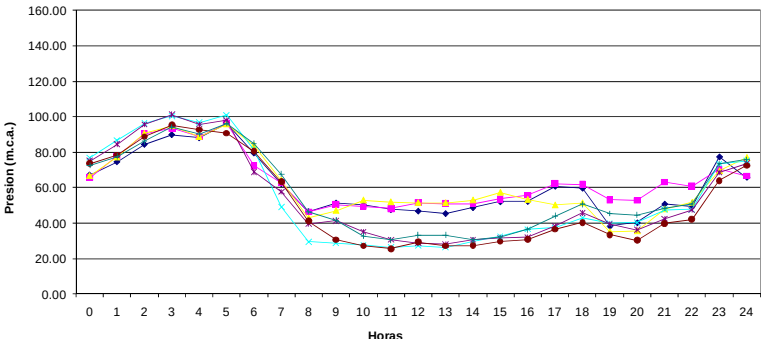
Sector 83



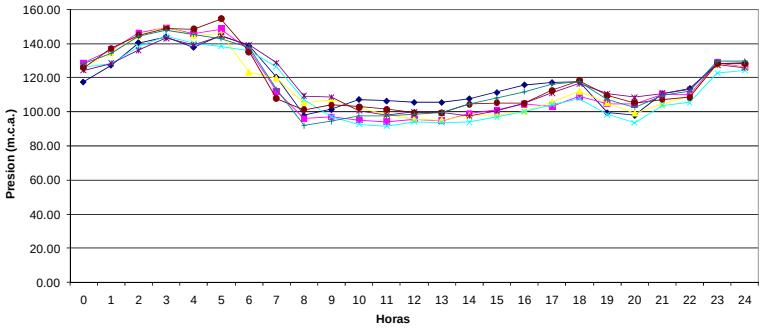
Sector 84



Sector 85



Sector 212



Sector 213

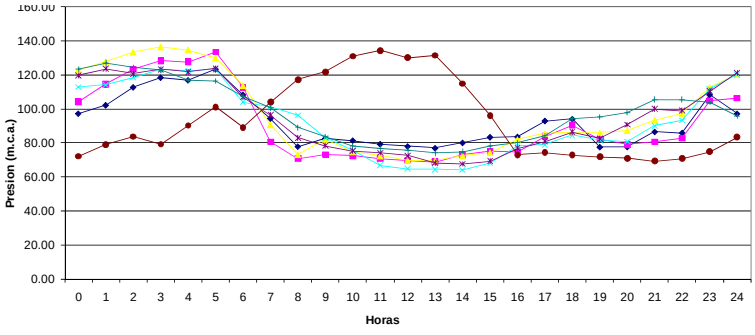
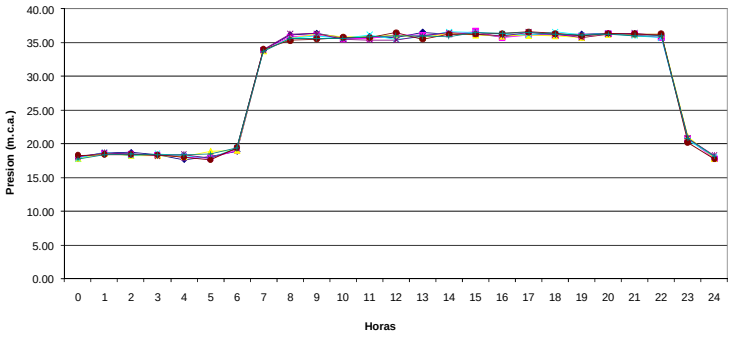
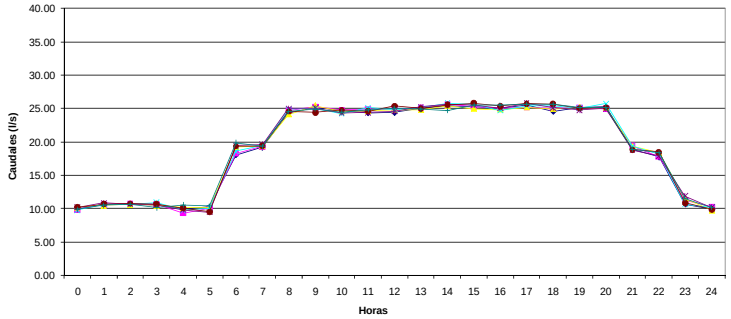


Figure 2.5.8-6: Water Pressure at Entrances of Monitored Sectors Before Pressure Control

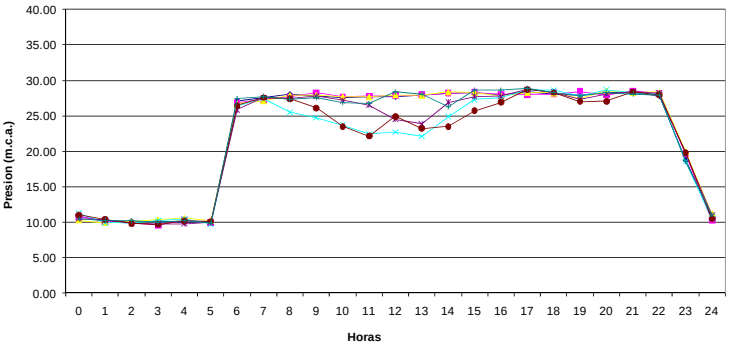
Sector 83



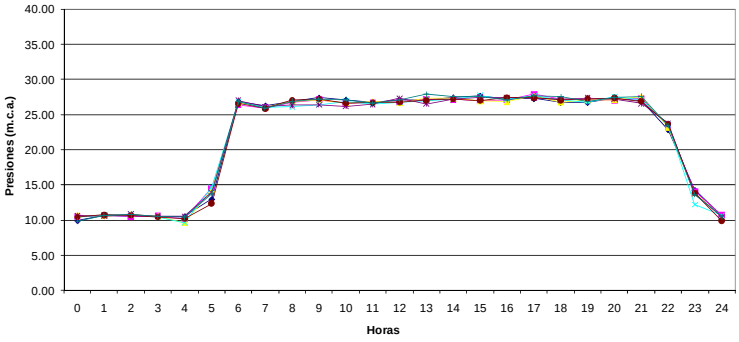
Sector 84



Sector 85



Sector 212



Sector 213

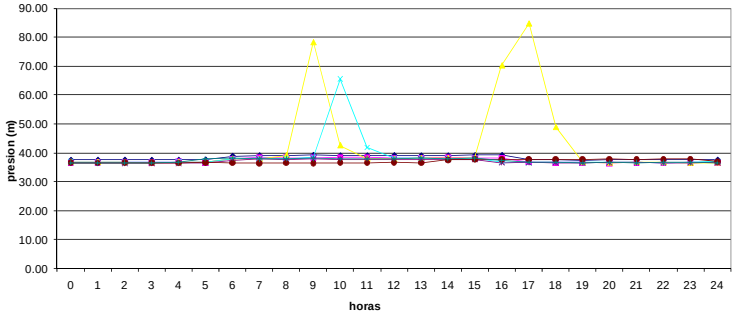


Figure 2.5.8-7: Water Pressure at Entrances of Monitored Sectors After Pressure Control

270000 275000 280000 285000

8685000 8680000 8675000

N

CARABAYLLO
PUENTE PIEDRA
VENTANILLA
COMAS
SAN JUAN DE LURIGANCHO
SAN MARTIN DE PORRES
LOS OLIVOS
CALLAO
INDEPENDENCIA
RIMAC
OCEANO PACIFICO

260 259 258 257 256 255 254 253 252 251 263 262 261 264 265 266 362 361 345 350 347-2 347-1 346-2 346-1 370 369 B 369 A 368 B 368 A-1 368 A-2 351-1 351-3 351-2 349 B-2 349 B-3 349 B-4 349 A-3 349 B-1 349 A-1 348 A 348 B-1 348 B-2 349 A-2 85 C 84 A-1 85 A 85 B-1 85 B-2 84 A-2 83 A-1 213-1 213-3 213-2 84 B-1 83 A-2 84 B-2 83 B-1 212 A-2 83 B-2 212 B-2 212 A-1 212 B-1

LEGEND

PRESSURE (m.c.a) MATERIAL PIPE SECONDARY NETWORK PA

Range 2008

- RANGE: < 10
- RANGE: 10-20
- RANGE: 21-30

- AC (Asbest Cement)
- ACER (Steel)
- FOFO (Cast Iron)
- PVC (Vinyl Polychloride)

- STUDY AREA
- DISTRICT BOUNDARY
- SECTOR BOUNDARY
- ROADS
- GREEN AREA
- BLOCKS
- RIVERS
- COAST

0 0.5 1 2 km

1:50,000
Proyection: UTM
Datum: WGS-84
Zone: 18 sur

sedapal

REPUBLICA DEL PERU

SERVICIO DE AGUA POTABLE Y ALCANTARILLADO DE LIMA

JICA

GRAFICO 2.5.8-8: PRESIONES EN REDES SECUNDARIAS DE AGUA POTABLE

FIGURE 2.5.8-8: WATER PRESSURE IN THE SECONDARY NETWORKS OF POTABLE WATER

(4) Service Conditions

1) Scale of Service

According to cadastre of SEDAPAL, the Study Area contained 77,573 connections and 94,971 units of user in 2009. The population served is 398,600 inhabitants, which is equivalent to approximately 65% of the total population in the area.

In the sectors with existing networks, the coverage ratio is as high as 80% in some sectors, while there are many sectors in which the coverage ratio is between 50% and 60% or less.

2) Incidents

Events which have been counted as "incidents" are visible failures which appear as water leakage on the ground with settlement of pavement. These events cause stoppages of water supply in the surrounding area, deterioration of transportation conditions, and sometimes flooding in streets or houses.

Table 2.5.8-3 presents the number and type of incidents in the Study Area. As shown in the table, many incidents have occurred particularly at the connection points of the secondary distribution networks and at household connection pipes. No incidents in the primary pipe were reported.

It is noted that incidents in the distribution pipes are increasing rapidly year by year, though the current number is not notably high. The locations where incidents were registered between 2006 and 2009 are shown in Figures 2.5.8-9 and 2.5.8-10.

More specific situations of the incidents and their causes will be presented and analyzed in the diagnoses in items "(10) Secondary Network" and "(11) House Connections and Micrometers".

Table 2.5.8-3: Records of Incidents

Category	2006	2007	2008	2009
Secondary Pipes	0.07 km/year 53 per year	0.19 km/year 144 per year	0.23 km/year 172 per year	0.43 km/year 162 per year
Connection Joints and Pipes	2.8 km/year 2,131 per year	3.08 km/year 2,341 per year	3.22 km/year 2,448 per year	1.29 km/year 983 per year

Source: JICA Study Team

As described in 2.5.8 (11) 2) (b), the Study Team analyzed the relation between frequency of incidents and pipe age/ pipe materials by sector. However, it could not show any relation between them.

3) Service Hours

SEDAPAL has achieved continuous service for most of the Study Area. In some areas of Collique and Márquez (sector 259), however, SEDAPAL has failed to offer 24-hour service, as shown in Figure 2.5.8-11. In case of Collique, its main cause of failure is that the Chillón WTP cannot send enough water to the area during dry season. In the case of Márquez, the area is fed by a groundwater source, which sometimes cannot cover all the area´s water demand.

4) Water Pressure

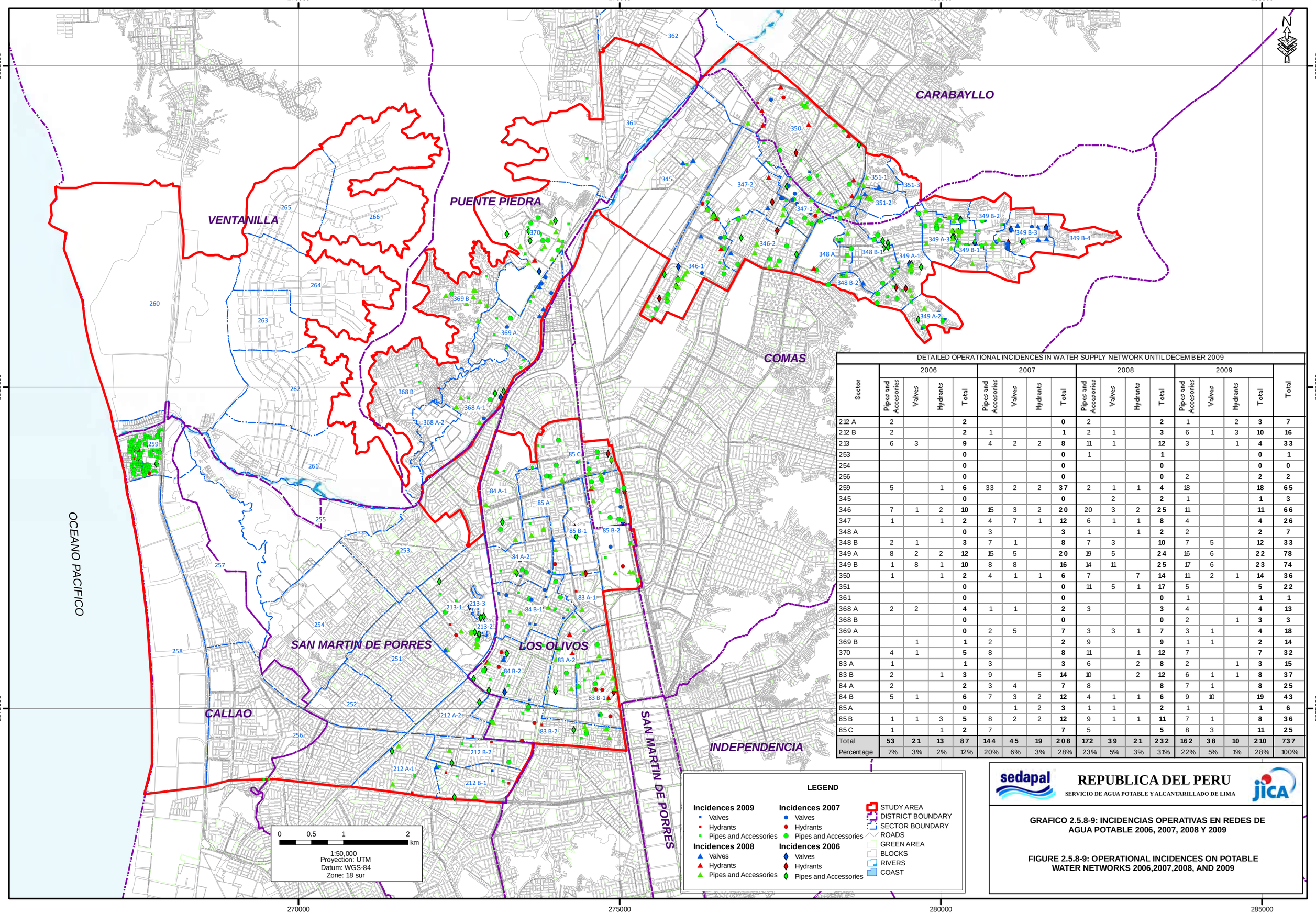
Water pressure at connections or in secondary distribution networks is not monitored in the Study Area. However, according to SEDAPAL and the feedback from local inhabitants, household water pressure tends to be unstable and sometimes it becomes too high or too low. The fluctuation of household water pressure is also supported by the data of water pressure at the entrance of existing sectors as presented in the previous item.

This issue of service pressure are caused by the following factors: i) water is mostly supplied to households not through the existing reservoirs, ii) water pressure at primary pipes is too high and unstable, iii) pressure control valves do not have enough capacity, and iv) pipe diameters of the secondary networks are not sufficient.

5) Problems of Service Conditions

Through the diagnoses above, problems of service conditions can be summarized as follows:

- Many incidents on distribution networks and connections, such as water leakage and settlement of pavement, are deteriorating living conditions of inhabitants.
- There are some areas in which 24-hour service has not been realized.
- Water pressure tends to be unstable and, in addition, it sometimes becomes too high or too low in some areas.



DETAILED OPERATIONAL INCIDENCES IN WATER SUPPLY NETWORK UNTIL DECEMBER 2009

Sector	2006				2007				2008				2009				Total
	Pipes and Accesories	Valves	Hydrants	Total	Pipes and Accesories	Valves	Hydrants	Total	Pipes and Accesories	Valves	Hydrants	Total	Pipes and Accesories	Valves	Hydrants	Total	
212 A	2			**2**				**0**	2			**2**	1		2	**3**	**7**
212 B	2			**2**	1			**1**	2	1		**3**	6	1	3	**10**	**16**
213	6	3		**9**	4	2	2	**8**	11	1		**12**	3		1	**4**	**33**
253				**0**				**0**	1			**1**				**0**	**1**
254				**0**				**0**				**0**				**0**	**0**
256				**0**				**0**				**0**	2			**2**	**2**
259	5		1	**6**	33	2	2	**37**	2	1	1	**4**	18			**18**	**65**
345				**0**				**0**		2		**2**	1			**1**	**3**
346	7	1	2	**10**	15	3	2	**20**	20	3	2	**25**	11			**11**	**66**
347	1		1	**2**	4	7	1	**12**	6	1	1	**8**	4			**4**	**26**
348 A				**0**	3			**3**	1		1	**2**	2			**2**	**7**
348 B	2	1		**3**	7	1		**8**	7	3		**10**	7	5		**12**	**33**
349 A	8	2	2	**12**	15	5		**20**	19	5		**24**	16	6		**22**	**78**
349 B	1	8	1	**10**	8	8		**16**	14	11		**25**	17	6		**23**	**74**
350	1		1	**2**	4	1	1	**6**	7		7	**14**	11	2	1	**14**	**36**
351				**0**				**0**	11	5	1	**17**	5			**5**	**22**
361				**0**				**0**				**0**	1			**1**	**1**
368 A	2	2		**4**	1	1		**2**	3			**3**	4			**4**	**13**
368 B				**0**				**0**				**0**	2		1	**3**	**3**
369 A				**0**	2	5		**7**	3	3	1	**7**	3	1		**4**	**18**
369 B		1		**1**	2			**2**	9			**9**	1	1		**2**	**14**
370	4	1		**5**	8			**8**	11		1	**12**	7			**7**	**32**
83 A	1			**1**	3			**3**	6		2	**8**	2		1	**3**	**15**
83 B	2		1	**3**	9		5	**14**	10		2	**12**	6	1	1	**8**	**37**
84 A	2			**2**	3	4		**7**	8			**8**	7	1		**8**	**25**
84 B	5	1		**6**	7	3	2	**12**	4	1	1	**6**	9	10		**19**	**43**
85 A				**0**		1	2	**3**	1	1		**2**	1			**1**	**6**
85 B	1	1	3	**5**	8	2	2	**12**	9	1	1	**11**	7	1		**8**	**36**
85 C	1		1	**2**	7			**7**	5			**5**	8	3		**11**	**25**
Total	**53**	**21**	**13**	**87**	**144**	**45**	**19**	**208**	**172**	**39**	**21**	**232**	**162**	**38**	**10**	**210**	**737**
Percentage	7%	3%	2%	12%	20%	6%	3%	28%	23%	5%	3%	31%	22%	5%	1%	28%	100%

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SERVICIO DE AGUA POTABLE Y ALCANTARILLADO DE LIMA

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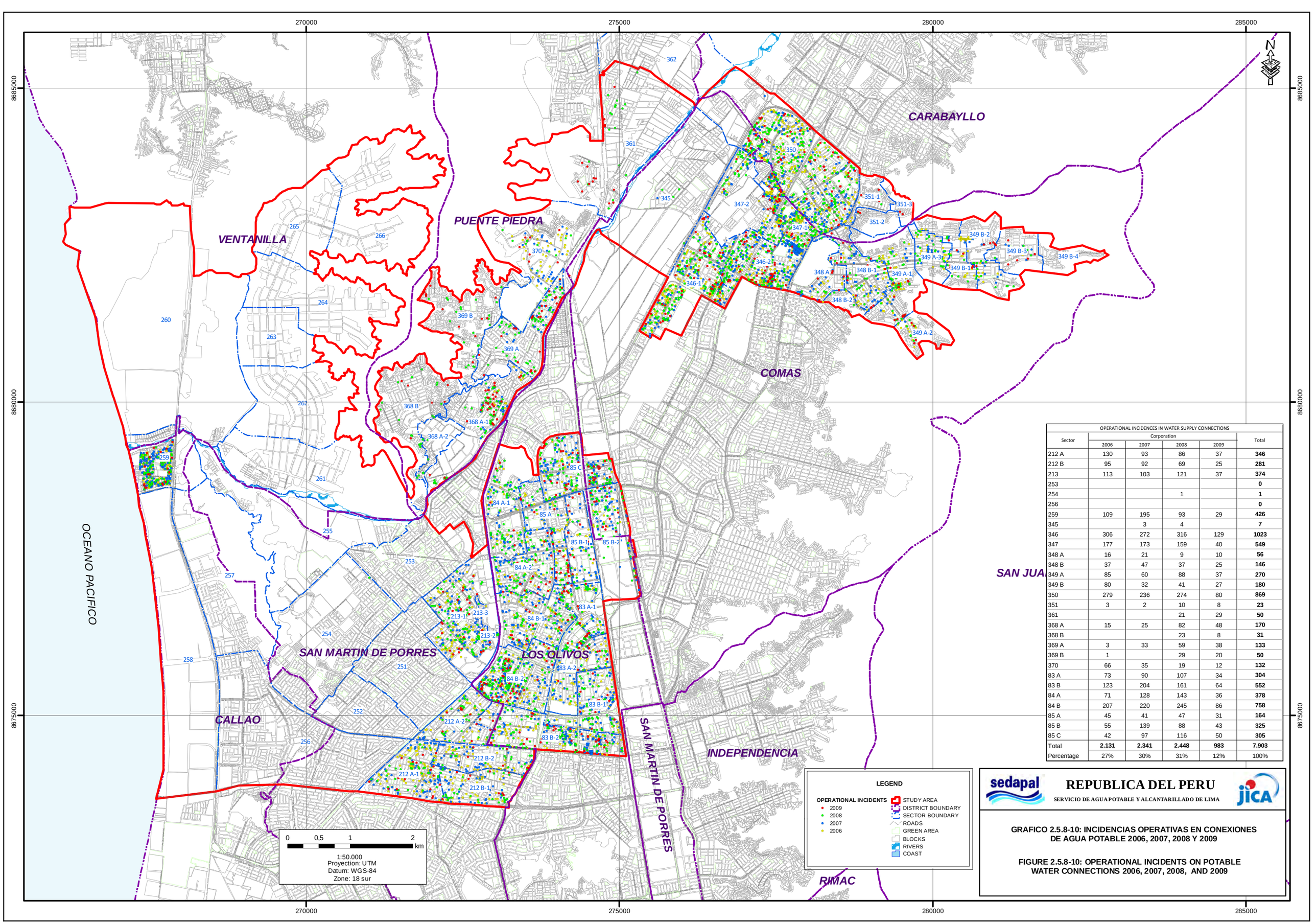
GRAFICO 2.5.8-9: INCIDENCIAS OPERATIVAS EN REDES DE AGUA POTABLE 2006, 2007, 2008 Y 2009

FIGURE 2.5.8-9: OPERATIONAL INCIDENCES ON POTABLE WATER NETWORKS 2006,2007,2008, AND 2009



OPERATIONAL INCIDENCES IN WATER SUPPLY CONNECTIONS

Sector	Corporation				Total
	2006	2007	2008	2009	
212 A	130	93	86	37	**346**
212 B	95	92	69	25	**281**
213	113	103	121	37	**374**
253					**0**
254			1		**1**
256					**0**
259	109	195	93	29	**426**
345		3	4		**7**
346	306	272	316	129	**1023**
347	177	173	159	40	**549**
348 A	16	21	9	10	**56**
348 B	37	47	37	25	**146**
349 A	85	60	88	37	**270**
349 B	80	32	41	27	**180**
350	279	236	274	80	**869**
351	3	2	10	8	**23**
361			21	29	**50**
368 A	15	25	82	48	**170**
368 B			23	8	**31**
369 A	3	33	59	38	**133**
369 B	1		29	20	**50**
370	66	35	19	12	**132**
83 A	73	90	107	34	**304**
83 B	123	204	161	64	**552**
84 A	71	128	143	36	**378**
84 B	207	220	245	86	**758**
85 A	45	41	47	31	**164**
85 B	55	139	88	43	**325**
85 C	42	97	116	50	**305**
Total	**2.131**	**2.341**	**2.448**	**983**	**7.903**
Percentage	27%	30%	31%	12%	100%

REPUBLICA DEL PERU

SERVICIO DE AGUA POTABLE Y ALCANTARILLADO DE LIMA

GRAFICO 2.5.8-10: INCIDENCIAS OPERATIVAS EN CONEXIONES DE AGUA POTABLE 2006, 2007, 2008 Y 2009

FIGURE 2.5.8-10: OPERATIONAL INCIDENTS ON POTABLE WATER CONNECTIONS 2006, 2007, 2008, AND 2009

270000 275000 280000 285000

8685000 8680000 8675000

CARABAYLLO
PUENTE PIEDRA
VENTANILLA
COMAS
SAN JUAN DE LURIGANCHO
SAN MARTIN DE PORRES
LOS OLIVOS
CALLAO
INDEPENDENCIA
RIMAC
OCEANO PACIFICO

362 361 350 345 347-2 347-1 351-1 351-3 351-2 349 B-1 349 B-2 349 B-3 349 B-4 349 A-3 349 A-1 349 A-2 348 A 348 B-1 348 B-2 346-2 346-1 265 266 370 264 260 263 369 B 369 A 262 368 B 368 A-1 368 A-2 259 261 255 253 257 85 C 84 A-1 85 A 85 B-1 85 B-2 84 A-2 213-1 213-3 213-2 84 B-1 83 A-1 254 258 251 83 A-2 84 B-2 83 B-1 252 212 A-2 256 83 B-2 212 B-2 212 A-1 212 B-1

N

LEGEND

SUPPLY HOURS	
3 Hours	STUDY AREA
5 Hours	DISTRICT BOUNDARY
7 Hours	SECTOR BOUNDARY
8 Hours	ROADS
12 Hours	GREEN AREA
24 Hours	BLOCKS
	RIVERS
	COAST

0 0.5 1 2 km

1:50,000
Proyection: UTM
Datum: WGS-84
Zone: 18 sur

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GRAFICO_2.5.8-11: CONTINUIDAD DE SERVICIO

FIGURE_2.5.8-11: SERVICE CONTINUITY

(5) Potable Water Sources

Water sources used in the Study area include surface waters from the Rímac River (La Atarjea Water Treatment Plant: La Atarjea WTP), the Chillón river (Chillón Water Treatment Plant: Chillón WTP), and groundwater from the aquifers in the Rímac and Chillón Valleys.

1) Surface water

(a) Rímac River

The Rimac River is the source of the La Atarjea WTP.

Due to the topographic and hydraulic characteristics of the water supply system in the Study Area, the La Atarjea WTP supplies the districts of Los Olivos and San Martín de Porres, as well as the southern and eastern parts of the Comas district.

(b) Chillón River

The Chillón River is the source of the Chillón WTP. The WTP is supplying the produced water to the northern part of the Study Area, which includes the districts of Puente Piedra, Comas and Carabayllo.

2) Groundwater

The current groundwater source includes the Rímac and Chillón aquifers that are fed from the seepages coming through both the river beds.

SEDAPAL extracts groundwater from 333 wells that are located in the Metropolitan Lima area. It jointly uses surface water and groundwater sources for supply purposes, and this contributes to the ground water preservation and recovery. Within the Study Area there are 72 wells are located.

(6) Potable Water Production

1) Existing Water Treatment Plants

The Table 2.5.8-4 shows water production in millions of m^3 from 2006 to 2009, according to the available surface water and groundwater supply sources for the city of Lima.

Table 2.5.8-4: Capacity and Actual Production of WTPs and Wells of SEDAPAL

Facility		Capacity		Actual Production						
				Annual (million m^3/year)					Average	
		(m^3/s)	(m^3/day)	2004	2005	2006	2007	2008	(m^3/s)	(m^3/day)
WTP	La Atarjea WTP	17.5	1,512,000	433.7	500.4	504.8	519.9	502.8	15.61	1,348,704
	Chillón WTP	2.5	216,000	18.0	18.0	20.7	25.3	22.6	0.66	57,024
	Total	20.0	1,728,000	451.7	518.4	525.5	545.2	525.4	16.27	1,405,728
Wells	Wells of Chillón	-	-	22.3	22.6	21.3	19.2	20.4	0.67	57,888
	Other Wells	-	-	152.2	120.8	118.1	86.4	113.0	3.74	323,136
TOTAL			-	626.2	661.8	664.9	650.8	658.8	20.68	1,786,752

Source: 2009 Annual Memoir and SEDAPAL

(a) La Atarjea Water Treatment Plant

The La Atarjea Water Treatment Plant (La Atarjea WTP) has two intakes, and their intake capacities are 15 and 20 m^3/s. Water treatment is carried out at 2 plants in the WTP, with a total combined capacity of 17.5 m^3/s.

(b) Chillón Water Treatment Plant

The Chillón Water Treatment Plant (Chillón WTP) was built between the years 2000 and 2002, and it is currently being operated by the Italian Agua Azul Consortium S.A., under BOT (Build, Operate, and Transfer) for a 25–year-period. The Chillón WTP has a nominal capacity of 2.5 m^3/s during the flood season.

In the dry season, the Chillón WTP does not operate well due to insufficient river flow; therefore, water to its distribution area is supplied by 28 wells located in the Punchauca area which have a total capacity of 1 m^3/s.

The Chillón WTP is expected to supply water to a target area of the project known as the "Potable Water and Sewerage System Extension and Enhancement for the Pachacutec Macro Project-Ventanilla District".

2) Enhancement of Chillón WTP, Construction of Huachipa WTP

(a) Necessity of Enlargement of Production Capacity

As described above, water is currently supplied to the Study Area by the two WTPs and by wells. However, SEDAPAL is facing some difficulties in water production. The main problems with water production can be summarized as follows:

- In the dry season, production of the Chillón WTP is not enough to meet the demand in its distribution area because of insufficient flow of the river.
- Apart from low flow in the dry season, the total current capacity of water production has been evaluated and found insufficient to meet the future demand.
- There are dozens of wells in the North Lima Area apart from the wells of Chillón, and this underground water is expected to supplement the lack of water supply, especially during dry season. However, many of the wells have problems with low water quality. (Concentration of NO_3 and NO_2 tend to be higher than drinking water standards.)

(b) Construction Plan

In order to solve or mitigate the problems above, SEDAPAL is constructing the Huachipa WTP under the "Huachipa Water Treatment Plant Project-Lima North Main," funded by JICA. In addition, SEDAPAL has planned some other projects to increase water production, and they have announced their intention to execute some of the projects in the "2009 Master Plan" (Plan Maestro 2009) as shown below:

Table 2.5.8-5: Outline of the Projects for Production Mentioned in the 2009 Master Plan

Project		Outline				Remarks
		Capacity		Progress	Schedule of completion	
		(m^3/s)	(m^3/day)			
Huachipa WTP	Phase-1	5.0	432,000	Recently completed	2010	To send water to the North Lima Area
	Phase-2	5.0	432,000	Master Plan	2021	To send water to the South Lima Area
Chillón WTP	Gangay Reservoir Project	-	-	Master Plan	-	To achieve stable production of 2.0m^3/s.
La Atarjea WTP	Blanco River Project (Marca II)	4.0	345,600	Master Plan	-	To divert water from the Yauli River basin to the Rimac River basin
Lima South Water Project			100,224	Master Plan	Master Plan	-

Source: JICA Study Team

(c) Huachipa Water Treatment Plant

The Huachipa Water Treatment Plant (Huachipa WTP) is located in the Lurigancho district. It has 18.73 ha of area at an elevation of 396 m.a.s.l. Its water source is the Rímac River, similar to the La Atarjea WTP, but it is located upstream of the La Atarjea WTP.

Construction is planned in two phases. The capacity of the WTP shall be 5.0m^3/s in the first phase, and it will be enhanced to 10.0m^3/s after the second phase.

The first phase is being executed through the JBIC PE-P30 loan, and was completed in 2010. The second phase is scheduled to be completed in 2021, according to 2009 Master Plan. In the first phase, the plant will supply water to the North Lima Area, including the areas of the Lima Norte I Project and the Lima Norte II Project. In the second phase, the plant will supply water to the South Lima area.

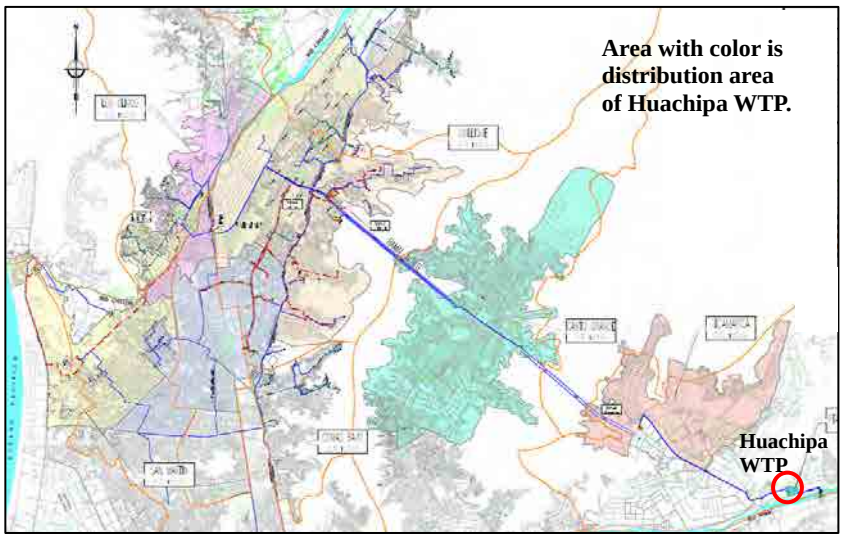
The distribution area of the Huachipa WTP (Phase-1) is illustrated in Figure 2.5.8-12. The distribution area covers project areas of Lima Norte I and Lima Norte II, to which the La Atarjea WTP and the Chillón WTP are currently supplying water. Table 2.5.8-6 presents sectors in the Study Area to be supplied by the Huachipa WTP, which is to be called the "Influence Area" in this Study.

(d) Risk of Water Production in Dry Season

It is noted that there is no comprehensive master plan of SEDAPAL currently exists to explain and present a clear vision on future water production, especially in the dry season, for their entire administration area.

The Huachipa WTP is planned to supply water to its command area, which will reduce the required amount from the Chillón WTP and the La Atarjea WTP, but there are also expansion projects of water supply networks by which the distribution areas of the Chillón and La Atarjea WTPs will be expanded. However, there is no explanation in SEDAPAL

master plan whether the Chillón WTP and the La Atarjea WTP will be able to satisfy the increasing demand in their expanded distribution areas. This implies that the Huachipa WTP may have to supply water to some areas outside of its planned distribution area in dry season, and supply capacity to the distribution area may be lowered. Therefore, it is necessary to take into account that the distribution area of Huachipa, not only the distribution area of Chillón WTP, can be affected by drought. This risk will be reduced after construction of water transfer project of Huascachocha – Rimac Deviation, by which Rimac river flow will be increased and additional water will be treated in Huachipa Water Treatment Plant; it will be distributed through the North Main Pipe.



Source: "Huachipa Water Treatment Plant Project-Lima North Main" and JICA Study Team

Figure 2.5.8-12: Distribution Area of Huachipa WTP

Table 2.5.8-6: Sectors to be covered by the Huachipa WTP in the Study Area (Distribution Area of Huachipa WTP)

District	Sectors
Callao	256, 258, 259
Ventanilla	260,261,262,263,264,265,266
Carabayllo	350, 351
Comas	345, 346, 347, 348A, 348B, 349A, 349B
Los Olivos	83A, 83B, 84A, 84B, 85A, 85B, 85C
Puente Piedra	361, 368A, 368B, 369A, 369B, 370
S.M de Porres	212A, 212B, 213, (251, 252)*, 253, (254, 257)* *, 255
Total Number	41

Source: JICA Study Team

Because of the plant´s topographic elevation, it can supply to most of the distribution areas by gravity. With this additional water, it is expected to achieve a 24-hour continuous service and a 100% coverage ratio in the distribution area. Supply by gravity from the Huachipa Plant will allow for a reduction in operation costs compared to the current pumping supply conditions.

(e) Other Construction Works

The project for the Chillón WTP is to construct the Gangay Reservoir, which will supply water to the WTP so that the WTP can consistently produce 2.0 m^3/s. It has been mentioned that the project aims at increasing production to the Carabayllo District, but the storage capacity and schedule were not mentioned.

The Marca II Project is to increase the flow of the Rímac River, which sources the La Atarjea WTP. If executed, this project will make enhancement of La Atarjea possible. The South Lima Water Project is a project to construct a desalination plant to supply water to southern area of the Province of Lima.

As for the Marca II Project and the South Lima Water Project, locations and capacities are indicated in the 2009 Master Plan, but their schedules for implementation are not mentioned.

4) Water Production Problems

Through the diagnoses above, problems of the water production can be summarized as follows:

- Existing water treatment plants (WTPs) cannot always satisfy the demand because the productions of the WTPs diminish significantly in the dry season.
- A comprehensive study on demarcation of the WTPs' distribution area is not available in SEDAPAL.

(7) Primary Networks

1) Type of Existing Pipes for Primary Networks

Primary networks are defined as transmission pipes which consist of i) main trunks which send water from water sources, ii) transmission branches which branch from the main trunks, and iii) other transmission pipes called "pumping lines" which send underground water from wells to reservoirs or superficial water from pumping chambers.

Table 2.5.8-7 shows the lengths of existing primary pipes in the Study area by sectors and materials. As presented in the table, there are four kinds of materials, which area asbestos cement pipe (AC), steel pipe (ACERO), ductile iron pipe (DI) and polyvinyl chloride pipe (PVC).

Table 2.5.8-7: Length of Existing Primary Pipeline by Sectors in the Study Area

Sector	Subsector	Type of Material				TOTAL (km)
		AC	ACERO	HD	PVC	
83 A	83 A-1			1.08		1.08
	83 A-2			1.45		1.45
83 B	83 B-1					
	83 B-2	0.35		0.81		1.16
84 A	84 A-1	0.28		0.46		0.74
	84 A-2			1.53		1.53
84 B	84 B-1			0.04		0.04
	84 B-2					
85 A	85 A	0.01		0.76		0.77
85 C	85 C			0.9		0.9
212 A	212 A-1	0.03		0.24		0.27
	212 A-2	0.01			0.01	0.02
212 B	212 B-1			1.09		1.09
	212 B-2			0.16		0.16
213	213-1			0.13		0.13
	213-2					
	213-3					
345	345			1.36		1.36
346	346-1			1.2		1.2
	346-2			1.06		1.06
347	347-1	1.18		2.08		3.26
	347-2	0.11		2.17	0.15	2.43
348 A	348 A	0.92		1.25		2.17
348 B	348 B-1	0.98		0.55		1.53
	348 B-2	0.17				0.17
349 A	349 A-1	0.29	0.15			0.44
	349 A-2					
	349 A-3					
350	350-1	0.98		3.45		4.43
	350-2	0.06		0.18		0.24
351	351-1			1.67		1.67
	351-2			0.19		0.19
	351-3			0.07		0.07
361	361			6.07	0.01	6.08
368 A	368 A-1			0.02		0.02
	368 A-2					
368 B	368 B					
369 A	369 A			1.44		1.44
370	370			2.82		2.82
TOTAL		**5.37**	**0.15**	**34.23**	**0.17**	**39.92**

Source: JICA Study Team

2) Main Trunks

In the Study Area, there are four main trunks, which are the La Atarjea – Comas main, the La Atarjea – Los Olivos main, the Chillón – Comas main, and the Chillón – Los Olivos main as shown in Table 2.5.8-8. Locations of the main trunks were illustrated in Figure 2.5.8-2. They are monitored and controlled by SCADA system.

Table 2.5.8-8: Main Trunks in the Study Area

Item	Main Trunks			
	La Atarjea – Comas Main	**La Atarjea – Los Olivos Main**	**Chillón – Comas Main**	**Chillón – Los Olivos Main**
Water Source	La Atarjea WTP	La Atarjea WTP	Chillón WTP and Wells	Chillón WTP and Wells
Distributing Sectors in the Study Area	-	83A, 83B, 84A, 84B, 85A, 85B, 85C, 212A, 212B, 213	345, 346, 347, 348A, 348B, 349A, 349B, 350, 351	361, 368A, 368B, 369A, 369B, 370
Diameter	600 to 1,600mm	450 to 800mm	600 to 800mm	500mm
Material	Ductile Iron and Pre-stressed Concrete	Ductile Iron	Ductile Iron	Ductile Iron

Source: JICA Study Team

(a) La Atarjea – Los Olivos Main and La Atarjea – Comas Main

The La Atarjea – Los Olivos main and the La Atarjea – Comas main feed water from the La Atarjea WTP to the districts in the northern area of Lima. They function as a supplement to the water from the Chillón WTP in the dry season. The La Atarjea – Comas main does not usually supply water to the Study Area, but it can supplement water when the Chillón WTP cannot produce enough water for Comas. On the other hand, the La Atarjea – Los Olivos main, which branches from the La Atarjea – Comas main, is the main line to supply water to Los Olivos in the Study Area.

The La Atarjea – Comas main starts at the outlet of Reservoir R5 and ends at Re-pumping Chamber CR-115 in the Comas district. It has a total length of 22 km, and its diameters vary between 1,600mm and 6,00mm. It is made of ductile iron (DI) and pre-stressed concrete, and it currently conveys about 5 m^3/s of flow at the initial span of 1,600mm dia.

The La Atarjea – Los Olivos main starts at the crossing between Av. Habich and Av. Alfredo Mendiola (Northern Panamerican Highway), and ends at the Trapiche – Chillón Highway, where it connects to the so-called Chillón – Los Olivos main through a control valve chamber, through Av. Carlos Izaguirre. It continues down Av. Palmeras, Calle Benavides (a street), Av. Universitaria, Av. De la Seguridad Social, Av. Huandoy, Av. Confraternidad, Calle 39 (a street), Av. Los Portales, and Av. Alfredo Mendiola (Northern Panamerican Highway). Pipe material is DI, and diameter ranges between DN 800 and 450 mm.

The La Atarjea – Los Olivos main directly supplies to the following sectors in the Study Area: original sectors 83, 84, 85, 212, and 213; and additionally, sectors 206, 79, 82, 81, 211, 121, and 86. These sectors belong to the Los Olivos district and part of the San Martín district.

(b) Chillón – Comas Main

The Chillón – Comas main branches from one of the main trunks of Chillón WTP, "Chillón Main Phase I," with a diameter of 1,200 mm. From the Chillón WTP, it runs

along Av. Túpac Amaru and ends at the CRP-2 pressure reducing chamber, where it joins the existing La Atarjea – Comas main at the CR-155 re-pumping chamber. It has a diameter ranging between 800 mm and 600 mm, a capacity of 1m^3/s, and a length of about 8.8 km. It is made of DI.

Water flow from the Chillón – Comas main is not measured, but that of the "Chillón Main Phase I" is approximately 1,000 l/s in flood season and 400 l/s during dry season.

This water main uses gravity, and it feeds the Carabayllo district and part of the Comas district, namely, the Collique and Año Nuevo areas. The main feeds sectors 345, 346, 347, 348A, 348B, 349A and 349B in the Comas district and 350 and 351 in the Carabayllo district. These are part of this study. Sector 349 is fed by sector 348 through successive re-pumping.

(c) Chillón – Los Olivos Main

The Chillón – Los Olivos main branches from one of the main trunks of the Chillón WTP, the "Chillón Main Phase II," with a diameter of 1,000 mm. From the Chillón WTP at the Northern Panamerican Highway, it runs along the Northern Panamerican Highway down to the Trapiche – Chillón highway crossing, where it joins the Los Olivos main through a DN 500 mm CDI control valve chamber.

This main also receives water from five wells: Ca-1, Ca-2, Ca-8, Ca-11, and Ca-12. Pipelines from these wells are joined to the water main through a control valve and pressure sustainer chamber. These wells supply the project area during low water seasons.

Water flow for the Chillón – Comas main is not measured, but that of the "Chillón Main Phase II" is approximately 1,500 l/s in flood season and 600 l/s during dry season.

In order to reduce pressure, the Chillón – Los Olivos main has 2 pressure reducing chambers, CRP-5 and CRP-6, and 4 major diversions.

At present, this water main supplies water to sectors 361, 362, 368A, 368B, 369A, 369B and 370 in the Puente Piedra district, which are parts of this Study's area.

3) Other Primary Pipes

Apart from the main trunks above, there are primary pipes called "transmission lines" which branch from the main trunks, and "pumping lines" which send underground water from wells to reservoirs or send water from booster pumping stations.

"Transmission lines" are made of DI. The "pumping lines", on the other hand, are made of various materials: asbestos cement piping (AC) is used for the pipeline to sector 259 (Márquez); polyvinyl chloride pipe (PVC) is used for pipelines to the high part of Collique, as well as the pumping lines from the wells (out of service) to the reservoir in the Los Olivos sector; and DI is used for pipelines to sector 350 in Carabayllo and sectors 368A, 368B, 369A and 369B in Puente Piedra.

4) Condition of Primary Network

According to the Primary Distribution Unit (Equipo de Distribución Primaria, or EDP) staff, no incidents have been reported on main trunks made of DI or on other

"transmission lines" made of DI. The AC pipeline to sector 259 is in poor condition: diversions have been made to users along its route and illegal connections might have been installed; it crosses private land; and some of its spans have been installed on the surface or at shallow depth. However, this line will not be used after the Project because new primary pipeline is planned to be installed in the Project to receive water from the Huachipa WTP.

Service pressure is not currently controlled properly in some areas because of fluctuation in the pressure of the primary network. However, the Project will solve this problem because the service pressure will be regulated by the reservoir.

5) Plan of Primary Network after commencement of the Huachipa WTP

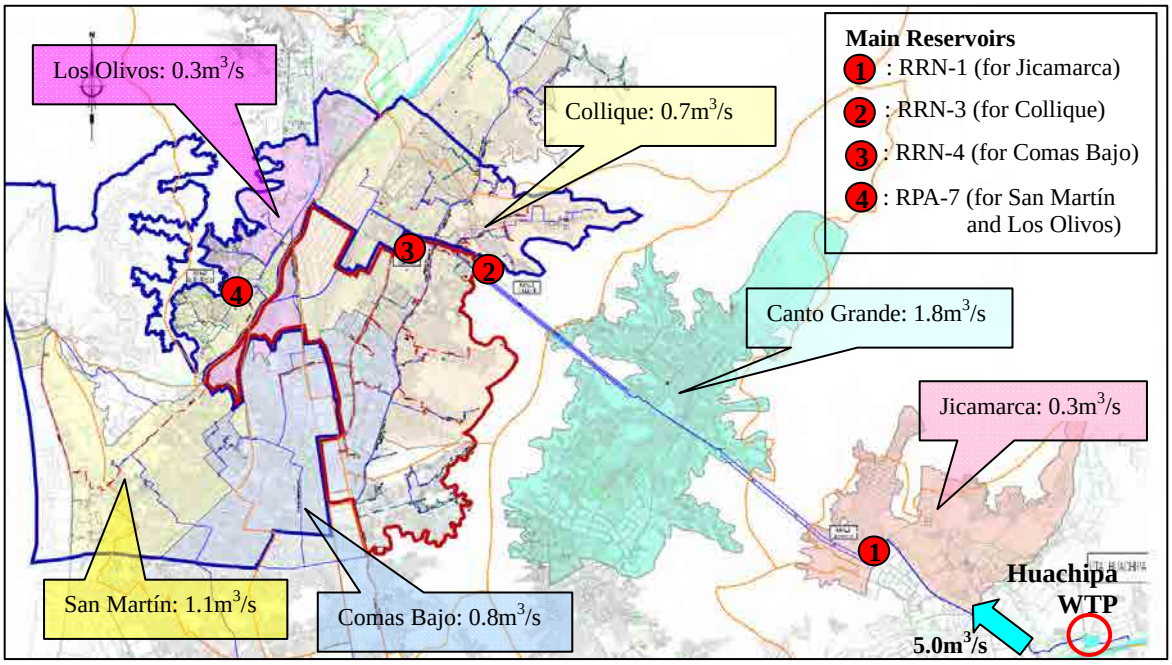
(a) General Concept in Establishing Primary Network from Huachipa WTP

After the Huachipa WTP begins operation, most of the Study Area (the Area of Influence) will receive water from the WTP. Therefore, it is necessary to restructure the existing primary network so that the WTP can send the water to the area.

In parallel with the Huachipa WTP, the construction works of the main trunk from the WTP and main reservoirs are also being executed. The primary network to the Influence Area will be established through a combination of the facilities under construction, the existing primary networks described above, and a new primary network to be constructed in the Project.

(b) Plan for Main Trunk from Huachipa WTP in "Huachipa Water Treatment Plant Project-Lima North Main"

Figure 2.5.8-13 and Table 2.5.8-9 show the water distribution plan for the Huachipa WTP in the first phase. Planned distribution to Lima Norte I and II is 2.9m^3/s in total. Water demand in each area of Lima Norte I and II is still not clear in SEDAPAL, but they can be estimated to be about 0.8 m^3/s and 2.1 m^3/s, respectively.



Source: "Huachipa Water Treatment Plant Project-Lima North Main"

Figure 2.5.8-13: Plan for Main Trunk from Huachipa WTP

Table 2.5.8-9: Planned Distribution of Water Produced at Huachipa WTP

Area	Planned Volume	Remarks
Jicamarca	0.3m^3/s	-
Canto Grande	1.8m^3/s	-
Comas Bajo	0.8m^3/s	North Lima Norte I and II
Collique	0.3 m^3/s	
Los Olivos	0.7 m^3/s	
San Martín	1.1m^3/s	Lima Norte II
Sub-total	2.9m^3/s	Lima Norte I and II
TOTAL	5.0m^3/s	-

Remarks: Water demand in the areas of North Lima I and North Lima II are not clear but can be estimated as about 0.8m^3/s and 2.1m^3/s, respectively.

Source: "Huachipa Water Treatment Plant Project-Lima North Main"

(8) Reservoirs and Pumping Stations

1) Reservoirs and Pumping Stations in the Study Area

In the Study Area, there are 63 reservoirs and 16 of them have pumping stations beside. Apart from them, there are 2 reservoirs under construction and 2 independent pumping stations. Within these, 38 reservoirs (14 of which have pumping stations) have been rehabilitated or to be rehabilitated by other projects. As for 2 of the 14 reservoirs with pumping stations, however, only reservoirs were rehabilitated and rehabilitation of their pumping stations were not carried out.

There are 23 reservoirs which are not operating but 7 of them are already or scheduled to be rehabilitated by other projects. Most of the non-operating reservoirs are located in Los Olivos (13 reservoirs) and San Martín de Porres (4 reservoirs), and none of them are scheduled to be rehabilitated. Those reservoirs were constructed to store groundwater from wells and then distribute, but now SEDAPAL is distributing water directly from La Atarjea to the area. Most of the reservoirs are not connected to the primary network from La Atarjea at present.

Table 2.5.8-10 summarizes the reservoirs and pumping stations in the Study Area. The JST appointed Consultant carried out a site survey of structure and electromechanical equipment. Survey covered the reservoirs and pumping stations for which there is no intervention planned by other projects. Results of the surveys are explained in the following, and more detailed information about the surveys is given in Appendix A4.

2) Objectives of Diagnosis and the Survey Activities

The objectives of the diagnosis are to evaluate the present conditions of the existing reservoirs and pumping stations and to recommend necessary actions so that the target facilities can recover or maintain their functions. The activities included in the diagnosis are site inspection and evaluation of i) the structures and ii) the electromechanical equipment.

The current conditions and evaluation of the controlling and operating system for the reservoirs and pumping stations is presented in diagnosis of "(11) Automation and SCADA System".

3) General Evaluation

Generally, the reservoir structures need some repairs in order to avoid any contamination of stored water and to facilitate maintenance works, though re-construction is not necessary. Regarding electromechanical equipment, for reservoirs not currently operated are required to be replaced before beginning any operations.

Table 2.5.8-10: Reservoirs and Pumping Stations in the Study Area and their Existing Conditions

District	Sector	Sub-Sector	Code/Name		With/Without Pumping Station	Volume (m^3)	Bottom Level (m)	Water Level (m)	Ground Level (m)	Type of Structure	Condition	Other Planned Projects to Intervene	
												Project*	Status of the Project
Los Olivos	83A	83A-1	R-800	VILLA SOL R-1	without	1300	97,00	103,00	74,66	Elevado	RESERVA	-	-
		83A-2	R-801	VILLA DEL NORTE R-1	without	1800	99,08	105,08	68,58	Elevado	RESERVA	-	-
	83B	83B-1	R-996	PARQUE DEL NARANJAL R-1	without	1400	89,70	101,00	63,50	Elevado	RESERVA	-	-
		83B-2	-	CUETO FERNANDINI R-1	without	1500	82,50	87,50	58,90	Elevado	RESERVA	-	-
	84A	84A-1	-	OLIVOS DE PRO R-1	without	1500	128,10	135,05	128,10	Apoyado	RESERVA	-	-
		84A-2	-	PROGRAMA CONFRATERNIDAD R-2	without	1600	99,50	107,95	78,50	Elevado	RESERVA	-	-
	84B	84B-1	-	PROGRAMA CONFRATERNIDAD R-1	without	1600	97,25	105,50	71,00	Elevado	RESERVA	-	-
		84B-2	-	COMITÉ APOSTE	without	500	85,71	90,51	59,35	Elevado	RESERVA	-	-
			-	PATRIA NUEVA R-1	without	70	97,20	100,70	87,00	Elevado	OPERATIVO	-	-
	85A	85A	R-805	PUERTA DE PRO R-1	without	1100	109,70	117,70	109,70	Apoyado	RESERVA	-	-
	85B	85B-1	-	RIO SANTA R-1	without	570	106,50	112,00	88,50	Elevado	RESERVA	-	-
		85B-2	R-997	PRO (shared with 85C)	without	1900	128,04				RESERVA	-	-
		85B-3	R-802	SANTA LUISA R-1	without	500	114,64	121,64	93,49	Elevado	RESERVA	-	-
	85C	85C	R-997	PRO (shared with 85B-2)	without	1900	128,04				RESERVA	-	-
SAN MARTIN DE PORRES	212A	212A-1	R-986	VIRGEN DE LAS NIEVES R-4	without	1500	64,85	69,85	32,25	Elevado	RESERVA	-	-
		212A-2	-	VIRGEN DEL ROSARIO R-1	without	1200	67,85	72,35	48,85	Elevado	RESERVA	-	-
	212B	212B-1	-	ROSARIO DEL NORTE R-3	without	1200	66,90	71,70	44,90	Elevado	RESERVA	-	-
		212B-2	-	JAZMINES DE NARANJAL R-2	without	1200	65,70	70,20	46,70	Elevado	RESERVA	-	-
	213	213-1	CR-243	VIPOL NARANJAL R-1	WITH	1900	96,00	102,00	-	Apoyado	OPERATIVO	-	-
		213-2	-	CERRO EL CHOCLO R-2	without	100	101,00	104,85	81,00	Elevado	OPERATIVO	-	-
		213-3	-	CERRO EL CHOCLO R-1	without	100	115,00	118,85	100,00	Elevado	OPERATIVO	-	-
CALLAO	259	259	R-522	MARQUEZ R-522	without	1200	36,00	42,50	-	Apoyado	OPERATIVO	-	-
COMAS	345	345	-	ALAMEDA DEL PINAR R-1	without	1300	177,00	183,25	150,00	Elevado	OPERATIVO	B	Being executed
	346	346-1	-	El Manantial R-1	without	1100	140,80	143,70	-	Apoyado	INOPERATIVO	A	Being executed
			-	El Manantial R-2	without	1100	140,80	143,70	-	Apoyado	INOPERATIVO	A	Being executed
		346-2	-	EL PINAR R-1	without	1200	184,65	192,05	150,00	Elevado	OPERATIVO	B	Being executed
CARABAYLLO	347	347-1	R-918	SAN FELIPE R-1	without	670	200,34	207,39	-	Apoyado	OPERATIVO	B	Being executed
		347-2	-	LA ALBORADA R-2	without	1200	185,97	192,77	162,97	Elevado	OPERATIVO	B	Being executed
			-	ALBORADA R-1	without	1200	186,25	192,05	155,15	Elevado	OPERATIVO	B	Being executed
COMAS	348	348A	R-921	COLLIQUE R-1	WITH	1100	218,00	-	-	Apoyado	OPERATIVO	B	Being executed
		348B-1	R-922	COLLIQUE R-2	WITH	1500	248,00	-	-	Apoyado	OPERATIVO	B and E	Being executed
		348B-2	RE-01	RE-01	without	100					OPERATIVO	B	Being executed
	349	349A-1	R-923	COLLIQUE R-3	WITH	1100	276,00	281,50	276,00	Apoyado	OPERATIVO	B	Being executed
		349A-2	CR-76**	Cisterna	-						OPERATIVO	-	-
			R-927	NVA. ESPERANZA R-1	without	400	340,00	344,00	340,00	Apoyado	OPERATIVO	-	-
		349A-3	R-924	COLLIQUE R-4	WITH	1000	307,00	312,87	-	Apoyado	OPERATIVO	B	Being executed
		349B-1	R-925	COLLIQUE R-5	WITH	800	340,00	347,18	340,00	Apoyado	OPERATIVO	E	Being executed
		349B-2	R-926	COLLIQUE R-6	WITH	800	370,00	376,56	370,00	Apoyado	OPERATIVO	-	-
		349B-3	R-820	COLLIQUE R-7	without	550	430,00	434,70	430,00	Apoyado	OPERATIVO	-	-
		-	-	COLLIQUE R-8	without	100				Apoyado	OPERATIVO	F	Executed (2009)
CARAB/ COMAS	350	350-1	R-934	SANTA ISABEL R-1	WITH	1400	197,72	203,22	-	Apoyado	OPERATIVO	B	Being executed
		350-2	R-935	SANTA ISABEL R-2	WITH	1500	197,84	203,40	-	Apoyado	OPERATIVO	B	Being executed
CARABAYLLO	351	351-1	RP-1	LOS ANGELES R-1	without	400	225,00	230,30	-	Apoyado	OPERATIVO	B	Being executed
			RP-02	LOS ANGELES R-2	without	150	280,00	283,90	-	Apoyado	OPERATIVO	G	Executed (2006)
		351-2	RP-3	LOS ANGELES R-3	without	100	315,00	319,00	-	Apoyado	OPERATIVO	-	-
		351-3	RP-4	LOS ANGELES R-4	without	100	280,00	283,00	-	Apoyado	OPERATIVO	-	-
PTE. PIEDRA	361	361	R-RP-1	LA CAPITANIA PAMPA GALLINAZO RP-1	without	1000	195,00	200,00	-	Apoyado	RESERVA	C	Being executed
	368	368A-1	RPA-6	RPA-6	WITH	2000	130	136,4	-	Apoyado	OPERATIVO	D	Executed (2008)
		368A-2	RPA-1	RPA-1	without	500	116	122,4	-	Apoyado	OPERATIVO	D	Executed (2008)
			CR-2**	Cisterna	-	30			262,6		OPERATIVO	D	Executed (2008)
		368B	RPA-2	RPA-2	WITH	1500	160	167,65	-	Apoyado	OPERATIVO	D	Executed (2008)
		368B	R-820	RP-17	without	100	190,00	193,55	-	Apoyado	OPERATIVO	D	Executed (2008)
		368B	R-924	RPA-5	without	150	260,00	263,9	-	Apoyado	OPERATIVO	D	Executed (2008)
		368B	R-925	RPA-4	WITH	200	225,00	228,9	-	Apoyado	OPERATIVO	D	Executed (2008)
		368B	R-926	RPA-3	WITH	600	190,00	196,4	-	Apoyado	OPERATIVO	D	Executed (2008)
		368B	RP-16	RP-16	without	100	225	228,55	-		OPERATIVO	D	Executed (2008)
	369	369A	RPA-17	RPA - 17	WITH	3000	168	175,3	-	Apoyado	OPERATIVO	D	Executed (2008)
		369B	R-1	LADERAS DE CHILLON R-1	without	400	165,00	169,00	-	Apoyado	OPERATIVO	D	Executed (2008)
		369B	R-2	LADERAS DE CHILLON R-2	WITH	200	196,00	199,00	-	Apoyado	OPERATIVO	D	Executed (2008)
		369B	R-3	LADERAS DE CHILLON R-3	without	100	226,00	228,50	-	Apoyado	INOPERATIVO	D	Executed (2008)
		369B	RP-11	RP-11	WITH	100	226,00	228,50	-	Apoyado	OPERATIVO	D	Executed (2008)
		369B	RP-12	RP-12	without	250	263,50	268,50	-	Apoyado	OPERATIVO	D	Executed (2008)
	370	370	-	SHANGRILA R-1	without	500	164,50	168,00	-	Apoyado	INOPERATIVO	C	Being executed
			-	SHANGRILA R-2	without	500	-	-	-	Apoyado	INOPERATIVO	H	Perfil
COMAS	-	-	RRN-3	Reservorio Collique	without	4000	340,00			Apoyado	Under Construction	B	Being executed
	-	-	RRN-4	Reservorio Comas Bajo	without	4000	155,00			Apoyado	Under Construction	B	Being executed
SAN MARTIN DE PORRES	-	-	RP-2	Cerro Oquendo	without	5000	72,50	79,70	-	Apoyado	INOPERATIVO	B	Being executed
	-	-	RP-1	Cerro Candela	without	5000	86,50	93,70	-	Apoyado	INOPERATIVO	B	Being executed

* : A: Proyecto de optimizacion del suministro del agua potable y alcantarillado de Lima Norte (I), "Lima Norte I"
B: Proyecto de Mejoramient Sanitario de las Areas Marginales de Lima Convenio de Prestamo Nº PE-30, Obras complementarias a los Lote 1, 2 y 3
C: Proyecto de Mejoramient Sanitario de las Areas Marginales de Lima Convenio de Prestamo Nº PE-30, Lote 7: Obras Redes Secundarias de Agua Potable y Alcantarillado del Sitrito de Puente Piedra
D: Proyecto de Mejoramient Sanitario de las Areas Marginales de Lima Convenio de Prestamo Nº PE-30, Lote 10: Distrito de Puente Piedra, Obras Redes Secundarias de Agua Potable y Alcantarillado Esquemas Jardines Valle Chillon - La Ensenada - Asoc. De Vivienda Chillon
E: Proyecto de Rehabilitacion de Reservorios y Cisternas dentro del Ambio del Centro de Servicios Comas
F: Contrato de Obra Nº 023-2007-CW-3196-BIRF-SEDAPAL Ampliacion de redes de agua potable y alcantarillado mediente sistemas condominiales en diversos del Cono Norte, Paquete 2
G: L. P. Nº 0002-2005-CO-SEDAPAL Ampliacion y Mejoramiento de los Sistemas de Agua Potable y Alcantarillado del Esquema los Angeles, Casuarinas y Anexos del Distrito de Carabayllo
H: Elaboracion del Estudio del Perfil del Proyecto de Ampliacion y Mejoramiento del System de Agua Potable y Alcantarillado del Esquema Cerro Las Animas y Anexos
**: Independent pumping station

Source: JICA Study Team

4) Structural Conditions

(a) Introduction

A survey has been carried out in the Study to evaluate the current structural conditions of the existing reservoirs and pumping stations, determine whether the structures need re-construction or not, and propose necessary rehabilitation works. Diagnosis of the structures consists of evaluation of the main structures and their accessories so that proposal on rehabilitations can be made. Details of the diagnosis with pictures can be found in Appendix A4.

(b) Survey of Existing Structural Condition of Reservoir an Pumping Stations

In general, the structural survey did not find any serious damage on the structures or deterioration caused by permanent load, impact load, earthquake load, corrosion, or ground subsidence. Although some exposed and oxidized reinforcement and chipped concrete on some reservoirs, and some shrinkage cracks on every reservoir were observed, it was evaluated that these would not deteriorate the structural strength of the facilities and that they could be rehabilitated by conventional methods of repairing concrete structures.

(c) Proposal for Structure of Reservoirs and Pumping Stations

Considering that there found no serious damage and that the structures were constructed in 1980s or 1990s, all facilities are evaluated that they do not need reconstruction but rehabilitation is required to bring them into a proper operating condition and prolong their service lives.

Required rehabilitation will include repair of cracks, repair of exposed reinforcement and chipped concrete, interior water proofing of the tank, reinstallation of ladders for maintenance, exterior painting of reservoirs, constructing concrete pits for drain and overflow of the reservoirs and other accessories. In addition, pumping stations need rehabilitation such as repair of cracks and painting.

In the detailed design of the Project, the following activities are recommended to be implemented in order to detect the current function of the reservoirs and secure their continuous operation.

- Operational test of the reservoirs by filling the tanks with water (All reservoirs should be checked.)
- Detailed visual structure survey by which cracks (location and width) and other damages of the structures are to be detected in detail
- Detailed physical structural survey such as laboratory test of concrete strength with sample cores, check of bar arrangement by ladder, geotechnical survey, modeling of the structures and structural calculation for the reservoirs (Target facilities can be selected based on their scale and age.)
- Detailed design of rehabilitation works based on the result of visual structure survey
- Plan of strengthening method if the structural calculation find the necessities

5) Electromechanical Conditions

(a) Introduction

A field survey has been carried out in the Study to evaluate the current electromechanical equipment used in the reservoirs for the water supply and to identify any limitations.

The previous study (Perfil) of this Project identified that electromechanical components of 30 reservoirs and 5 pumping stations could be used, either in their current state or after rehabilitation. Under the current Study, the rehabilitation of 23 wells, 27 reservoirs and 4 pumping stations are defined. In table 2.5.8-11 the hydraulic installations to be rehabilitated are shown.

List of conditions of the electromechanical facilities is mentioned as following:

- Discharging pipes

  Within 27 reservoirs taken into account, 22 of them have no discharging pipes installed. Only 5 reservoirs have discharging pipes already installed, but their outlet sluice valves do not have enough capacity as for SCADA system integration. Besides, macro-meters do not have necessary technology to be monitored by the SCADA system.

- Electrical panel

  No reservoirs have power electric panel for valve control by actuator or SCADA system.

- Altitude valve

  Only 5 reservoirs have altitude valves.

- Chlorination system

  No reservoir has chlorination system

Table 2.5.8.11 List of Reservoirs to be Rehabilitated

Number	District	Sector	Sub-Sector	Code	Code/Name
1	Los Olivos	83A	83A-1	R-800	VILLA SOL R-1
2			83A-2	R-801	VILLA DEL NORTE R-1
3		83B	83B-1	R-996	PARQUE DEL NARANJAL R-1
4			83B-2	R1	CUETO FERNANDINI R-1
5		84A	84A-1	R1	OLIVOS DE PRO R-1
6			84A-2	R2	PROGRAMA CONFRATERNIDAD R-2
7			84B-1	R1	PROGRAMA CONFRATERNIDAD R-1
8		84B	84B-2	R1	COMITÉ APOSTE
9				-	PATRIA NUEVA R-1
10		85A	85A	R-805	PUERTA DE PRO R-1
11			85B-1	-	RIO SANTA R-1
12		85B	85B-2	R-997	PRO
13			85B-3	R-802	SANTA LUISA R-1
14	SAN MARTIN	212A	212A-1	R-986	VIRGEN DE LAS NIEVES R-4
15	DE PORRES		212A-2	-	VIRGEN DEL ROSARIO R-1
16		212B	212B-1	-	ROSARIO DEL NORTE R-3
17			212B-2	-	JAZMINES DE NARANJAL R-2
18			213-1	CR-243	VIPOL NARANJAL R-1
19		213	213-2	-	CERRO EL CHOCLO R-2
20			213-3	-	CERRO EL CHOCLO R-1
21	CALLAO	259	259	R-522	MARQUEZ R-522
22	CALLAO	259		R-1	OQUENDO
23	COMAS	349		R-927	NVA. ESPERANZA R-1
24			349B-1	R-820	COLLIQUE R-7
25			349B-2	R-926	COLLIQUE R-6
26	CARABAYLLO	351	351-2	RP-3	LOS ANGELES R-3
27			351-3	RP-4	LOS ANGELES R-4

Source: JICA Study Team

In Table 2.5.8-12, the summary of the electromechanical facilities conditions of reservoirs is shown.

Diagnosis on physical facilities and the operation conditions was based on pictures taken and interviews made with the field personnel. Details are shown in Annex A6.

Table 2.5.8-12 Electromechanical Facilities Conditions of Reservoirs

Number	Code	Name	Diameter mm	Flow lps	Volume m^3	Type	Condition	Electromechanical Accessories	Control Panel	Altitude Valve	Chlorination System
1	R-800	VILLA SOL R-1	200	53,04	1300	Elevated	For emergency	Operable	Operable	Operable	No
2	R-801	VILLA DEL NORTE R-1	250	97,63	1800	Elevated	For emergency	Operable	Non operable	Operable	Without equip
3	R-996	PARQUE DEL NARANJAL R-1	250	89,45	1400	Elevated	For emergency	Operable	Non operable	Operable	Without equip
4	R1	CUETO FERNANDINI R-1	300	162,03	1500	Elevated	For emergency	Non operable	Non operable	Non operable	Without equip
5	R1	OLIVOS DE PRO R-1	300	79,76	1500	Not elevated	For emergency	Without equip	Without equip	Without equip	Without equip
6	R2	PROGRAMA CONFRATERNIDAD R-2	250	77,64	1600	Elevated	For emergency	Without equip	Without equip	Without equip	Without equip
7	R1	PROGRAMA CONFRATERNIDAD R-1	250	100,69	1600	Elevated	For emergency	Without equip	Without equip	Without equip	Without equip
8	R1	COMITÉ APOSTE				Elevated	For emergency				
9	-	PATRIA NUEVA R-1				Elevated	For emergency				
10	R-805	PUERTA DE PRO R-1	300	92	1100	Not elevated	For emergency	Without equip	Without equip	Non operable	Without equip
11	-	RIO SANTA R-1	200	50,51	570	Elevated	For emergency	Without equip	Without equip	Without equip	Without equip
12	R-997	PRO				Elevated	For emergency				
13	R-802	SANTA LUISA R-1	250	76,12	500	Elevated	For emergency	Operable	Operable	Operable	Without equip
14	R-986	VIRGEN DE LAS NIEVES R-4	250	106,43	1500	Elevated	For emergency	Without equip	Without equip	Without equip	Without equip
15	-	VIRGEN DEL ROSARIO R-1	300	79,26	1200	Elevated	For emergency	Without equip	Without equip	Without equip	Without equip
16	-	ROSARIO DEL NORTE R-3	250	87,51	1200	Elevated	For emergency	Without equip	Without equip	Without equip	Without equip
17	-	JAZMINES DE NARANJAL R-2	250	77,71	1200	Elevated	For emergency	Without equip	Without equip	Without equip	Without equip
18	CR-243	VIPOL NARANJAL R-1	300	121,2	1500	Not elevated	Operable	Without equip	Without equip	Without equip	Without equip
19	-	CERRO EL CHOCLO R-2	100	4,6	1200	Elevated	Operable	Without equip	Operable	Without equip	Without equip
20	-	CERRO EL CHOCLO R-1	100	2,2	1200	Elevated	Operable	Operable	Operable	Operable	Without equip
21	R-522	MARQUEZ R-522				Elevated	Operable	Without equip			
22	R-927	NVA. ESPERANZA R-1	150	18,1	400	Not elevated	Operable	Without equip	Operable	Operable	Without equip
23	R-1	OQUENDO	350		400	Not elevated	For emergency	With equipment			
24	R-820	COLLIQUE R-7	200	34	550	Not elevated	Operable	Without equip	Without equip	Without equip	Without equip
25	R-926	COLLIQUE R-6	250	29,8	800	Not elevated	Operable	Without equip	Without equip	Without equip	Without equip
26	RP-3	LOS ANGELES R-3	200	14,48	100	Not elevated	Operable	Without equip	Without equip	Without equip	Without equip
27	RP-4	LOS ANGELES R-4	200	15,93	100	Not elevated	Operable	Without equip	Without equip	Without equip	Without equip

Source: JICA Study Team

1 Electromechanical Equipments in General – Valve Included with Actuator and Accessories

2 Automatic Control Panel

3 Altitude Control Valve

4 Chlorination System Incluyes Injection Pump, Leakage Detector and Waste Chlorine Analyzer

In Table 2.5.8.13 the pumping station to be rehabilitated are shown.

Table 2.5.8.13 Pumping Stations

Number	Code	Name
1	CR-243	VIPOL NARANJAL R-1
2	CR-76	CISTERNA
3	CR-96	COLLIQUE R-5
4	CR-97	COLLIQUE R-6

Source: JICA Study Team

(b) Survey of Existing Condition of Electromechanical Equipment

Field visits were conducted for visual inspection in order to evaluate the facilities' physical and operational conditions (i.e., operational or non-operational). In case of non-operational status, an investigation was made to determine the reasons. In addition, interview surveys were carried out with the operators. During those field visits, pictures were taken to document the physical conditions of the visually inspected facilities.

Existing electromechanical facilities are as following:

- Motor-Pump Equipment

  Existing motor pump equipments are older than their operational life.

- Discharge pipes

  Existing flow meters are mechanical which can not be integrated to SCADA system. Existing valves are obsolete and do not fulfill present SEDAPAL's standards.

- Chlorination injection equipment

  Only one reservoir with chlorination system was found. However, it doesn't fulfill present technical specifications to be integrated to SCADA system.

In Table 2.5.8-14 a summary of the existing electromechanical facilities is shown.

Table 2.5.8-14 Electromechanical Elements Conditions

Number	18	23	24	25
Code	CR-243	CR-76	CR-96	CR-97
Name	VIPOL NARANJAL R-1	CISTERNA	COLLIQUE R-5	COLLIQUE R-6
Pumping equipment + Electric motor	Obsolete	Obsolete	Obsolete	Average
Hydraulic pipes	Obsolete	Average	Average	Average
Flow meter	Obsolete	Obsolete	Obsolete	Obsolete
Discharging valve of the pump	Obsolete	Average	Average	Average
Line purge valve	Obsolete	No equipment	No equipment	No equipment
Pumping closing valve	Obsolete	Average	Average	Average
Retaining valve	Obsolete	Average	Average	Average
Miscellaneous hydraulic accessories	Obsolete	Average	Average	Average
Chlorination pump	Obsolete	No equipment	No equipment	No equipment

Source: JICA Study Team

6) Problems in Reservoirs and Pumping Stations

Through the diagnoses above, the problems of reservoirs and pumping stations can be summarized as follows:

- There are no reservoirs whose structures are too damaged to be used. However,

rehabilitation of the structures of many of the existing reservoirs and pumping stations is necessary.

- Non-operational mechanical and electric equipment in the reservoirs shall be renewed to begin the operations.
- Some of mechanical and electric equipment in the operating reservoirs need rehabilitation or replacement in order to maintain their proper operation.

(9) Wells and Groundwater

1) Wells and Groundwater in the Study Area

Within the Study area, SEDAPAL possesses a good number of groundwater wells. In Table 2.5.8-15 the list of wells in the Study Area is shown.

However, not all of them are currently used. The Study identified that 23 wells could be used for emergency purpose in case of serious draught. Selection of them was based according to the closeness of well to reservoirs to be rehabilitated.

JICA Study Team carried out an investigation entrusting local Consultant to diagnose the situation of these groundwater wells and therefore determine their suitability for use. These wells are located in the Los Olivos and San Martín de Porres districts.

In the Study, it was found out that out of these 23 wells, 12 wells have complete pumping equipment, 5 have partial pumping equipment and 6 have no pumping equipment. Also, it was observed that 3 of the wells are in operation, 10 wells are used as reserve or emergency backup and 10 wells are not operated due to poor quality water. It is necessary to point out that, according to Technical Information of Wells (ITP) of December 2009 prepared monthly by the Groundwater Team, the most wells are being used for contingency or they are stopped because they do not fulfill parameters of drinking water quality. In most cases, water coming from wells surpasses the maximum acceptable values for most of the parameters. Acceptable parameters are values less than: Electric Conductivity 1500 μmhos/cm, Carbonate CaCO3 500 mg/l, Sulphate SO4 250 mg/l, Chloride Cl 250 mg/l, and Nitrate NO3 50 mg/l.

However the ITP shows that three wells were under operation. Regarding to wells 498 and 716 they were working only when the network pressure was required to be increased. Usually, La Atarjea plant, at certain hours of the day, was able to keep pressure of 18 or 19 PSI only, but those zones require 28 PSI. Therefore, it was necessary to keep the two wells under operation even though they do not fulfill water quality parameters.

Regardng to well 569, this is the only water source in the area, so it was necessary to exploit the well for the water supply in Marquez zone of Callao. Water quality of this well sometimes surpasses the acceptable maximum values of water quality, but they are not so high (CaCO3 surpasses by 67 mg/l and SO4 surpasses in 26 mg/l).

In order that the wells can fulfill the drinking water regulations for human consumption, it is necessary to mix groundwater with surface water coming from Huachipa plant. In order to guarantee suitable water mixing, measuring instrumentations will be installed to

measure sulphate quantity at all wells, nitrates at 16 wells and electric conductivity at 1 well only. These sensors will measure the parameters on-line through a Derivation Integration Process (PID) which will be installed in the PLC to determine amount of mixing to reduce surpassing values of Physical-Chemical quality parameters.

The 23 wells to be rehabilitated are shown in the Table 2.5.8.16.

2) Objective of Diagnosis and Activities

The objective of this diagnosis is to identify and verify the hydro-geological characteristics and the state of the infrastructure of wells, in order to determine if it is possible to extract groundwater for the Project. Recommendations have also been made to solve the problems, if any, in order to extend the useful life span of the wells.

The activities conducted are summarized below:

- Collection and analysis of information available.
- Carrying out short duration pumping tests for 10 wells (those with complete pumping equipment installed) in order to identify hydro-geological problem.
- Determination of recommended operating flow for 10 wells.
- Studying the variations of the water levels with respect to time through the development of piezometric variation hydrographs.
- Diagnosis of infrastructure of 11 wells by inspection with CCTV camera in order to identify infrastructure problems.
- Estimation of water extraction capacity of the wells.

3) Hydro Geological Evaluation

The Hydro geological evaluation involves integrating the results of the short duration pumping tests with the historical data of static level hydrographs obtained from SEDAPAL.

Particular attention has been given to technical characteristics of each well in terms of its current operations: filter length, location of filters, static and dynamic levels, flow rates, depression, location of the dynamic level in respect to the top level of filters, thickness of saturated aquifer, percentage drawdown of saturated aquifer and specific water flow.

The structural and hydraulic characteristics that largely correspond to the stage of drilling have been correlated with the updated data obtained from short duration pumping tests in order to recommend the volume of groundwater exploitation.

Moreover, the interpretation of the evolution of groundwater levels in wells distributed over the two districts allows for the analysis of the general condition of the state of the groundwater, as well as the determination of areas of depression and the assessment of recharge of groundwater. This interpretation is important for assessing the future possibilities of greater groundwater exploitation.

Results for each well, as well as conclusions and recommendations, can be found in Appendix A3. A brief summary is given below.

4) Recovery of the Groundwater Reserves and Change of Groundwater Levels with Time

In order to diagnose the state of the groundwater in the area, the historical water levels of the 23 wells between 1993 and 2010 were analyzed. It was observed that for the variations in water levels in the wells located in these districts, the Chillón aquifer has an important role. Between the years 1997 and 2001, the maximum depths of descent have been reached. After that, a continuous process of recovery has been observed for the 23 wells, and in 2010, the levels have reached a magnitude that exceeded the water levels prevailing at the time of drilling of the wells. This increase in the water levels varies from 8.40 to 39.54 m. There were 13 wells (60.86% of the total), for which the rise of the water levels falls in the bracket of 20.00 to 30.00 m. For another 8 wells (30.43% of the total), the water level recovery is greater than 30.00 m.

This progressive recovery of the water levels of the wells in this area that has been taking place in the last twelve years has produced a significant increase in the exploitable aquifer thickness, resulting in increased groundwater reserves. This situation is particularly related to the gradual reduction of groundwater exploitation; beginning ten years ago, SEDAPAL started discontinuing the pumping of wells.

Table 2.5.8-15 List of Wells in the Study Area Zone

Location		WELL		Sit.	Equipment	Electric Motor				Pump				OPERATION CONDUCTION						Depth	Physical - Chemical Conditions						
Item	District	Code	Name	Well		Maker	HP	Amp	Vol	Lg-Bm	Type	Maker	Model	Date	Static level (m)	Dynamic level (m)	P1(psi)	P2(psi)	Q(l/s)	Well m	Date	Conduct. µ mhos/cm	Total Hardness mg/l $CaCO_3$	Sulphates mg/l SO_4	Chloride mg/l Cl	Nitrates mg/l NO_3
1	7	161	San Felipe 2	Stand by	Complete	SUM	100	139	220		Submersible			2009/11/4	15.00	18.55	52	51	40	72.70	2009/5/20	1136	468	315	89	59
2	31	162	Palao	Stand by	Complete	IEM	75	167	217	97.20	Vertical turbulence	PEER-6	10MA-8	2009/2/27	43.80	54.25	27	27	30	99.50	2009/3/10	907	396	182	59	55
3	7	215	Retablo 4	Stand by	Complete	HIT	20	59	222	75.45	Submersible	LAY-4	6RKHC-5	2009/11/3	12.60	27.30	11	10	17	103.00	2009/2/18	1240	648	398	43	37
4	31	225	San German	Stand by	Complete	P	50		223	84.30	Submersible	DPUM-6	8M23-5	2009/9/30	33.58				35	92.00	2009/5/20	1297	565	345	157	26
5	7	226	Pascana	Under Operation	Complete	P	49	51	220	88.33	Submersible			2009/12/14	13.10	19.30	20	20	13	102.95	2009/1/27	1772	844	391	202	42
6	39	280	Pro 3	No function	No Equipment				224					2008/8/6	20.75				45	103.50	2006/4/21	879	423	286	48	22
7	7	303	San Carlos	Stand by	Complete	D	50	97	218	54.39	Vertical turburance	HID-6	8MQH-7	2009/12/14	12.90	13.60	30	30	30	75.00	2009/8/12	1439	630	342	72	53
8	7	312	Pro6 9no Sec	Stand by	Complete	D	50	84	210	83.50	Vertical turburance	LAY-10	8URC-3	2009/8/19	9.30	31.00	13	12	8	85.00	2009/1/27	1137	567	399	77	40
9	39	316	Pro Lima	No function	No Equipment				220					2009/9/7	2.73				3	85.00	2005/11/22	1824	1123	886	89	16
10	7	337	Sangarara 2	Stand by	Complete	SAE	20	48	222	68.28	Submersible	GPUM-6	10MA-10	2009/8/19	15.60	29.70	10	8	17	83.00	2009/5/20	1244	595	348	49	42
11	7	344	Collique 1	No function	No Equipment				225					2008/12/16	18.83				23	68.80	2000/4/11	1439	588	311	96	59
12	7	348	Santa Luisa	Stand by	Complete	D	20	40	218	50.51	Vertical turburance	BJ-5	8GH-6	2008/12/9	23.90	25.40	30	28	10	110.00	2008/10/17	1535	823	355	78	70
13	39	351	Puerta Pro	Stand by	Complete	HIT	75		212	90.30	Submergible	HID-5	7MQL-5	2009/2/25	21.60				13	94.00	2009/9/16	1297	696	436	53	20
14	7	378	Ano Nuevo	Stand by	Complete	SUM	40	36	215	63.96	Submersible	HID-6	10GL-9	2009/12/4	8.60	26.10	16	15	10	66.50	2009/4/29	1237	636	406	58	44
15	31	382	Vipol 1	Stand by	Complete	US	100		221	78.35	Vertical turburance	BJ-10	12GM-5	2009/9/7	7.18				52	94.00	2009/4/29	1619	799	423	142	29
16	7	385	Ano Nuevo 2	No function	No Equipment				220					2007/6/4	9.00				9	61.50	2004/9/20	1638	867	639	71	31
17	7	401	Sta Luisa	No function	Partial	HIT	40		218	77.50	Submerginal	HID-4	6MQH-6	2008/8/6	20.35				30	217.00	2005/9/20	1468	700	422	59	53
18	39	423	Sta Luisa 4	No function	Partial	D	40		220	103.90	Vertical turburance	HID-6	8MQH-11	2008/4/21	18.30				20	140.90	2006/4/12	1283	562	411	66	52
19	31	95	San Martin 2	Stand by	Complete	US	125		220	100.00	Vertical turburance	BJ-8	10H60-10	2009/10/28	42.96				30	150.00	2008/8/12	690	319	160	43	25
20	31	99	Condevilla	Stand by	Complete	IEM	75		220	101.23	Vertical turburance	BJ-5	8MQL-16	2009/9/30	40.52				30	103.70	2009/5/20	826	357	229	42	48
21	31	141	Canta	Under Operation	Complete	D	50	120	216	91.40	Vertical turburance	BJ-6	10CGL-9	2009/9/30	47.59				17	138.00	2009/4/29	846	381	164	84	48
22	31	142	Amalia Puga	Stand by	Complete	P	75	165	220	84.29	Submersible	DPUM-6	8H38-4	2009/9/30	33.67				43	132.20	2009/5/20	782	342	238	36	42
23	31	776	El Trebol 3	No function	No Equipment				220					2001/8/21	60.50				45	145.00	2006/5/9	934	443	216	64	37
24	31	780	Palao 3	No function	No Equipment				220					2004/3/5	45.41				25	139.00	2006/8/21	1022	397	164	86	48
25	7	430	Primavera 2	Stand by	Complete	SAE	75	72	221	66.85	Submersible	GPUM-6	8GH-10	2009/9/7	15.10	38.65	38	38	16	79.13	2009/4/29	1304	674	468	61	31
26	31	781	Lola Ferreyros 2	No function	No Equipment				220					2007/8/17	52.49				30	150.00	2006/4/5	1091	451	413	113	59
27	7	431	Collique 4	Stand by	Complete	US	100		440	23.24	Vertical turburance	BJ-8	12GL-10	2009/6/10	8.00				33	29.95	2000/3/16	1191	594	429	49	45
28	39	785	Vipol 4	No function	No Equipment				220					2007/2/12	3.07				8	85.00	2006/3/28	1198	577	76	79	10
29	7	437	Retablo 5	Stand by	Complete	FKL	30		217	93.00	Submersible	GOULD-4	6CHC-4	2009/9/7	13.18				17	117.00	2009/9/16	1515	803	395	76	53
30	39	788	San Roque	No function	No Equipment				220					2009/9/4	12.78				17	110.00	2006/4/29	1139	545	399	95	21
31	39	474	Pro 12	Stand by	Complete	SUM	25		217	73.10	Submergible	BJ-6	10CGL-8	2009/5/14	19.50				20	120.00	2008/12/13	1235	623	439	69	44
32	31	789	Trebol de Chavarria	No function	No Equipment				448					2009/10/28	27.20				43	125.00	2005/9/20	1077	493	167	115	53
33	7	487	El Pinar-Teo	Stand by	Complete	SAE	30	86	216	42.00	Submersible	GPUM-6	9RCLC-5	2009/12/14	2.80	16.40	16	16	40	60.00	2009/8/12	1263	552	348	45	37
34	39	791	Prolima	Under Operation	Complete	IEM	50	99	225	74.23	Vertical turburance	BJ-6	10GH-6	2009/10/13	9.70	51.05	27	27	13	100.00	2009/2/18	1505	804	259	63	40
35	39	489	Los Naranjos	No function	No Equipment				227					2008/8/18	18.97				17	106.20	2004/1/29	1400	754	538	77	44
36	39	498	Pro 11	Under Operation	Complete	US	40	92	220	103.50	Vertical turburance	PEER-5	8MA-14	2009/8/26	19.40	50.80	18	16	17	129.00	2009/1/27	1119	540	353	77	29
37	31	569	Chuquitanta	Under Operation	Complete	IEM	60	103	220	45.72	Vertical turburance	HID-6	8MQH-3	2009/11/23	10.50	23.80	12	12	40	119.00	2009/1/27	1128	567	326	98	15
38	31	606	El Establo	No function	No Equipment				213					2007/10/11	42.20				17	120.00	2000/3/21	745	318	116	50	42
39	7	616	Pinar 2	Stand by	Complete	IEM	30	89	221	57.60	Vertical turburance	BJ-4	300S-4	2009/10/21	9.14	38.30	22	22	16	58.00	2009/8/12	1285	596	349	47	31
40	39	618	Wiesse	Stand by	Complete	D	50		227	84.72	Vertical turburance	BJ-6	10GL-9	2009/9/30	12.02				30	118.00	2008/9/17	1227	629	364	68	26
41	7	619	Pinar 1	Stand by	Complete	FKL	25	115	214	51.50	Submersible	DEMIN-4	MGEA-4	2009/12/14	7.90	41.50	72	36	16	59.50	2009/8/12	1270	581	343	42	35
42	31	656	Malaspina	Stand by	Complete	HIT	80		220		Submersible			2009/9/30	29.27				17	119.84	2008/8/14	847	413	168	160	66
43	31	657	Vipol Naranajal	No function	No Equipment				220					2009/9/30	11.50				10	89.90	2006/5/9	1564	801	628	84	59
44	31	666	San Martin 5	Stand by	Complete	D	125		220	100.08	Vertical turburance	BJ-8	10GH-8	2009/8/27	34.80				40	150.00	2008/8/12	735	362	155	62	34
45	31	670	El Rosario	Stand by	Complete	US	125	175	221	75.05	Vertical turburance	HID-8	12GM-4	2009/5/14	33.20	48.65	36	35	50	117.00	2009/1/27	1209	603	157	172	51
46	31	679	Chicmabamba P-4	No function	Partial	IEM	75		212		Vertical turburance	BJ-6		2007/11/14	12.20				36	120.00	2006/2/9	1106	635	381	53	27
47	31	680	La Florida P-9	No function	No Equipment				220					2008/8/8	8.08				20	120.00	2006/3/8	1155	528	356	51	23
48	39	684	Aposte	No function	Partial	D	30	45	220	44.00	Vertical turburance	BJ-5	8GH-6	2008/8/4	10.60				10	115.00	2009/5/20	1965	909	345	287	57
49	31	687	Virgen Fatima P-10	Stand by	Complete	US	75		225	69.00	Vertical turburance	BJ-8	10GM-8	2009/9/2	6.87				30	120.00	2008/11/18	1411	692	418	130	42
50	39	688	Aznapuquio P-5	No function	Partial	IEM	50		220		Vertical turburance	BJ-6		2009/9/2	8.14				27	120.00	2004/1/26	1129	591	455	63	18
51	31	689	Aznapuquio P-12	Stand by	Complete	HIT	40		220		Submergible			2009/9/2	5.31				18	120.00	2005/8/19	1551	816	404	144	43
52	31	690	Aznapuquio P-13	Stand by	Complete	HIT	30	122	220	72.40	Submersible	PLEU-4	S/PLAC-5	2009/9/2	4.96				23	120.00	2009/3/10	2100	1012	429	312	57
53	39	691	Milla Ochoa 2	No function	No Equipment				216					2009/9/4	18.23				15	120.00	2006/5/10	971	487	382	48	13
54	39	692	Milla Ochoa 3	No function	No Equipment				223					2009/9/4	17.95				27	120.00	2004/1/29	1222	655	416	70	27
55	39	693	Milla Ochoa 10	Stand by	Complete	IEM	40	105	220	85.19	Vertical turburance	HID-4	7MQH-22	2009/9/4	19.33				17	120.00	2008/10/17	1055	536	332	53	18
56	39	694	AH.Sn Martin 4	No function	No Equipment				220					2009/9/4	17.88				20	112.00	2006/6/16	1133	515	386	55	18
57	39	695	A.H San Martin 5	Stand by	Complete	IEM	75		220	88.78	Vertical turburance	BJ-6	10GL-13	2009/5/14	14.95				20	120.00	2008/10/17	993	474	335	50	15
58	39	696	Laura Calle 6	No function	No Equipment				213					2009/9/4	18.11				14	110.26	2006/2/8	934	410	312	48	16
59	39	704	Rio Santa	Stand by	Complete	SIEM	30		212	81.00	Vertical turburance	JHON-8		2009/12/14	20.30				13	100.00	2009/3/10	876	391	302	29	15
60	39	716	Santa Elisa	Under Operation	Complete	US	40		222	53.62	Vertical turburance	HID-6	10CGL-6	2009/5/14	14.80				26	110.00	2008/10/17	1191	632	270	56	24
61	39	717	Estrella	No function	No Equipment				225					2009/9/14	17.91				12	92.60	2006/4/20	1016	471	273	41	24
62	39	719	Los Olivos Pro-P1	Stand by	Partial	HIT	40		223	93.54	Submersible	HID-4	5.5CGH-9	2009/3/10	18.50				12	119.10	2004/7/14	1270	578	342	68	21
63	39	720	Los Olivos Pro-P2	Stand by	Complete	US	50		211	55.98	Vertical turburance	GPUM-6	9RCHC-6	2009/5/14	12.75				40	120.00	2009/9/16	1323	463	443	114	2
64	7	721	Alborada-PT1	Stand by	Complete	D	40	59	218	58.00	Vertical turburance	PEER-6	8MA-10	2009/12/14	8.25	32.80	32	30	13	100.00	2009/8/12	1087	479	265	41	15
65	7	722	Alborada-PT3	Stand by	Complete	ATU	40	75	223	54.90	Submerginal	NASJHO	NJ-7CC-4	2009/10/16	14.70	17.60	43	42	21	84.00	2009/8/12	1322	588	335	51	46
66	7	723	Alborada-PT4	Stand by	Complete	D	40		220	54.44	Vertical turburance	BJ-6	10GM-9	2009/2/25	7.15				23	100.00	2006/3/6	1197	590	371	87	55
67	7	724	Alborada-PT5	Stand by	Complete	US	40		210	43.96	Vertical turburance	HID-5	10GL-4	2009/3/17	9.85				33	97.65	2008/11/18	1004	501	321	41	31
68	7	725	Alborada-PT2	Stand by	Complete	SAE	20	52	224	44.23	Submersible	GPUM-4	7WALC-3	2009/12/14	4.70	18.15	38	36	13	74.00	2008/12/22	793	376	264	32	13
69	31	727	Asnapuquio C1	Stand by	Partial	IEM	60		210		Vertical turburance			2009/9/1	11.87				36	120.00	2005/11/30	1235	671	435	62	36
70	31	728	Asnapuquio C2	No function	Partial	IEM	60	116	211	65.81	Vertical turburance	DPUM-6	10CGL-9	2009/9/1	12.44				33	120.00	2004/3/4	1326	716	482	59	32
71	31	729	Asnapuquio C4	No function	Partial	IEM	60	138	220	77.63	Vertical turburance	NAT-6	10CGL-9	2009/9/1	11.03				33	120.00	2006/2/9	1253	647	447	62	34
72	31	730	Asnapuquio P9	Stand by	Complete	IEM	100		213	66.43	Vertical turburance	BJ-8	12GL-6	2009/12/14	3.97				43	111.20	2006/10/16	1341	602	390	63	29
73	31	748	San Martin 6	No function	Partial	US	125		227	87.77	Vertical turburance	BJ-6	12 GM	2009/9/30	27.15				30	150.00	2006/3/30	809	369	139	55	51

Source: Technical Information of Well ITP December 2010 - Groundwater Team – SEDAPAL

Selected wells for rehabilitation

Table 2.5.8-16: Existing Wells to be Rehabilitated in the Study Area

General Characteristis					Equip ment	Physical - Chemical Conditions					
Location		WELL		Sit.		Muestreo	Conduct.	Har. Total	Sulphates	Chlorides	Nitrates
CS	Dis	No	Name	Well		Fecha	µmhos/cm	mg/l $CaCO_3$	mg/l SO_4	mg/l Cl	mg/l NO_3
1	39	351	Puerta Pro	Rse*	Complete	16/09/2009	1297	696	436	53	20
2	39	474	Pro 12	Rse*	Complete	13/12/2008	1235	623	439	69	44
3	39	498	Pro 11	F	Complete	27/01/2009	1119	540	353	77	29
4	31	569	Chuquitanta	F	Complete	27/01/2009	1128	567	326	98	15
5	39	618	Wiesse	Rse*	Complete	17/09/2008	1227	629	364	68	26
6	31	687	Virgen Fatima P-10	Rse*	Complete	18/11/2008	1411	692	418	130	42
7	31	689	Aznapuquio P-12	Rse*	Complete	19/08/2005	1551	816	404	144	43
8	39	693	Milla Ochoa 10	Rse*	Complete	17/10/2008	1055	536	332	53	18
9	39	695	A.H San Martin 5	Rse*	Complete	17/10/2008	993	474	335	50	15
10	39	704	Rio Santa	Rse*	Complete	10/03/2009	876	391	302	29	15
11	39	716	Santa Elisa	F	Complete	17/10/2008	1191	632	270	56	24
12	39	720	Los Olivos Pro-P2	Rse*	Complete	16/09/2009	1323	463	443	114	2
13	39	423	Sta Luisa 4	Pca	Partial	12/04/2006	1283	562	411	66	52
14	39	688	Aznapuquio P-5	Pca	Partial	26/01/2004	1129	591	455	63	18
15	31	727	Asnapuquio C1	Rse*	Partial	30/11/2005	1235	671	435	62	36
16	31	728	Asnapuquio C2	Pca	Partial	04/03/2004	1326	716	482	59	32
17	31	729	Asnapuquio C4	Pca	Partial	09/02/2006	1253	647	447	62	34
18	39	280	Pro 3	Pca	Without	21/04/2006	879	423	286	48	22
19	39	691	Milla Ochoa 2	Pca	Without	10/05/2006	971	487	382	48	13
20	39	692	Milla Ochoa 3	Pca	Without	29/01/2004	1222	655	416	70	27
21	39	694	AH.Sn Martin 4	Pca	Without	16/06/2006	1133	515	386	55	18
22	39	696	Laura Calle 6	Pca	Without	08/02/2006	934	410	312	48	16
23	39	717	Estrella	Pca	Without	20/04/2006	1016	471	273	41	24

Wells under operation

Wells for contingency

Wells stopped

Source: ITP Groundwater Team – SEDAPAL

5) Distance of the Dynamic Water Level from the Top of the Filter

The analysis of updated information from SEDAPAL and results of the short duration pumping tests performed between May and June of 2010, shows that the dynamic groundwater tables are located above the top levels of the filters for all the wells investigated. The distance varies between 7.63 and 49.55 m. In most cases, these distances were between 25.09 and 49.55 m, meaning the filters are totally submerged throughout their length. This represents a favorable situation regarding their exploitation and useful life span.

6) Drawdown / Depression of Saturated Aquifer

With the rising of the groundwater tables in the recent years, the thickness of saturated aquifer has also been increased. Therefore the recorded drawdown in 2010 for 17 wells showed decreased values compared to what considered as good. This means increase in exploitation capacity.

The rate of depletion of the saturated aquifer during pumping varies from 3.51% (well No. 569) to 43.88% (Well No. 280), though the majority of the wells show a rate of under 25%, which is considered to be good.

The wells that had the highest percentage of lowering of saturated aquifer during pumping tests were No. 280 with 43.88%, No. 351 with 34.16% and No. 689 with 28.20%.

7) Pumping Tests

Between May 4 and June 9 of 2010, short-duration pumping tests were carried out in the following 10 wells in the Los Olivos district: Wells N° 351,474,498, 618, 687, 693, 695, 704, 716, and 720. This was carried out in order to determine the hydraulic parameters like statistic levels, static levels, dynamic levels, depression, water flow and specific capacity. The executions of the pumping tests were conducted in coordination with SEDAPAL staff following SEDAPAL´s pumping regulations 1 and 3.

The short duration pumping tests were conducted for a variable time period, between 2h 15m and 2h 30m using vertical shaft pumps powered by electric motors and electric submersible pumps.

The comparative analysis of the performance curves of the pumping tests show a significant improvement in the hydraulic parameters (static and dynamic levels and flow), the thickness of the saturated aquifer, the percentage of drawdown, submergence situation of the filters, and specific flow volume.

8) Inspection of Wells Using CCTV Cameras

CCTV camera inspection have been carried out in 11 wells, out of which 5 wells did not have pumping equipment (N° 280, 694, 696, 717, and 689), and 6 wells did have pumping equipment (N° 423,691,618, 687, 689 and 727). For wells with pumping equipment, this inspection required removal of pumping equipment and later reinstallation. From the inspection, it was found that there was no serious damage of the casings, sedimentation or cloggings in the wells which may prevent usual operation of the wells.

9) Water Extraction

The possible water production has been calculated from the pumping tests performed in 10 wells and the hydro-geological evaluation of 13 wells. The possible total water extraction from the 23 boreholes investigated is 531.50 liters / sec., which is equivalent to 0.531 m^3 / sec.

10) Diagnosis of Electromechanial Equipment of Wells

Apart from the inspection of the wells explained above, the Consultant has carried out site surveys for the wells' electromechanical equipment. From the result of these surveys, it was observed that:

<u>Pumping equipment of wells</u>

Within 23 inspected wells, 9 of them didn't have any pumping equipment.

Within 14 wells with existing pumping equipment, 4 of them have submersible pumping equipment and the others have vertical turbine pumping equipment (VT) which is lubricated by water. It must be mentioned that the pumping equipment maintenance staff prefers VT equipments that are lubricated by water instead of submersible pumping equipments. This is because VT pumping equipments are easier to install compared to submersible pumps because for the later, there are difficulty of

installation of power cable in the motor located underneath the pumping equipment. Besides, in many cases the location is deeper than 70 meters.

At present there is no control system, so maintenance of pumping equipments are done only when it needed to be repaired.

Electrical equipments:

- Electric motors

  Existing electrical motors surveyed are 10 VT pumping motors lubricated by water.

  As mentioned before, these stations have no telemetry, so preventive maintenance in motors could not be done.

- Electric panels

  Inspected power electric panels are in bad conditions. Some wells have no electronic starters and speed changer. Some wells have network analyzers and condenser banks, but these elements are obsolete and they are not compatible with the controls required by SEDAPAL. Existing electric components, such as sectioners, relays and contacts are obsolete.

  Some wells have incomplete panels but the technology is rather old and not possible to be integrated to SCADA of SEDAPAL.

- Discharging pipes

  Within 23 wells, six of them have no discharging pipes. The others have discharging pipes that are partially installed. 16 wells have mechanical seat type flow meter; and only one well has electromagnetic flow meter. None of these flow meters could be used for SCADA system integration. All of these meters shall be replaced by new ones. Also, none of the inspected outlet sluice valve fulfill the condition required to be controlled remotely. Valves shall be replaced.

- Chlorination system

  Within 23 wells, 15 wells have ithe injection pump for chlorine system, the security system and chlorine tanks. In all cases, it is necessary to replace the injection system of chlorine gas because they are obsolete and can not be integrated to SCADA system.

In Table 2.5.8-17 a summary of existing accessories in selected wells is shown.

In annex A6, the well evaluation sheets are shown.

11) Problems of Wells

Many of the 23 wells to be used for emergency purpose do not have pumping equipment or are not equipped with enough equipment for suitable operation. New installation of pumping equipment as well as rehabilitation and improvement of existing equipment are necessary.

Table 2.5.8-17 Electromechanical Characteristis of Wells

WELL		Electromechanical Equipment											Discharging Pipes							Chlorination System				Automation and Control Panel		
			Mechanical Equipment				Electrical Equipment																			
No	Name	Motor Pump Eqiupment	Lg-Bm	Type	Maker	Model	Mar	HP	Amp	Vol.	Network Analizer	Condenser Banks	Discharging Pipes diameter	Oultel Valve	Lamp	Relief	Dresser	Flow Meter	Pressure Meter	Pump	Panel	Security System	Chlorine Cylinder	PLC	Radio	Antenna
280	Pro 3	No equipment								224	No	No	8	Sluice	No	No	Yes	No	No	No	No	No	No	No	No	No
351	Puerta Pro	Complete	90,30	SU	HID-5	7MQL-5	HIT	75		212	Si	Si	4	Sluice	Codo	Yes	Yes	Mc Crometer	Yes	Yes	Yes	Yes	Yes	No	No	No
423	Sta. Luisa 4	Partial	103,90	VT	HID-6	8MQH-11	D	40		220	Si	Si	8	Sluice	Yes	Aire	Yes	Mc Crometer	Yes	No	No	No	No	No	No	No	No
474	Pro 12	Complete	73,10	SU	BJ-6	10CGL-8	SUM	25		217	Si	Si	6	Sluice	Codo	Yes	Yes	Mc Crometer	Yes	Yes	Yes	Yes	Yes	No	No	No	No
498	Pro 11	Complete	103,50	VT	PEER-5	8MA-14	US	40	92	220	Si	Si	6	Sluice	YES	YES	Yes	Mc Crometer	Yes	Yes	Yes	Yes	Yes	No	No	No	No
569	Chuquitanta	Complete	45,72	VT	HID-6	8MQH-3	IEM	60	103	220	No	Si	8	Sluice	Yes	Yes	Yes	Electromag.	Yes	Yes	Yes	Yes	Yes	No	No	No	No
618	Wiesse	Complete	84,72	VT	BJ-6	10GL-9	D	50		227	No	Si	6	Sluice	Yes	Yes	Yes	Mc Crometer	Yes	Yes	Yes	Yes	Yes	No	No	No	No
687	Virgen Fátima P-10	Complete	69,00	VT	BJ-8	10GM-8	US	75		225	No	Si	8	Sluice	Yes	Niple	Yes	Mc Crometer	Yes	Yes	Yes	Yes	Yes	No	No	No	No
688	Aznapuquio P-5	Partial		VT	BJ-6		IEM	50		220	No	Si	6	Sluice	Yes	No	Yes	Mc Crometer	Yes	Yes	Yes	Yes	Yes	No	No	No	No
689	Aznapuquio P-12	Complete		SU			HIT	40		220	No	Si	6	Sluice	Yes	Yes	Yes	Mc Crometer	Yes	Yes	Yes	Yes	Yes	No	No	No	No
691	Milla Ochoa 2	Partial		VT						216	Si	Si	4	Sluice	Yes	Yes	Yes	Mc Crometer	Yes	Yes	Yes	Yes	Yes	No	No	No	No
692	Milla Ochoa 3	No equipment		SU						223	Si	Si	6	Sluice	Codo	Yes	Yes	Mc Crometer	Yes	Yes	Yes	Yes	Yes	No	No	No	No
693	Milla Ochoa 10	Complete	85,19	VT	HID-4	7MQH-22	IEM	40	105	220	No	No	6	Sluice	Yes	Yes	Yes	Mc Crometer	Yes	Yes	Yes	Yes	Yes	No	No	No	No
694	AH.San Martin 4	No equipment								220	No	No	No	Sluice	No	No	No	No	No	No	No	No	No	No	No	No	No
695	A.H San Martin 5	Complete	88,78	VT	BJ-6	10GL-13	IEM	75		220	Si	Si	6	Sluice	Yes	Yes	Yes	Mc Crometer	Yes	Yes	Yes	Yes	Yes	No	No	No	No
696	Laura Calle 6	No equipment								213	No	No	No	Sluice	No	No	No	No	No	No	No	No	No	No	No	No	No
704	Rio Santa	Partial	81,00	VT	JHON-8						Si	Si	4	Sluice	Yes	Yes	Yes	Mc Crometer	Yes	Yes	Yes	Yes	Yes	No	No	No	No
716	Santa Elisa	Complete	53,62	VT	HID-6	10CGL-6	US	40		222	No	Si	6	Sluice	Yes	Yes	Yes	Mc Crometer	Yes	Yes	Yes	Yes	Yes	No	No	No	No
717	Estrella	No equipment									No	No	No	Sluice	No	No	No	No	No	No	No	No	No	No	No	No	No
720	Los Olivos Pro-P2	Complete	55,98	VT	GPUM-6	9RCHC-6	US	50		211	Si	Si	4	Sluice	Yes	Yes	Yes	Mc Crometer	Yes	Yes	Yes	Yes	Yes	No	No	No	No
727	Aznapuquio C1	Partial		VT			IEM	60		210	No	No	6	Sluice	Yes	Yes	Yes	Mc Crometer	Yes	No	No	No	No	No	No	No	No
728	Aznapuquio C2	Partial	65,81	VT	DPUM-6	10CGL-9	IEM	60	116	211	No	No	6	Sluice	No	No	No	No	No	No	No	No	No	No	No	No	No
729	Aznapuquio C4	Partial	77,63	VT	NAT-6	10CGL-9	IEM	60	138	220	No	No	6	Sluice	No	No	No	No	No	No	No	No	No	No	No	No	No

Source: Technical Information of Wells (ITP) Groundwater Team - SEDAPAL, Field Visit, EOMASBA team

(10) Valve pits

1) Condition of Valve Pits

Control structures that supervise and control inflow to each sector have been located at eleven (11) points, as presented in Table 2.5.8-18. These structures usually include sluice valves, regulating valves, and telemetry equipment. Filters have been installed in some cases to protect regulation valves.

Within the eleven valve pits, five (5) of them can store the monitoring data but have no filters along the inflow line, thus, the valves are exposed to higher maintenance needs due to strange particle incrustations.

Table 2.5.8-18: Existing Valve Pits

No	District	Location	Code	Original Sector
1	Los Olivos	Av. Las Palmeras / Calle Río Marañon	S0083	83*
2		Av. Huandoy / Calle 69	S0084	84*
3		Av. Mendiola / Av. Los Portales	S0085	85*
4	San Martín	Av. Universitaria / Av. Los Mirlos	S0212	212*
5		Autopista Lima-Canta / Av. Universitaria	S0213	213*
6	Comas	Av. Túpac Amaru/ Las Lomas	-	350
7		Av. Túpac Amaru/ San Felipe	-	345 – 346
8		Av. Túpac Amaru	-	347 - 346
9	Pte. Piedra	Capitana Sector	-	361
10		Ensenada Sector	-	368
11		Sureños Sector	-	369

*: Original sectors which can be controlled and monitored automatically.

Source: SEDAPAL ECRF Cadastre plan

Among the eleven, five valve pits, which are located in the original sectors 83, 84, 85, 212 and 213, can be controlled and monitored automatically.

The five valve pits have an automated ring valve that is connected to the SCADA system for its remote command; it regulates flow and inflow pressure to the sector, according to its specific regulation regime criterion; upstream of this valve there is a guard butterfly valve, and a gate valve is available downstream. The by-pass valve also has a butterfly valve available both upstream and downstream.

An electromagnetic meter is available at the valve pit entrance that registers flow data through the SCADA system.

A pressure translator is also available to register pressure data both upstream and downstream of the control valve. Only 2 valve pits have air valves, and none of them have filters.

The Table 2.5.8-19 below shows valve pits and their equipment:

Table 2.5.8-19: Major Components for Automation of Valve Pits

Original Sector	Inlet valve	Automated control valve	Flow meter	Valve	Emergency By-pass Valves			Inflow and inflow pressure	Pressure transducer (data)		Air valve	Filter
	Butterfly	300 mm ring	Electromagnetic	Sluice	Globe type	Inlet butterfly	Outlet valve	Regulated	Upstream	Downstream		
83	x	300 mm	x	x	x	x	x	x	x	x	-	-
84	x	300 mm	x	x	x	x	x	x	x	x	-	-
85	x	300 mm	x	x	x	x	x	x	x	x	-	-
212	x	300 mm	x	x	x	x	x	x	x	x	x	-
213	x	300 mm	x	x	x	x	x	x	x	x	x	-

Source: JICA Study Team

2) Problems of Valve Pits

Among the eleven valve pits, only five can automatically control the flow. The remaining valve pits cannot control the pressure and water flow properly and cannot provide basic data of water flow and pressure.

The control carried out by these five valve pits shall be changed because after changing of water source (i.e., from Huachipa WTP) it is expected that the sector inlet will be controlled by head reservoirs.

(11) Secondary networks

1) Scale of Existing Networks

In the Study Area, 26 sectors out of 41 sectors have existing secondary networks, which are located in the Comas, Carabayllo, San Martín de Porres, Los Olivos, and Callao districts. The elevations of these areas range between 5.00 m.a.s.l. and 565 m.a.s.l. The total length of secondary networks in the Study Area is 773.45 km. Table 2.5.8-20 shows the lengths of secondary networks by materials and sectors.

As presented in the table, there are four kinds of materials, which are asbestos cement pipe (AC), iron pipe (ACERO), galvanized iron pipe (FoFo) and polyvinyl chloride pipe (PVC). The prevailing materials are AC (46.73%) and PVC (53.10%). AC had been used in the network until 10 to 15 years ago, after which PVC started to be used. These two kinds of pipe material make up 99.83 % of the total installed pipelines.

Table 2.5.8-21 presents number of the accessories such as valves in the Study Area by sector.

In the 26 sectors with existing networks, 3 sectors (361, 368B and 369B) have networks which were recently established/rehabilitated, and 1 sector (370) will be rehabilitated by other projects of SEDAPAL. Moreover, a part of sector 348A (sub-sector 348A-2) has been also recently rehabilitated.

SEDAPAL has an intention to expand the water supply network in area of influence of the Huachipa WTP at an early date, but the target year or schedule to complete the expansion to the entire Influence Area is not yet established.

Table 2.5.8-20: Lengths of Existing Secondary Pipes by Sector and Material in the Study area

Sector	Type of Material				Total (km)
	AC	ACER	FOFO	PVC	
83 A-1	9.29			1.87	11.16
83 A-2	18.75			2.60	21.35
83 B-1	10.06			0.19	10.25
83 B-2	29.84			5.78	35.62
84 A-1	15.70			18.39	34.09
84 A-2	20.42			4.05	24.47
84 B-1	26.10			3.76	29.86
84 B-2	3.79			9.60	13.38
85 A	11.25			6.13	17.38
85 B-1	4.79		0.03	4.46	9.27
85 B-2	8.34			0.26	8.60
85 B-3	5.51			0.41	5.92
85 C	13.10			2.52	15.62
212 A-1	3.62			26.69	30.31
212 A-2	6.76			13.31	20.07
212 B-1	0.92			13.55	14.47
212 B-2	0.54			12.10	12.64
213-1	12.65			22.69	35.34
213-2				0.62	0.62
213-3	0.03			1.05	1.08
253				0.21	0.21
256				4.32	4.32
259	12.40	0.22		1.43	14.05
345	0.06			13.31	13.37
346-1	4.67			4.68	9.35
346-2	9.25			6.38	15.63
347-1	3.92			14.44	18.36
347-2	11.61			19.84	31.45
348 A	7.64				7.64
348 B-1	17.37			3.22	20.59
348 B-2	0.24		0.13	0.01	0.38
349 A-1	12.90	0.70		3.51	17.11
349 A-2	1.61			2.11	3.72
349 A-3	0.84	0.06		7.63	8.53
349 B-1	0.71			8.71	9.42
349 B-2	3.03			6.12	9.15
349 B-3	5.63			2.19	7.82
350-1	34.81				34.81
350-2	22.65			14.43	37.08
351-1	0.93			2.06	2.99
351-2				2.63	2.63
351-3			0.19	0.46	0.65
361				26.90	26.90
368 A-1	0.02			21.96	21.98
368 A-2	0.01			5.59	5.60
368 B	0.06			33.85	33.91
369 A	0.23			25.11	25.34
369 B	0.48			27.95	28.43
370	8.90			1.62	10.52
Total	**361.41**	**0.98**	**0.35**	**410.70**	**773.45**
Percentage	**46.73%**	**0.13%**	**0.05%**	**53.10%**	**100.00%**

Source: SEDAPAL Cadastre and JICA Study Tea

Table 2.5.8-21: Numbers of the Accessories by Sector

VALVES BY TYPE OF MATERIAL AND PIPE DIAMETER IN SECONDARY NETWORKS OF SEWERAGE BY SUB-SECTOR

HYDRANT VALVES

Sector	SubSector	AC 75	AC 100	AC 150	AC 200	AC 250	AC 300	AC Total	PVC 63	PVC 75	PVC 90	PVC 100	PVC 110	PVC 150	PVC 160	PVC 200	PVC 250	PVC 300	PVC 315	PVC Total	Total
83 A	83 A-1		6		1	3		10												0	10
	83 A-2		12	5	3	4		24					2							2	26
83 B	83 B-1		10	7				17							2					2	19
	83 B-2		40	14	2	1		57					4		1					5	62
84 A	84 A-1		12	1	2		2	17					10		1	1	1			13	30
	84 A-2		4	3	4	1		12					2			3				5	17
84 B	84 B-1		20	6	5			31					2		2					4	35
	84 B-2		6	1	2			9			1		4		3	1				9	18
85 A	85 A		14	4	1			19					4							4	23
85 B	85 B-1		6	1	2			9					5		3	1				9	18
	85 B-2		13	4		2		19					1							1	20
	85 B-3		1	5	4	4		14												0	14
85 C	85 C		16	14		1		31					3							3	34
212 A	212 A-1		3			2		5			1		24		5					30	35
	212 A-2	1	5	4	3			13					10		4		1			15	28
212 B	212 B-1		1					1					12		2					14	15
	212 B-2		1					1					6		1	3				10	11
213	213-1		10	6	2			18			1		14		2	1				18	36
	213-2							0			1									1	1
	213-3							0			1		1							2	2
253	253							0					1							1	1
256	256							0												0	0
259	259	4	5	4	2			15	1		1									2	17
345	345							0					9		2					11	11
346	346-1		2	3	2			7					10		2					12	19
	346-2		9	7				16					8				2			10	26
347	347-1		6	1	1			8					8		2					10	18
	347-2		9	5	1	1		16					10		1	1				12	28
348 A	348 A	2	8	3				13												0	13
348 B-1	348 B-1		16	6	1	1		24			1		1		2					4	28
348 B2																					
349 A	349 A-1		14	6		2		22		1	1		1							3	25
	349 A-2		1					1					3		1					4	5
	349 A-3							0		1			2							3	3
349 B	349 B-1							0					3							3	3
	349 B-2		5		1			6					2							2	8
	349 B-3		7	3				10												0	10
350	350-1		56	21	3		4	84												0	84
	350-2		43	11	4	1		59					7		1			1		9	68
351	351-1		2					2					1			1				2	4
	351-2							0					1							1	1
	351-3							0					1							1	1
361	361							0					23		9		2		2	36	36
368 A	368 A-1							0		1		2	8	1	4	2	2			20	20
	368 A-2							0		1		1	2		2					6	6
368 B	368 B							0		6		17	2	3	1	3				32	32
369 A	369 A							0					8		8	5				21	21
369 B	369 B							0		3		15								18	18
370	370		5	8	1			14												0	14
Total general		**7**	**368**	**153**	**47**	**23**	**6**	**604**	**1**	**13**	**8**	**35**	**215**	**4**	**61**	**22**	**8**	**1**	**2**	**370**	**974**

SLUICE VALVES

Sector	SubSector	AC 50	AC 75	AC 90	AC 100	AC 150	AC 200	AC 250	AC 300	AC Total	PVC 50	PVC 63	PVC 75	PVC 90	PVC 100	PVC 110	PVC 150	PVC 160	PVC 200	PVC 250	PVC 300	PVC 315	PVC Total	Total
83 A	83 A-1				45		5	6	2	58						9							9	67
	83 A-2				70	22	8	4		104				1		8		4		1	1		15	119
83 B	83 B-1				39	12		6	3	60								1			1		2	62
	83 B-2	4	3		110	53	4	11		185						26		18	2	1			47	232
84 A	84 A-1				54	8	6		3	71						72		4	7	6	1		90	161
	84 A-2				80	10	10	13		113						17			3				20	133
84 B	84 B-1				108	27	14			149			4			6		9					19	168
	84 B-2				16	2	5	1		24			11	7		24		9	2				53	77
85 A	85 A				53	15	11	1	1	81	1					31		8		3			43	124
85 B	85 B-1				11	5	2			18						19		4	6				29	47
	85 B-2				28	8	5	4		45						1							1	46
	85 B-3				6	5	6	8		25						1							1	26
85 C	85 C				47	26	1	3		77						12		1					13	90
212 A	212 A-1		1	1	11	2	2	2		19		2	5	10		138		8	3	1			167	186
	212 A-2		6		22	8	7	2		45				8		59		13	3	1	1		85	130
212 B	212 B-1				2		1			3			4			67		8	1				80	83
	212 B-2					1	1			2				1		52		9	13				75	77
213	213-1		2		52	20	4	4		82				34		71		13	7				125	207
	213-2													3		1							4	4
	213-3													2		2							4	4
253	253																							
256	256													8		8		1					17	17
259	259		18		25	19	4			66		1	2	5		2							10	76
345	345													5		67		9	1	3			85	85
346	346-1				17	9	6	2		34						25		3					28	62
	346-2				39	13		1	1	54		1	3			29		7		1			41	95
347	347-1				15	2	1			18		1	13			57		9	6	1			87	105
	347-2				39	15	2	5	3	64						63		9	3	5			80	144
348 A	348 A		11		16	13	2			42														42
348 B-1	348 B-1		13		72	28	1	3		117			2	6		8		6					22	139
348 B2																								
349 A	349 A-1		18		38	15	3	2		76			8	6		5							19	95
	349 A-2		1		5	2				8			3			7		2					12	20
	349 A-3				1					1			12			12		6	2				32	33
349 B	349 B-1												11	6		21		4		1			43	43
	349 B-2				9	1	5			15		6	5	6		8		2					27	42
	349 B-3		1		11	9	1	1		23			9			2							11	34
350	350-1				177	40	11	1	3	232													0	232
	350-2				117	23	7	4	1	152			1	17		53		13			1		85	237
351	351-1				4					4						5		2	8				15	19
	351-2															22							22	22
	351-3															4							4	4
361	361															81		22	4	8		5	120	120
368 A	368 A-1				1					1			10		14	74	1	2	9	2			112	113
	368 A-2												8		3	14		4					29	29
368 B	368 B												54		93	6	13	3	8	2		1	180	180
369 A	369 A													4	6	82	2	8	9	1			112	112
369 B	369 B						2			2			18		65		6	2	2	1			94	96
370	370				3	5	2	1		11						1			1	1			3	14
Total general		**4**	**74**	**1**	**1,343**	**418**	**139**	**85**	**17**	**2,081**	**1**	**11**	**183**	**129**	**181**	**1,272**	**22**	**223**	**100**	**39**	**5**	**6**	**2,172**	**4,253**

DRAIN VALVES / ...ULAS Y GRIFOS POR LONG. TUB. POR SUB - SE...

Sector	SubSector	AC 50	AC 100	AC 150	AC 200	AC 250	AC Total	PVC 75	PVC 90	PVC 100	PVC 110	PVC 160	PVC Total	Total	Total Hidrante	Total Válvula	Total Válv Purga	Long. Tubería Sub-Sector	Ratio (Cant. / km) Hidrante	Ratio (Cant. / km) Válvula	Ratio (Cant. / km) Válv Purga
83 A	83 A-1				1		1				1		1	2	10	67	2	11.16	0.90	6.00	0.18
	83 A-2		1	1			2							2	26	119	2	21.35	1.22	5.57	0.09
83 B	83 B-1			1			1							1	19	62	1	10.25	1.85	6.05	0.10
	83 B-2		1				1					1	1	2	62	232	2	35.62	1.74	6.51	0.06
84 A	84 A-1														30	161	0	34.09	0.88	4.72	0.00
	84 A-2			1		1	2							2	17	133	2	24.47	0.69	5.44	0.08
84 B	84 B-1		1	2			3					1	1	4	35	168	4	29.86	1.17	5.63	0.13
	84 B-2														18	77	0	13.39	1.34	5.75	0.00
85 A	85 A		1				1							1	23	124	1	17.38	1.32	7.13	0.06
85 B	85 B-1														18	47	0	9.27	1.94	5.07	0.00
	85 B-2		1	1			2							2	20	46	2	8.60	2.33	5.35	0.23
	85 B-3			1			1							1	14	26	1	5.92	2.36	4.39	0.17
85 C	85 C														34	90	0	15.62	2.18	5.76	0.00
212 A	212 A-1										3		3	3	35	186	3	30.31	1.15	6.14	0.10
	212 A-2				1		1				2		2	3	28	130	3	20.07	1.40	6.48	0.15
212 B	212 B-1														15	83	0	14.47	1.04	5.74	0.00
	212 B-2														11	77	0	12.64	0.87	6.09	0.00
213	213-1		1	1			2		2		6		8	10	36	207	10	35.34	1.02	5.86	0.28
	213-2														1	4	0	0.62	1.61	6.45	0.00
	213-3								1				1	1	2	4	1	1.08	1.85	3.70	0.93
253	253														1	0	0	0.21	4.76	0.00	0.00
256	256														0	17	0	4.32	0.00	3.94	0.00
259	259								2				2	2	17	76	2	14.05	1.21	5.41	0.14
345	345										2		2	2	11	85	2	13.37	0.82	6.36	0.15
346	346-1											1	1	1	19	62	1	9.35	2.03	6.63	0.11
	346-2														26	95	0	15.63	1.66	6.08	0.00
347	347-1														18	105	0	18.36	0.98	5.72	0.00
	347-2														28	144	0	31.45	0.89	4.58	0.00
348 A	348 A		1				1							1	13	42	1	7.64	1.70	5.50	0.13
348 B-1	348 B-1														28	139	0	20.59	1.36	6.75	0.00
348 B2																		0.38			
349 A	349 A-1														25	95	0	17.11	1.46	5.55	0.00
	349 A-2														5	20	0	3.72	1.34	5.38	0.00
	349 A-3														3	33	0	8.53	0.35	3.87	0.00
349 B	349 B-1														3	43	0	9.42	0.32	4.56	0.00
	349 B-2														8	42	0	9.15	0.87	4.59	0.00
	349 B-3														10	34	0	7.82	1.28	4.35	0.00
350	350-1	2	5				7							7	84	232	7	34.81	2.41	6.66	0.20
	350-2			1			1							1	68	237	1	37.08	1.83	6.39	0.03
351	351-1														4	19	0	2.99	1.34	6.35	0.00
	351-2														1	22	0	2.63	0.38	8.37	0.00
	351-3														1	4	0	0.65	1.54	6.15	0.00
361	361										5	1	6	6	36	120	6	26.90	1.34	4.46	0.22
368 A	368 A-1										3		3	3	20	113	3	21.98	0.91	5.14	0.14
	368 A-2														6	29	0	5.60	1.07	5.18	0.00
368 B	368 B							3		1			4	4	32	180	4	33.91	0.94	5.31	0.12
369 A	369 A										3		3	3	21	112	3	25.34	0.83	4.42	0.12
369 B	369 B							1		1			2	2	18	96	2	28.43	0.63	3.38	0.07
370	370		7	12	1	3	23	4			6		10	33	14	14	33	10.52	1.33	1.33	3.14
Total general		**2**	**19**	**21**	**3**	**4**	**49**	**8**	**5**	**2**	**31**	**4**	**50**	**99**	**974**	**4,253**	**99**	**773.45**	**1.34**	**5.34**	**0.15**

Source: SEDAPAL Cadastre and JICA Study Team

2) Pipe Materials, Diameter and Ages of Pipes

(a) Distribution of Pipes by Materials, Diameter and Ages

Distribution of the four kinds of pipe materials, ages and diameters of the pipes are presented in the following figures and tables:

- Table 2.5.8-22 : Length of Secondary Pipe by Age
- Table 2.5.8-23 : Length of AC Pipe by Age
- Table 2.5.8-24 : Length of PVC Pipe by Age
- Table 2.5.8-25 : Length of Pipe by Diameter and Material
- Figure 2.5.8-14 : Distribution of Secondary Pipes by Material
- Figure 2.5.8-15 : Distribution of Secondary Pipes by Age
- Figure 2.5.8-16 : Distribution of AC Pipes in the Secondary Networks by Age
- Figure 2.5.8-17 : Distribution of PVC Pipes in the Secondary Networks by Age
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Table 2.5.8-22: Length of Secondary Pipe by Age

Sectors	No data	Less than 5 years	From 5 to 10 Years	From 10 to 15 Years	From 15 to 20 Years	From 20 to 25 Years	From 25 to 30 Years	From 30 to 35 Years	More than 35 Years	Total (Km)
83 A-1				5.27	0.07	0.44		5.38		11.16
83 A-2			1.11	5.08	1.42	7.38		6.36		21.35
83 B-1					0.13	6.50			3.62	10.25
83 B-2			0.05	12.36	0.01	10.42		8.25	4.53	35.62
84 A-1		0.20	1.44	28.07	4.34	0.04				34.09
84 A-2				24.40	0.07					24.47
84 B-1		0.30	1.69	22.13	4.43			1.31		29.86
84 B-2			3.01	8.29	1.20			0.89		13.39
85 A		0.28	5.26	3.23	4.41	4.20				17.38
85 B-1		0.30	0.88	3.33	0.40	4.33			0.03	9.27
85 B-2	1.00	0.23				7.37				8.60
85 B-3	0.28		0.61		0.41	0.52		4.10		5.92
85 C	0.17		0.17	3.10	3.59	1.70	6.89			15.62
212 A-1		0.78	15.86	13.67						30.31
212 A-2			13.13	6.94						20.07
212 B-1			0.25	14.05	0.17					14.47
212 B-2			1.83	10.81						12.64
213-1		3.11	21.66	9.70	0.87					35.34
213-2			0.62							0.62
213-3			1.08							1.08
253		0.21								0.21
256				4.32						4.32
259					13.83				0.22	14.05
345		7.14	6.23							13.37
346-1					9.26	0.09				9.35
346-2			0.41	7.46	5.01	2.75				15.63
347-1			0.42	8.07		9.87				18.36
347-2	0.83	0.16	13.47	16.38	0.61					31.45
348 A						7.64				7.64
348 B-1		0.07	0.04	1.12	4.14	14.15			1.07	20.59
348 B-2			0.02			0.23			0.13	0.38
349 A-1		0.10	0.28	1.03	5.41	9.59			0.70	17.11
349 A-2			0.18		3.54					3.72
349 A-3					8.47					8.47
349 B-1			2.14		7.28					9.42
349 B-2			2.55		6.60					9.15
349 B-3	0.74		0.22		6.86				0.06	7.88
350-1	0.23			0.15		4.22		1.28	28.93	34.81
350-2		3.01	8.78	2.49	1.42	1.96	1.09	18.33		37.08
351-1	0.17	1.73	0.24		0.20	0.65				2.99
351-2		0.62	2.01							2.63
351-3		0.46							0.19	0.65
361	0.04	24.29	2.57							26.90
368 A-1		12.41	9.57							21.98
368 A-2		2.17	3.43							5.60
368 B		31.56	2.35							33.91
369 A		20.69	4.65							25.34
369 B		26.43	1.96		0.04					28.43
370		0.78	0.02	1.54	0.07			8.11		10.52
Total	**3.46**	**137.03**	**130.19**	**212.99**	**94.26**	**94.05**	**7.98**	**54.01**	**39.48**	**773.45**
Percentage	**0.45%**	**17.74%**	**16.85%**	**27.54%**	**12.23%**	**12.24%**	**1.03%**	**6.98%**	**4.93%**	**100.00%**

Source: JICA Study Team

Table 2.5.8-23: Length of AC Pipe by Age

Sectors	No data	Less than 5 years	From 5 to 10 Years	From 10 to 15 Years	From 15 to 20 Years	From 20 to 25 Years	From 25 to 30 Years	From 30 to 35 Years	More than 35 Years	Total (Km)
83 A-1				3.44	0.03	0.44		5.38		**9.29**
83 A-2				4.63	1.08	6.68		6.36		**18.75**
83 B-1						6.44			3.62	**10.06**
83 B-2				6.80		10.26		8.25	4.53	**29.84**
84 A-1			0.33	11.03	4.33	0.01				**15.70**
84 A-2				20.35	0.07					**20.42**
84 B-1		0.15	1.13	19.08	4.43			1.31		**26.10**
84 B-2				1.71	1.19			0.89		**3.79**
85 A			0.86	1.96	4.23	4.20				**11.25**
85 B-1			0.05	0.05	0.40	4.28				**4.78**
85 B-2	1.00					7.34				**8.34**
85 B-3	0.28		0.61			0.52		4.10		**5.51**
85 C	0.17			1.29	3.26	1.49	6.89			**13.10**
212 A-1			0.98	2.64						**3.62**
212 A-2			0.93	5.83						**6.76**
212 B-1			0.02	0.78	0.12					**0.92**
212 B-2				0.54						**0.54**
213-1		0.41	2.00	9.37	0.87					**12.65**
213-3			0.03							**0.03**
259					12.40					**12.40**
345			0.06		0.00					**0.06**
346-1					4.58	0.09				**4.67**
346-2			0.41	5.66	0.81	2.37				**9.25**
347-1			0.20	0.10		3.62				**3.92**
347-2	0.83		1.07	9.12	0.59					**11.61**
348 A						7.64				**7.64**
348 B-1					2.38	13.92			1.07	**17.37**
348 B-2			0.01		0.00	0.23				**0.24**
349 A-1					3.31	9.59				**12.90**
349 A-2			0.18		1.43					**1.61**
349 A-3					0.84					**0.84**
349 B-1					0.71					**0.71**
349 B-2					3.03					**3.03**
349 B-3	0.62				5.01					**5.63**
350-1	0.23			0.15		4.22		1.28	28.93	**34.81**
350-2		0.03	0.08	1.12	0.04	1.96	1.09	18.33		**22.65**
351-1	0.17		0.07		0.04	0.65				**0.93**
368 A-1			0.02							**0.02**
368 A-2			0.01							**0.01**
368 B			0.06							**0.06**
369 A		0.23								**0.23**
369 B		0.07	0.41							**0.48**
370		0.70		0.09				8.11		**8.90**
Total	**3.30**	**1.59**	**9.52**	**105.74**	**55.18**	**85.95**	**7.98**	**54.01**	**38.15**	**361.42**
Percentage	0.91%	0.44%	2.63%	29.26%	15.27%	23.78%	2.21%	14.95%	10.55%	100.00%

Source: JICA Study Team

Table 2.5.8-24: Length of PVC Pipe by Age

Sector	No data	Less than 5 years	From 5 to 10 Years	From 10 to 15 Years	From 15 to 20 Years	From 20 to 25 Years	Total (km)
83 A-1				1.83	0.04		1.87
83 A-2			1.11	0.45	0.34	0.70	2.61
83 B-1					0.13	0.06	0.19
83 B-2			0.05	5.56	0.01	0.16	5.79
84 A-1		0.20	1.11	17.04	0.01	0.03	18.39
84 A-2				4.05			4.05
84 B-1		0.15	0.56	3.05			3.76
84 B-2			3.01	6.58	0.01		9.60
85 A		0.28	4.40	1.27	0.18		6.13
85 B-1		0.30	0.83	3.28		0.05	4.46
85 B-2		0.23				0.03	0.26
85 B-3					0.41		0.41
85 C			0.17	1.81	0.33	0.21	2.54
212 A-1		0.78	14.88	11.03			26.68
212 A-2			12.20	1.11			13.31
212 B-1			0.23	13.27	0.05		13.55
212 B-2			1.83	10.27			12.10
213-1		2.70	19.66	0.33			22.69
213-2			0.62				0.62
213-3			1.05				1.05
253		0.21					0.21
256				4.32			4.32
259					1.43		1.43
345		7.14	6.17				13.31
346-1					4.68		4.68
346-2				1.80	4.20	0.38	6.39
347-1			0.22	7.97		6.25	14.44
347-2		0.16	12.40	7.26	0.02		19.84
348 B-1		0.07	0.04	1.12	1.76	0.23	3.22
348 B-2			0.01				0.01
349 A-1		0.10	0.28	1.03	2.10		3.50
349 A-2					2.11		2.11
349 A-3					7.63		7.63
349 B-1			2.14		6.57		8.71
349 B-2			2.55		3.57		6.12
349 B-3	0.12		0.22		1.85		2.20
350-2		2.98	8.70	1.37	1.38		14.43
351-1		1.73	0.17		0.16		2.06
351-2		0.62	2.01				2.62
351-3		0.46					0.46
361	0.04	24.29	2.57				26.90
368 A-1		12.41	9.55				21.96
368 A-2		2.17	3.42				5.59
368 B		31.56	2.29				33.85
369 A		20.46	4.65				25.10
369 B		26.36	1.55		0.04		27.96
370		0.08	0.02	1.45	0.07		1.62
Total	0.16	135.44	120.67	107.25	39.08	8.10	410.70
Percentage	0.04%	32.97%	29.38%	26.12%	9.52%	1.98%	100.00%

Source: JICA Study Team

Table 2.5.8-25: Length of Pipe by Diameter and Material

Diameter (mm)	Pipe Length by Diameter and Material				Total (km)
	AC	ACERO	FOFO	PVC	
50	1.08		0.13	0.27	1.48
63				2.25	2.25
75	18.49			40.14	58.63
90	0.03			24.31	24.34
100	215.26		0.19	42.39	257.84
110				219.81	219.81
150	72.52			5.18	77.70
160				40.35	40.35
200	28.77		0.03	22.05	50.85
250	19.49	0.22		11.08	30.79
300	5.78	0.76		1.58	8.12
315				1.29	1.29
Total	**361.42**	**0.98**	**0.35**	**410.70**	**773.45**

Source: JICA Study Team