CHAPTER 1 INTRODUCTION

1.1 Background

The Study Team of Japan International Cooperation Agency (hereinafter referred to as Study Team) for the Study on Integrated Water Resources Development in the Cañete River Basin in the Republic of Peru submitted Interim Report, the result of [PHASE I] to Potable Water and Sewage Service of Lima (hereinafter referred to as SEDAPAL) on February 22, 2000. The Interim Report summarized the output of Phase I Master Plan Formulation that was executed from March to December 1999.

SEDAPAL and JICA discussed about possibility of implementation of [PHASE II] based on Interim Report as stipulated in the Scope of Work signed on November 22^{nd}, and agreed on implementation procedure of PHASE II as described in item 2 of the Minutes of Meeting signed on March 1, 2000, in which:

(1) SEDAPAL requested the work procedure in Phase II as illustrated in the attached diagram, and

(2) JICA proposed that it would like to proceed with the supplemental investigation of water use and water loss in the Rímac River at first to clarify uncertain supply capacity of raw water at La Atarjea intake, but it would like to determine the implementation of Phase II and the content of its TOR based on the result of the supplemental investigation.

The Study Team commenced the Supplemental Investigation on August 7, 2001, and the scope of the study was agreed upon between SEDAPAL and JICA as stipulated in the Minutes of Meeting signed August 27, 2001.

The report presents the results of the study.

1.2 Purpose of the Supplemental Investigation

The purpose of the Supplemental Investigation is:

(1) To obtain necessary data and information of the water use and water quality in the main stream of the Rímac River, and the main stream of the tributaries, the Santa Eulalia River and the San Mateo River.

(2) To identify and to confirm problems in water use, water quality, and water demand.

(3) To assess if the water losses in the main stream of the Rímac River in the dry season are larger than or equal to that estimated in the SEDAPAL's Water Supply Master Plan for Lima Metropolitan Area (December 1998).

(4) To clarify the implementation of the feasibility study for Phase II.

1.3 Study Area

The Study area is the Rímac River basin, one of the most important rivers of Peru, where, the capital city, Lima occupies its coastal and middle stretch. It provides the basic needs of water resources to support its natural environment and the greatest socio-economic activity of the country, where more than 30 % of the national population, about 7.5 million in 2001, and more than 60 % of the industries are concentrated.

CHAPTER 2 EXISTING CONDITIONS OF THE RÍMAC RIVER BASIN

2.1 Topography and Geology

(1) Topography and Geology

The catchment area of the Rímac River is about 3,583 km^2, of which altitude varies from sea level to 4,850 m.a.s.l. The length of the main stream is 143 km and its average river gradient is 1/29.5 (0.0339). The main river divides upstream of Chosica into two tributaries, the Santa Eulalia River and the Rímac River. (The stretch higher than elevation 2,500 m.a.s.l. yields water resources.)

In general, the basin is covered by elastic sedimentary and volcanic formations of the age from Jurassic to Tertiary, intrusive rocks of the age from Cretaceous to Tertiary and also Quaternary deposits. The geological map of the Rímac River basin is shown in Figure 2.1.1. The kinds of rock formulating the Rímac River basin, the lithology units are shown in Table 2.1.1.

Jurassic formations are exposed in the northern part of Lima and extend to NW-SE direction along the Pacific Coast. The formations consist predominantly of Andesitic extrusives associated with chart, shale, and etc.

Cretaceous formations are distributed in the North-West direction, and found with irregular form in the Rímac River basin. The formations are rich in calcareous marine facies indicating unconsolidated condition. These are composed of limestone associated with marl, shale and quartzite. Some volcanic facies, however, consisting of predominant andesitic lava and volcaniclastics are exposed in the coastal area. The cretaceous rocks have been notably subjected to folding with NW-SE axis, and also are cut by many faults with NW-SE and EW directions.

Tertiary groups and formations are extensively distributed in the middle and upper reaches. These are divided into three zones, the lower, the middle and the upper. The rocks of this age are characterized by the presence of predominant volcanic materials.

The volcanic extrusives from the lower zone to the lower half of the middle zone are andesitic facies which consist mainly of lavas, breccias and tuffs intercalated with tuffaceous sandstone, lapilli's tuff, sandstone and mudstone.

Andesitic and basaltic rocks are seen in the uppermost horizon of the upper zone. These rocks are probably Mio-Pliocence in age.

Various facies of intrusive rocks are found in the western area of the Western Cordillera. These intrusives consist of granite, granodiorite, and tonalite, etc. of Cretaceous and Tertiary ages and andesite of Cretaceous. Their general trend is NW-SE parallel to the Western Cordillera. Some plutonic rocks exist in large batholiths.

Small intrusive bodies such as andesite, rhyodacite, and trachyandesite are found in the Tertiary area.

There are many metal mines in the investigated area. Principal mineralization has been associated with igneous activity in Miocene deformation stage during Andean geotectonic process. The minings excavate various types of minerals which consist of galena, spherlite, chalcopyrite, barite with pyrite, etc.

Quaternary deposits, divided into Pleistocene and Helocene, consist of terrace with various levels, glacial, recent river and talus deposits. The deposits forming the ground of Lima is largest among them in scale. Thick piles of sand and gravel with clay are found. Major part of the deposits are presumably Pleistocence in age and covered by fan deposits of the Rímac river.

(2) Weathering and Unconsolidated Deposits

The basin is situated in the arid or semi-arid climate area with less vegetation. Furthermore, the mountains in the basin (the Andes mountains) upheaved during the Tertiary are accompanied with various faults and fractures. As such, the basin is severely exposed to weathering, making the basin vulnerable to the various disasters.

River terraces formed at Pleistocene are found in several places along the Rímac and Santa Eulalia river. There is a distribution of two or three-layered terrace deposits having its height ranging from 10 to 50 m in the vicinity of Chosica. There is also terrace deposits in the upstream of Chosica. These deposits consist of boulder, gravel, sand, and clay having its thickness ranging from 30 to 50 m. Gravels and boulders that occupy a large part of the deposit have its size from a fist size to block more than 1 m. These are shaped roundly.

There are also old deposits which have a height of around 120 m above river bed in the upstream of Santa Eulalia river. These deposits presumed to be formed during glacial epoch are composed of various size of angular rocky materials. The similar type of deposits is also extensively distributed in many tributaries of the basin. This is the so-called “Older Huaycos” in Peru.

The deposits categorized as the formation of Holocene age are classified into various size of fan deposits, recent river and glacial deposits, and deposits on slopes of mountains or hilly side.

The recent river deposits are independently identified, although they include fan deposits. In the area from middle to lower reaches, thick deposits consisting of various size of boulder, gravel, sand, and clay sediment on river bed exist extensively. This sedimentation volume is considered to be enormous particularly downstream of Carapongo.

Slope deposits are widely distributed in the areas, middle to upper reaches of the basin as talus deposits or debris cones. These deposits are distributed on steep slope having gradient from 36 to 38 degrees.

2.2 Meteorology and Hydrology

2.2.1 General

The Rímac river basin is composed of the sub basins of the Santa Eulalia and San Mateo rivers. These two rivers merge into the Rímac river at the immediately upstream of Chosica city. The basin area is 3,583 km^2, and the altitude of the Rímac river basin is from coast to 4,818 m.a.s.l. at Anticona in Ticlio. The elevated area of 2,211 km^2 is located at humid basin over 2,500 m.a.s.l. The area is characterized by a quite large ground relief, therefore the climatic feature in the basin is complex through the 150 km from the coast to the mountainous area. Oceanic climate system generates two distinct seasons, i.e. the wet season from November to April and the dry season from May to October. Less rainfall has been observed in the coastal area due to an effect of the Humboldt current, which provides cool air mass and it prevent an ascending air current.

2.2.2 Rainfall

River basins for supplying water source to Lima city consist of the river basins of the Rímac, Chillón, Lurín and most upstream area of the Mantaro. The basins has steep slope of average 1:25 towards their upstream areas of the elevation of 5,000 m except the upstream area of the Mantaro river basin which lies on mountainous area at the elevation of 4,000 m to 5,000 m. Figure 2.2.1 and Table 2.2.1 show location of the rainfall observation stations and mean monthly rainfall, respectively. The distribution of mean annual rainfall amount on each altitude is illustrated in Figure 2.2.2. In the coastal area, the rainfall amount is very few throughout the year, i.e. less than 50 mm. Rainfall amount gradually increases corresponding to the altitude, e.g., about 250 mm at El. 2,000 m, 400 mm at El. 3,000 m and 600 to 900 mm at El. 4,000 m or higher.

Most of the rainfall observation stations in the Mantaro river basin are located at their altitude of 3,700 to 4,600 m. Mean annual rainfall ranges between 550 mm to 900 mm. The largest annual mean and maximum annual rainfall amounts were observed at Marcapomacocha (El. 4,600 m) about 1,308 mm and 2,209 mm during 27 years (1969 - 1995). In the recent three decades, the principal El Nino has occurred in 1972-73, 1982-83 and 1991-92 and 1997. The following table shows probable rainfall amount and observation year at the stations at Milloc (El. 4,400 m, Rímac river basin) and Marcapomacocha (El. 4,600 m, Mantaro river basin).

Probable Rainfall Amount

Return period (year)	Milloc Station		Marcapomacocha Station	
	Probable Rainfall (mm)	Year occurred (rainfall amount)	Probable Rainfall (mm)	Year occurred (rainfall amount)
2	838.7		1,244.7	
5	683.4	1983(714mm)	864.8	
10	621.1	1976(653mm)	697.6	1976(669mm), 1972(676mm)
20	577.4	1991(581mm), 1992(576mm)	573.4	1971(561mm)
50	535.3		447.4	
100	510.9		370.5	

2.2.3 Meteorological Data

There are 12 climatological stations in and adjacent basins of the Rímac river basin as shown in Figure 2.2.3. Meteorological data are available for estimating evaporation from the catchment area during run-off analysis and also for a calculation of a crop water requirement.

(1) Temperature

Temperature in the Rímac and Mantaro river basins has been observed in several stations. Monthly mean temperature records are in Table 2.2.2. The mean yearly temperatures are recorded 18.6 ^{o}C at Campo de Marte, 19.8 ^{o}C at Chosica, 14.5 ^{o}C at Matucana and 5.0 ^{o}C at the altitude of 150 m, 870 m, 2,380 m and 4,400 m, respectively. Monthly temperature varies 15.3 ^{o}C to 22.7 ^{o}C at Campo de Marte and 14.1 ^{o}C to 15.2 ^{o}C at Matucana station.

(2) Humidity

The monthly relative humidity are presented in Table 2.2.3. The mean yearly relative humidity ranges from 85 % at Campo de Marte, 71 % at Chosica and 67 % at Matucana, corresponding to its altitude.

(3) Wind Velocity and Direction

Monthly wind velocity records are presented in Table 2.2.4. The mean monthly wind velocity fluctuates over the year ranging from 9.3 km/day (or 2.6 m/sec) to 14.8 km/day (or 4.1 m/sec) at Campo de Marte, and from 13.0 km/day (or 3.6 m/sec) to 17.2 km/day (or 4.8 m/sec) at Matucana. The constant wind direction of SW is observed at Campo de Marte and Matucana stations through the year.

(4) Sunshine

The longest mean monthly sunshine hour is 64 % or 7.6 hour/day in April at La Molina station, meanwhile the shortest is 5.2 % or 0.6 hour/day in August at the Hipolito Unanue station. The mean monthly sunshine duration is shown in Table 2.2.5.

(5) Evaporation

Annual evaporation varies mainly sunshine duration and relative humidity, e.g., higher rate of 1,690 mm/year or 4.6 mm/day at the Matucana station, while 516 mm/year or 1.4 mm/day at the Hipolito Unanue station. Mean monthly evaporation data are in Table 2.2.6.

(6) Preparation for Reference Crop Evapotranspiration (ETo)

A set of climatological data observed at the La Molina station are prepared for the Reference Crop Evapotranspiration (ETo) calculation of irrigation water demand. Reference Crop Evapotranspiration is estimated by the modified Penman method

ETo Calculation (Mean Monthly ETo)

(unit : mm/day)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
La Molina	4.8	4.9	4.8	3.8	2.7	2.0	1.9	2.2	2.9	3.3	3.9	4.1	3.4

2.2.4 Hydrology

(1) River System

(a) River System in and around the Rímac River Basin

There are two (2) major river basins adjacent to the Rímac river basin, namely the Chillón and Lurín river basins at the north and the south, which supply water to the Lima city and surroundings at present. In addition, the upstream area in the Mantaro river basin supplies water to the Lima city, which are situated at the most upstream of the Rímac and Chillón river basins. The Chillón, Rímac and Lurín river basins have been developed in parallel originating from the Andes mountainous area of more than 4,500 m a.s.l. and flows down to the estuary along the Pacific Ocean. The Mantaro river is one of the major tributaries of the Amazon river located at the most upstream of the river. The upstream area of the Mantaro river basin lies on highly elevated mountainous area from 3,800 m to 5,000 m or higher.

Several lagoons (glacial lakes) have been developed at highly elevated areas of these river basins. The lagoons contribute to control the run-off from their catchment areas and also increase their storage capacity for the water supply to Lima city, especially in the dry season since 1965.

The catchment area of the river basins are as follows:

Catchment Areas of River Basins

River Basins	Catchment Area (km^2)	Remarks
Chillón river	2,237	
Rímac river	3,583	
Lurín river	1,642	
Mantaro basin	827.5	Marca I : 147.0 km^2 Marca II : 335.0 km^2 Marca III : 116.5 km^2 Carispacocha : 229.0 km^2

Note: Master Plan (SEDAPAL, 1998)

(b) River System in Rímac River Basin

The principal rivers in the Rímac river basin is the Rímac (San Mateo at upstream) and Santa Eulalia rivers. The Rímac river flows towards south-west, and the Santa Eulalia river flows almost parallel with the Rímac river of its upstream and joins to the Rímac river at Chosica, 55 km from the estuary. The

Rímac river has other tributaries at the most upstream, 115 km from the estuary, namely the Antaranra and the Blanco rivers. The catchment areas of the Rímac and Santa Eulalia rivers at the confluence are 1,228 km^2 and 1,085 km^2, respectively. The Blanco river originates at the Quiullacocha lagoon (El. 4,850 m) and joins to the Rímac river at about El. 3,500 m. The Santa Eulalia river originates at Milloc (El. 4,345 m), 115 km from the estuary, and joins to the Rímac river at the elevation of 870 m. Longitudinal slope of the Rímac and Santa Eulalia rivers are 1/23 and 1/17 at the upstream of the confluence, and 1/65 at the lower reach after the confluence. Longitudinal profile of the Rímac river is in Figure 2.2.4.

(c) River System in Mantaro River Basin

Upstream area of the Mantaro river basin contributes to supplying water to the Lima and surrounding area for the purposes of a potable water, hydropower generation, industrial, irrigation water supply, etc. Several lagoons are located at the most upstream of the Mantaro river basin. The plural number of the glacial lakes rink each other with small streams, and the tributaries originate from these lagoons merge into the Mantaro river.

(2) Run-off of River System

(a) Hydrological Station and Available Data

Location of the water level gauging stations in and around the Rímac river basin are presented in Figure 2.2.5. These observation data are available for the run-off analysis. (see Annex I)

(b) Run-off of Rímac River Basin

Mean annual discharge observed at Chosica station (SENAMHI) is estimated at approximately 25.8 m^3/sec, 814 MCM for a period of 30 years, 1965 to 1994 after the Marca I project and lagoon rehabilitation works upstream of the Santa Eulalia river have been completed in 1965. Figure 2.2.6 explains a quantitative effect of water diversion from the Mantaro basin in the minimum discharge level, and also clearly shows decrease of maximum discharge accompanied by re-routing effect by the lagoons in the Santa Eulalia basin since 1965. Major reservoirs and lagoons are listed in Table 2.2.7, and their storage sequence in 2000 is illustrated in Figure 2.2.7. Total effective storage volume of 125 MCM in the Rímac river basin contributes to constantly maintain river flow about 6.9 m^3/sec for the period of May to November except drought year.

(c) Reservoirs and Lagoons in Mantaro River Basin

Water source development plans in the Mantaro river basin have been implemented since 1962 corresponding to an increase of the water demand in Lima and surrounding area including a hydropower generation, i.e., a series of Marca projects. The main feature of these project from a view point of hydrological potential are as follows:

Description of Marca and Other Related Projects

Project Title	Reservoir and Lagoons	Diversion Capacity	Remarks
Marca I+III	Marcapomacocha, Marcacocha : 25.50 MCM Antacoto : 120.00 MCM	7.0 m^3/sec	
Marca II	Huacracocha : 7.50 MCM Huascacocha : 9.30 MCM Huallacocha Alto : 0.74 MCM Huallacocha Bajo : 18.00 MCM Pomacocha : 70.00 MCM Total : 105.54 MCM	6.5 m^3/sec	
Huascacocha	52.50 MCM	2.5 m^3/sec	
Mantaro-Carispacha	Carispacha : 22.50 MCM Marcapomacocha : 100-140 MCM (*) Antacoto : 120.00 MCM	5.0 m^3/sec	

Notes: (*) Existing capacity is 14.8 MCM

2.3 Existing Water Use and Water Rights

2.3.1 Irrigation Facility

Although it is located in the capital of the Republic, the Rímac River Valley has a deficient irrigation facility, which is mostly primitive with land channels without control gates at the intakes (except for La Estrella Channel, which has a metallic caterpillar gate). The quick reduction of the agricultural area is a main reason that troubles the cultivation and irrigation expansion plans and the appropriate technical distribution as well.

In the Rímac River Irrigation District, from Chosica to Callao, there are 18 intakes for irrigation and industry use, La Atarjea intake for potable water supply and diversion channel for the Huampaní Hydroelectric Power Station. Only one of these channels has a determined intake, corresponding to the Huampaní Hydroelectric Power Station. Only La Estrella, Nievería, and the Old Chosica channels count with RBC(*) discharge meters, with a total catchment of 6.8 m^3/sec for agricultural purposes in the Rímac Irrigation District, including all the intakes from Surco to Chosica (Figure 2.3.1).

The Chillón-Rímac-Lurín Irrigation District Technical Administration, the Rímac River Board of Users, and SEDAPAL were going to sign an agreement on the Rímac River water distribution in drought season (1999) for a better water use and management. But, although it was not carried out, the fifth clause of the agreement determined the flow rates for the different uses, as follows:

(*) RBC = Open channel broad crest discharge meters and stand for:

R = Reploge, B = Boss, C = Clemens

(a)	Population	80%
(b)	Agriculture (Carapongo, La Estrella, Nevería, Huachipa, Ate and Surco)	13%
(c)	Mining Industry (Cajamarquilla)	1%
(d)	Infiltration	6%

In addition, the Rímac River minimum flow was established in 9.88 m^3/sec (1921-1997), considering a persistence of 90%.

2.3.2 Present Water Use Evaluation for Irrigation and Its Problems

There are several problems on the water use for irrigation, as follows:

(1) Seasonal Inconsistency in the Water Demand and the River Discharge

There are problems about the lack of water for irrigation, due to seasonal aspects and river flow irregularities.

(2) High Contamination

The shanty towns throw industrial wastes and garbage to the Rímac river, contaminating the crops, particularly the low-stem crops (vegetables).

(3) Deterioration of Intake Works and Irrigation Channels

Many of the channels are land conduits, that is the reason for high conveyance losses. Frequently, there are no intake gates or they are deteriorated.

(4) Inappropriate Management of the Water Resources

Most of the times there are no measuring facilities and there is no maintenance of the irrigation channels. This situation thus contributes with the water losses.

(5) Poor Irrigation Proficiencies

This situation occurs in areas with bad constructed ditches and water wells; consequently, the infiltration is not uniform.

(6) The Board of Users does not have any policy to save water for better irrigation proficiencies.

(7) The farmers do not comply with their water rates and fees.

This situation does not allow the implementation of an appropriate control and measuring facility.

2.3.3 Water Rights

(1) Jurisdiction and Management Authority

The Irrigation District is a geographical area upon which the Irrigation District Technical Administrator exercises authority. The Ministry of Agriculture will establish the area of each Irrigation District based on real aspects of the watershed and the needs for effective water management.

Watersheds with regulated irrigation and intensive multi-sectoral water use, like the Rímac River, are managed by the Rímac River Basin Autonomous Authority, which is responsible for formulating water resource development plans in its jurisdiction. As the main public user, SEDAPAL belongs to the Board of Directors.

The Rímac River Basin Self-Governed Authority is responsible for formulating master plans on water resource development, supervising watershed management and water-related actions, solving ultimately any appeals lodged against the directives issued by the Irrigation District Technical Administrator.

(2) Board of Users

This organization represents all the water users of the Irrigation District. It is conformed by one or more representatives of each Irrigation Users Commission, one delegate of the Sanitation Service Agencies to which SEDAPAL belongs, two delegates named by the users of the Energy and Mining Sectors, respectively; and one delegate of other sectors. As the main user of the Rímac basin water resources for domestic and public purposes, SEDAPAL has preference and priority before the agricultural uses, according to the General Law of Waters.

(3) Government Bodies

The Board of Users, the General Assembly, and the Board of Directors are government bodies; but the General Assembly is the most important one because all the water users constitute it.

(4) SEDAPAL Administrative Proficiency

SEDAPAL, as a water user of the Rímac Irrigation District, is part of the Board of Users; and, consequently, has the monthly assignment of supplying water for public use, complying with the payment of rates.

The organization of the water use and management and its relation with SEDAPAL in the Rímac River basin are shown in Figure 2.3.2.

Source: *Law for Boards of Users and Irrigation Commissions*
Edited by the National Board of Users of the Irrigation District of Perú
March 2001

2.4 Water Quality and Environment

(1) General Description of Water Quality and Environment

It has been reported since 1960^{th} that the water quality of the Rímac River is significantly contaminated from its origin in Ticlio to the river mouth in Callao due to toxic chemical substances (acids, pesticide, fertilizer, nitrate, sulfates, heavy metals, etc.), non degradable materials (plastic, rubber, metal, etc.) and microorganism (coliforms, viruses, general pathogen, etc.). Those are discharged from more than 107 entities (domestic, industrial, mining and agricultural-farming). The water quality of the tributary, the Santa Eulalia River is reported to be fairly good.

It was reported that biological resources, wild life, plant life, and land ecosystems were completely transformed since 1960th, in particular the ecosystems induced in the agricultural fields, the river forests, and the urban parks. Those transformed include high diversity of birds, rodents, insects and reptiles. The hydro-biological resources are also practically extinct. The river shrimp and an endemic fish, pejerrey were extinct since 1960th. However, many of natural springs in the valley between Chosica and La Atarjea still sustain very small and ornamental fish.

The legislation decree No. 613, Environmental and Natural Resources Code was enacted on September 8, 1990. The general water law, D.L. No. 17752 was enacted on July 24, 1969. Under the general water law and its norms, the environmental sanitation office of the Ministry of Health is the institution in charge of enforcing compliance to these established norms. The legislation decree No. 613, Environmental and Natural Resources Code was enacted on September 8, 1990.

(2) Water Quality Monitoring Method and Result

SEDAPAL has established its monitoring water quality program including establishment of sampling stations in order to evaluate and determine the water quality of the entire Rímac River basin. Physical and chemical analyses of water samples for the program started from 1993 in the SEDAPAL's laboratory for the following parameters:

Physiochemical pH, temperature, muddiness, specific conductivity, dissolved oxygen, total solids, dissolved oxygen, total solids, dissolved solids, suspended solids, cyanide, total carbon, inorganic carbon, organic carbon, trihalomethanes, iron, manganese, lead, cadmium, chrome, copper, zinc, aluminum, barium, arsenic.

Metals iron, manganese, lead, cadmium, chrome, copper, zinc, aluminum, barium, arsenic.

These parameters are mainly total metals and dissolved in water. All the metals in the list are considered toxic. These parameters are required to evaluate the level of contamination. Some parameters are also used to evaluate the environmental impact or the toxicity level of the water, whether for human health reasons, aquatic resources, agriculture or irrigation.

SEDAPAL's laboratory adopts the physical-chemical analysis, metal analysis, cyanide analysis, organic carbon analysis, trihalomethane analysis. The analytical method for respective parameters is shown in Table 2.4.1. The annual average results of the water quality analysis in the period 1993-1996 are summarized in Table 2.4.2. The conditions of 1999-2000 period was reported to be more ore less same. The location and condition of the sampling station is shown in Figure 2.4.1. These values are compared to the permissible limits for watercourses, Classes I of the general water law, D. L. No. 17752 shown in Table 2.4.3 and the level of the WHO guidelines. The condition of the water quality is summarized below.

Parameters	Limits of General Water Law	WHO Guidelines	Quality Level
Physical-chemical analysis			
pH	5 – 9	< 8	Within the permissible limit for Classes I & III
Suspended solids (turbidity)	0 mg/l	5	Fairly high value (34.5mg/l) at La Atarjea, increasing from Graton tunnel to Tamboreque intake, Lower in Huanpani-La Atarjea stretch than the mountain reach (21-61mg/l)
Dissolved Oxygen (DO)	> 3.0 mg/l		Within the permissible limits for all the classes
Metal Analysis			
Aluminum, Al	-	0.2 mg/l	High concentrations identified in the complex in Tamboreque (0.5-6.0 mg/l) and the Aruri river (0.9-1.5 mg/l), La Atarjea intake (0.6-2.1 mg/l), the rest below 2.0 mg/l)
Arsenic, As	0.1 mg/l	0.01 mg/l	Identified above the permissible limit for Class I and III (0.2 mg/l), The complex in Tamboreque (0.04-2.1 mg/l), Ruri river (0.31-0.63), La Atarjea intake (0.02-0.07), the rest below the permissible limit
Barium, Ba	0.1 mg/l	0.7 mg/l	Identified above the permissible limit for Class I at all stations, La Atarjea intake (max.0.14 mg/l)
Cadmium, Cd	0.01 mg/l	0.003 mg/l	Identified above the permissible limit for Class I at several stations (0.01-0.03 mg/l), La Atarjea intake (0.004-005 mg/l)
Zinc	5.0 mg/l	3.0 mg/l	Mostly below permissible limit for human consumption for Class I (5.0 mg/l) and Class III (25.0 mg/l), Maximum identified at Tamboreque (6.3 mg/l) and Arui river (5.1 mg/l)
Copper, cu	1.0 mg/l	2.0 mg/l	Below permissible limit for Class I (1.0 mg/l) at all stations, The complex in Tamboreque (1.1-0.29 mg/l), La Atarjea intake (0.006-0.09 mg/l)
Chrome, Cr	0.05 mg/l	0.05 mg/l	Below permissible limit for Class I (0.05 mg/l) at all stations, The complex in Tamboreque (0.0007-0.01 mg/l), La Atarjea intake (max. 0.013 mg/l)
Iron, Ir	1.5 mg/l	0.3 mg/l	Identified above the permissible limit for Class I at all stations, La Atarjea intake (2.7-5.3 mg/l), Santa Eulalia river (0.58-1.55 mg/l), Tamboreque II bridge (max 9.36 mg/)
Manganese	0.1 mg/l	0.5 mg/l	Above permissible limit for Class I at most stations except Santa Eulalia river (0.04-0.12 mg/l), La Atarjea intake (max. 0.13-0.22 mg/l)
Lead, Pb	0.05 mg/l	0.01 mg/l	Above permissible limit for Class I at all stations, lowest in Santa Eulalia river, La Atarjea intake (max. 0.17-0.26 mg/l)
Cyanide	0.2 mg/l	0.07 mg/l	Below permissible limit for Class I at all stations, The complex in Tamboreque (0.005-0.01 mg/l), La Atarjea intake (max. 0.0011 mg/l)
Trihalomethane analysis	-	-	1.88-13.93µg/l (from other data 1993-1996)

Concentration of most of the toxic substances are identified significantly higher than the permissible maximum limits, in particular lead and arsenic at Station No. 6 downstream of the Tamboreque mine complex.

Domestic wastewater contains fecal liquid and solids. Bacteriologic contamination is caused mainly by this source. This problem was confirmed through an invertebrate macro study by FAO (1993). High concentration of fecal coliforms were reported downstream of Chosica all the year, in particular in the area between Ricardo Palma and Chaclacayo (30,00-160,000 NMP/100ml in 1993-2000). It varied from 1,000 to

240,000 NMP/100ml at the La Atarjea Intake in 1993-2000. Main sources of organic contamination result from the industries located along the river, mainly between Ricardo Plama and Ñaña with small contribution from agricultural and domestic sources (CEPIS 1992). BOD was recorded in a range 1.2-7.3 mg/l in 1993-2000.

Assessment of these values is presented in Section 3.3.

2.5 Hydrogeology and Ground Water

The aquifer of Lima is made of complex fluvial-alluvial formations, intercrossed with bedding levels and its thickness varies from 100 m in Vitarte (Huachipa Bridge) to 400-600 m in the coastal area, according to geophysical studies.

There are isolated outcrops in the valley like hills arising at several points of the fluvial-alluvial plain and the plain continues to the Western Andean Mountain foothills, among which the Rímac and Chillón Rivers run, crossing the valley.

The wells located at the alluvial plain of the valley reach up to 200-m depth. However, it is not known which are the deepest parts of the alluvial aquifer.

It has been possible to check lithological profiles and geophysical conditions of the upper part of the alluvial plain of the lower reach of the Rímac river basin. The plain is composed of granular sediments, and these tend to accumulate a greater quantity of fine sediments in deeper portion, becoming less usable as an aquifer.

In the valley, the rock foundation is at depths varying from 100 m in Vitarte to 400-600 m toward the Coastal area.

Hydrogeological parameters of transmissivity at the valley are between 6×10^{-2} and 6×10^{-3} m^2/sec; and average discharges for wells are approximately 35 l/sec. In the tubular wells of 100-m depth the permeability is between 8 and 80 m/day or the equivalent to 1.0×10^{-4} to 1.0×10^{-3} m/sec. However, reductions in piezometric levels of ground water in the valley have made necessary to drill wells at greater depths, finding lithological strata with less pervious, clayey characteristics, and recording permeability values lower than 10^{-7} to 10^{-5} m/sec. There is not a clear trend in the distribution of hydrodynamic values in the valley.

Regarding storage coefficients, these have been obtained from different pumping tests carried out in development wells in the valley; and values varied from 0.2 % to 5.0%. Testing carried out in wells after the 1980s, which are drilled at greater depths, show less favorable values ranging from 0.1% to 5.0%. The representative storage coefficient obtained from tests of wells built for the induced recharge pilot project on the Rímac riverbank is 15%.

The recharge of the Rímac River Valley aquifer is carried out basically from ground water flows of the upper part of the valley (7.20 m^3/sec); filtration flows from irrigation channels and leaks of the sewerage network in the urban area (1.60 m^3/sec); the interchange between Chillón River, Rímac River and the aquifer (3.90 m^3/sec); and from the interchange between the aquifer and the sea (seawater inflow or fresh water outflow) (1.30 m^3/sec).

The Amsa-Antea Association made these calculations in 1998.

The map on water level isodepth - prepared by Antea-Amsa in 1997 - shows that ground water depths in relation to ground level, on the Rímac left riverbank, vary from 10 to 40 m in the valley inlet, 50 to 60 m to the West and the Pacific Ocean between the limits of Lima and Callao. The ground water depths decrease lower than 10 m near the coast. The piezometric levels in the valley in relation to the mean sea level for 1997 vary from -15 m.a.s.l in the coastal area to more than 300 m.a.s.l between Huachipa and Carapongo.

On the Rímac right riverbank, at the junction of Rímac and Chillón rivers, the ground water depth varies from less than 10 m near the coast to 60 m in the direction of the Andean Mountain foothills, to the east of the coastline.

In the comparison of hydroisohipsa curves for water depths referred to the mean water level of 1971 with those of 1997, it can be noted a displacement of curves for 1971 to the valley in about 7.0 km for similar levels. This demonstrates that water levels in the aquifer are getting deeper.

The evolution of ground water development in the Rímac River Valley has increased in 5 m^3/sec in almost 28 years, from 7 m^3/sec in 1969 to12 m^3/sec in 1997, out of 12 m^3/sec, 8.3 m^3/sec was exploited by SEDAPAL and 3.70 m^3/sec by private sector.

The valley ground water has suffered an unbalance in the last 30 years due to the overexploitation of ground water through tubular wells. This unbalance, interpreted as permanent decreases in ground water, has caused a decline of ground water levels at a rate of 1.5 m/year, and there are many borderlines of aquifer with decreases of up to 4.0 m per year. These decreases have caused the inflow of seawater into the aquifer, contaminating it. The damaged areas are the districts located in the coastal zone.

To date, the ground water exploitation at the valley is of 12 m^3/sec (6 m^3/sec by SEDAPAL and 6 m^3/sec by private sector), including the aquifers of Rímac and Chillón rivers. In order to maintain the balance of inflow and outflow water in the aquifer of Lima, ground water exploitation should not exceed 8.0 m^3/sec, expressed in a constant discharge or its equivalent to 240 MCM (Amsa-Antea, 1999), in the other hand SEDAPAL as conservationist policy is limiting ground water exploitation to 5 m^3/sec.

In 1997, the aquifer exploited 12 m^3/sec using 1,100 tubular wells (from which 400 were for population use, with discharges of 8.3 m^3/sec, and 700 were for the industrial use with discharges of 2.45 m^3/sec), and 50 wells for private agricultural use with discharges of 1 m^3/sec.

The evolution of values for electric conductivity that measures the global concentration of dissolved salts in water has shown variations. The electric conductivity data for 1971, obtained from the hydrogeological map of Lima was between 0.6 and 3.0 mmhos/cm at +25°C, while the conductivity data recorded for 1994 are between 0.4 and 6.0 mmhos/cm at + 25 °C.

This increase in conductivity denotes the chemical damage that the Rímac River Valley aquifer suffers, due to an overexploitation of ground water, without considering the ground water salinity due to seawater inflow.

The valley waters are classified chemically in bicarbonate-calcium waters and sulfate-calcium waters.

The induced recharge pilot project operates along 6 km of the middle Rímac river valley, upstream from La Atarjea treatment plant, by drilling 30 wells located near the Rímac riverbanks: 18 on the right riverbank and 12 on the left riverbank, with a production capacity of 1.5 m^3/sec.

Based on the results of the induced recharge pilot project, consideration is being given to carry on and expand the project until reaching 22 km, to the town of Chaclacayo. From the 400 m^3/sec surface water that currently discharge to the sea during flood seasons, it is expected to divert 5 m^3/sec surface water.

CHAPTER 3 ASSESSMENT OF WATER QUANTITY AND QUALITY

3.1 Rainfall and Discharge

3.1.1 Rainfall

(1) Mean Rainfall Amount

Mean rainfall amount in the Rímac river basin is estimated at about 450 mm as below due to the fact that the rainfall amount is correlated to the altitude as shown in Figure 2.2.2.

Mean Annual Rainfall Amount in Rímac River Basin

Altitude				Drainage Area	Area Percentage	Mean Rainfall	Weighted Rainfall
(m.a.s.l.)				(km^2)	(%)	(mm/year)	(mm/year)
0	-	1,000		816	22.8	0	0.0
1,000	-	2,000		484	13.5	150	20.3
2,000	-	3,000		395	11.0	350	38.5
3,000	-	4,000		444	12.4	550	68.2
4,000	-	Higher		1,444	40.3	800	322.4
Total				3,583	100.0		449.4

(2) Probable Rainfall

In addition to the vertical rainfall distribution shown in above, horizontal rainfall distribution in the Rímac and Mantaro river basins was studied. Probable rainfall is applicable to examine a fluctuation of the annual rainfall amount in each rainfall station. Probable annual rainfall amount in the Rímac and Mantaro river basins are enumerated in Table 3.1.1. It is notified that the annual rainfall in the Mantaro river basin is about 200 mm larger than that in the Rímac river basin in the same altitude. Furthermore a difference of the annual rainfall amounts among several stations are less observed in the Mantaro river basin than the Rímac river basin.

3.1.2 Discharge

(1) Availability of Discharge Records

There are several discharge measurement stations, especially in the river basins of the Rímac and Mantaro as shown in location map in Figure 2.2.5. The SENAMHI, EDEGEL and SEDAPAL are responsible for the data collection and processing in most of the stations. The discharge data have been practicably analyzed in monthly and annual basis.

The annual run-off in the Rímac river basin (1965-1994) is estimated at about 21.3 m^3/sec (672 MCM) in average referring to the discharge balance observed at the Chosica station (EDEGEL, 25.8 m^3/sec, 814 MCM) and at the Milloc station (4.5 m^3/sec, 142 MCM) which has been diverted from the Mantaro river basin. Duration curve of the Rímac river observed at the Chosica station is shown in Figure 3.1.1. The discharge of 50 % and 90 % reliability, which include diversion flow from the

Mantaro river basin and also regulated flow from the Yuracmayo reservoir, are 22.1 m^3/sec and 14.7 m^3/sec, respectively.

The historical discharge records well indicate the water resources development in both river basins for four decades. However as explained in Sub-section 2.2.4, the hydropower plants have depleted and varied the stream flows so as to meet daily and seasonal power demand. Furthermore the reservoirs as well as natural and artificial lagoons regulate the stream flow during the dry season. Consequently complex operation of reservoirs and power plants does not allow accurate run-off calculation.

Run-off coefficient is an important indicator to estimate actual run-off amount. Run-off coefficient of 0.56 was observed at the Yauli river basin (Pomacocha) of Marca II project in the Mantaro river basin. While run-off coefficient in the Rímac river basin is roughly estimated at 42 % as shown in table below based on the mean annual run-off and rainfall data described in Sub-section 3.2.1. It is assumed that higher run-off coefficient in the Mantaro river basin is due to the low permeability of the surface layer and less vegetation cover.

Mean Annual Run-off in the Rímac River Basin

Altitude (m.a.s.l.)	Drainage Area (km^2)	Mean Rainfall (mm/year)	Effective Rainfall (mm/year)	Run-off (m^3/sec)
0 - 1,000	816	0	0	0.0
1,000 - 2,000	484	150	63	1.0
2,000 - 3,000	395	350	146	1.8
3,000 - 4,000	444	550	229	3.2
4,000 - Higher	1,444	800	334	15.3
Total	3,583			21.3

Run-off coefficient :42 %

(2) Other Surface Water Records

Other than the monthly discharge records, hourly discharge records have been collected to scrutinize the discharge losses along the Rímac river despite complexity which fluctuates from one hour to another. Hourly discharge data observed at the Chosica station (SENAMHI) and La Atarjea intake (SEDAPAL) have been collected to estimate a stream flow loss in lower reach of the Rímac river basin in 30 km long, where a wide and deep river deposit causes infiltration loss. Furthermore monthly discharge data at Sheque and Tamboraque stations under the EDEGEL have been collected for a stream flow loss calculation in the middle and upper reach. Other discharge data observed at the hydropower stations located upstream the Chosica station are unlikely to be used for estimating loss because their flow measurement is limited to the hydropower generation, and discharge is controlled by regulating ponds in response to the power demand from time to time.

3.2 Surface Water Quantity and Loss

3.2.1 Discharge Measurement

(1) Finding at Discharge Measurement

It is notified that the discharge records used for several study reports have notable discrepancy in quantity, in particular the loss calculation of the river flow of the 1998 SEDAPAL Master Plan, this loss was assumed to be 5 % in the dry season mean discharge which amounts 0.67 m^3/sec as shown in Tables 4.3.1, 4.3.2 and Annex II. In this regard, a discharge measurement has been conducted to examine the physical water loss in the river channel, confirming also accuracy of the discharge records measured at several gauging stations.

Field investigation and discharge data analysis have identified the following conditions:

(a) Five (5) hydropower stations control stream flow by the regulating ponds from time to time to meet power demand in Lima and surroundings. Variation of the power plant flow interrupts loss estimation as well as flow arrival time lag: i.e., 7.5 to 9 hours between the Huinco, Matucana hydropower stations and the La Atarjea intake.

(b) As described in (a) above, river discharge fluctuates in a short period due to the hydropower plant operation. SEDAPAL therefore estimates the intake discharge at the La Atarjea intake site subtracting about 6.0 m^3/sec from the total discharge observed at the upstream gauging stations of the Huinco and the Matucana hydropower stations in the Santa Eulalia and the Rímac rivers, respectively. This 6.0 m^3/sec is equivalent to the discharge loss. With respect to an accuracy of discharge measurement, SEDAPAL observes intake discharge at just downstream of the intake gates and also upstream of the sediment settlement pond. The latter is assessed to be reliable to scrutinize hourly fluctuation of the intake discharge from stand point of hydraulical measurement.

(c) There exist several diversion weirs along the Rímac river for the use of the industrial and irrigation purposes. The loss mentioned above includes those water use.

(d) The channel training works of the Rímac river, widening the channel width from about 20 m to 180 - 200 m for improving groundwater recharge through the permeable river deposits in the stretch of 6.0 km long immediately upstream of the La Atarjea intake site.

(e) The monthly discharge data at the intakes of Sheque and Tamboraque are used for a loss calculation in the middle and upper reach in the Rímac river basin.

(f) The discharge records at the Chosica SENAMHI station are assessed as most reliable for the run-off analysis because there is no bypass or overflow at the station. In addition its rectangular channel section and less sediment deposition due to high flow velocity keep relatively stable flow conditions that allow relatively less measurement error in long observation period.

(g) Diversion discharge through the existing irrigation intakes varies from time to time depending on the water level of the Rímac river.

After review of the foregoing findings, several sites have been selected for the Study Team's direct discharge measurement as indicated in Figure 3.2.1. Measurement at the sections 1B to 5B aims at infiltration rate measurement in the 6.0 km stretch where groundwater recharge project is under operation at present. Sections 1A to 4A aim at counterchecking accuracy of the existing discharge records of SENAMHI and EDEGEL.

Discharge Measurement Sites

No.	Location	Measurement Purpose
1A	Chosica (SENAMHI)	Accuracy of discharge record
2A	Sheque intake, Sacsa river (EDEGEL)	
3A	Sheque intake, Pallca river (EDEGEL)	
4A	Tamboraque intake (EDEGEL)	
1B	200 m upstream of La Atarjea intake	Loss calculation
2B	3,000 m upstream of La Atarjea intake	
3B	7,000 m upstream of La Atarjea intake (Huachipa bridge)	
4B	Downstream of Huampaní hydropower plant	
5B	6,000 m upstream of La Atarjea intake	

3.2.2 Amount of Water Loss

(1) Loss in the Lower Reach of the Rímac river

With regard to the water loss in the main stream of the Rímac river basin, the findings are as follows:

(a) Majority of the water loss in the main stream of the Rímac river basin occurs in the lower reach of the Rímac river, in particular in the stretch between Chosica and La Atarjea.

(b) The total mean water loss in the 30 km stretch between Chosica and La Atarjea will be in a range of 6.0 - 10.0 m^3/sec, at least 6.0 m^3/sec during the dry season. This is due to the fact that the minimum discharge balance between Chosica and La Atarjea intake is about 6.0 m^3/sec as shown in Figure 3.2.2. The loss is composed of the riparian water use (irrigation and industry) and infiltration loss including evaporation. The component of irrigation and industrial water use seems to be predominant. No clear infiltration area or spot has been identified. It is assumed that the irrigation and industrial water use and the infiltration loss is 4.0 m^3/sec (70 %) and 2.0 m^3/sec (30 %). Discharge data at Chosica (SENAMHI) and La Atarjea intake are in Tables 3.2.1 and 3.2.2, respectively.

(c) The total discharge of 17 irrigation intakes located upstream of the La Atarjea intake, 6.8 m^3/sec measured by the Study Team seems to be the maximum amount. (refer to Table 3.2.3) The daily average withdrawal for irrigation and industrial use is assumed to be 4.0 m^3/sec with consideration of the existing irrigation area of about 4,750 ha.

(d) It is assumed that infiltration loss in the 7 km stretch between Huachipa bridge (3B, 5B) and the La Atarjea intake (1B) including the 6 km river training works is about 2.0 m^3/sec. Discharge data observed by the Study Team are shown in Table 3.2.4. (the cause of the increase of the river discharge towards downstream is 1) fluctuation of river discharge and 2) flow-out of subsurface flow to the river surface, etc. in Table 3.2.4)

Flow Balance of the Rímac is shown in Table 3.2.5. Discharge in the table were calculated by following conditions:

1) Calculates actual discharge (Observation agencies are in the parentheses)

2) Assumes overflow discharge at La Atarjea intake to be negligible from 1991 to 1997 (No. 5 in table)

3) Estimates infiltration discharge at 2.0 m^3/sec through the calculation period.

4) Estimates industry/irrigation discharge as below:

Industry/irrigation discharge = Discharge at Chosica (No. 3)

- Intake discharge at La Atarjea intake (No. 4)

- Infiltration

In Table 3.2.5, infiltration discharge of 2.0 m^3/sec is quantitatively reasonable comparing with the total water loss of 3.5 - 3.6 m^3/sec between Chosica and La Atarjea intake during the drought years, 1991 - 1992.

Discharge records at Sheque and Tamboraque intakes of EDEGEL have been also obtained to calculate stream flow losses in the upper reach of the Rímac river with comparison to that at the Chosica station. It is difficult to estimate the water losses accurately because discharge and subsurface flow from the residual catchment area of 1,180 km^2 is included in the flow record at Chosica.

(2) Accuracy of Discharge Records and Measurement

The error range of the discharge records of SENAMHI, EDEGEL and SEDAPAL seems 10 - 20 %. The flow measurement done directly by the Study Team seems to include an error of 10 - 20 %. The details are as follows:

Discharge Measurement Errors

No.	Location	Measurement Purpose (Comparison with JICA Study Team)
1A	Chosica (SENAMHI)	Measurement by SENAMHI is about 6 % larger. (*1)
2A, 3A	Sheque (EDEGEL)	Measurements by EDEGEL and JICA Study Team are almost same. (*2)
4A	Tamboraque (EDEGEL)	Measurement by EDEGEL is about 13 % smaller. (*3)
1B-5B	River discharge between Chosica and La Atarjea intake	Measurement error in several observations ranges 10 - 20 %. (see Figure 2 and 3 in Annex I)

(*1) Error in measurement. Measurement error of 6 % is not applicable to long period discharge data by SENAMHI because discharge measurement by the JICA Study Team was carried out in quite short period. (see Figure 1 in Annex I)

(*2) Hourly discharge data observed by EDEGEL are shown in Table 3.2.6.

(*3) EDEGEL converts water level in the tunnel section into discharge. Water level is measured by sensor, and calibration of sensor is necessary. Measurement error of 13 % is not applicable to long period data by EDEGEL for the same reason as (*1) above. Hourly discharge data observed by EDEGEL are shown in Table 3.2.6.

In addition, Figure 3.2.3 shows discharge data observed at Chosica by SENAMHI and EDEGEL (Huampaní intake for hydropower plant), both observation stations are closely located. Discharge data in two stations are almost the same measurement during low water periods (the dry season). While discharge data during high water periods (the wet season) are inaccurate in several years because of its higher run-off coefficient, and these are found in both stations especially January to March. Considering this fact, water balance calculation by monthly basis or shorter period is recommended to minimize an effect of discharge measurement error during high water periods.

3.3 Water Quality

3.3.1 Preliminary Assessment of Water Quality

The water quality of the Rímac River has been contaminated significantly since 1960th due to toxic chemical substances, non-degradable materials and microorganism. Though some improvement has been reported, the condition is basically kept unchanged at present in spite of greatest effort of the agencies concerned, such as environmental sanitation office of the Ministry of Health, SEDAPAL, etc.

Present raw water quality standard, the permissible limits for watercourses, Classes I to IV of the general water law, D. L. No. 17752 is shown in Table 2.4.3. Class I and II basically stands on the same concept of the WHO Guideline for drinking water, bacteriological quality of drinking-water, chemicals of health significance in drinking-water (a. inorganic constituents, b. organic constituents, c. pesticides, d. disinfectants and disinfectant by-product), chemical not of health significant at concentrations normally found in drinking-water, radioactive constituents of drinking-water, etc. The environmental quality standard for general watercourses in Japan is shown in Table 2.4.4. The environmental quality standard for river water concerning conservation of the living environment in Japan is shown in Table 2.4.5. Combination of Table 2.4.4 and Table 2.4.5 corresponds to Class I and II of Peru.

Presently high concentration of fecal coliforms and heavy metals (chromium, lead, arsenic etc.) are at the center of public dispute in the Rímac River basin. The water quality test results listed in Section 2.4 is assessed with comparison of Japanese standard as follows:

1) If any of lead, cadmium, chromium, arsenal and cyanide is identified in the raw water of a proposed water source, it is not accepted as a water source for drinking in Japan.
2) Under the Japanese environmental water quality standard for river concerning the conservation of the living environment, the raw water which contains the suspended solid of more than 30 or 60 mg/l is not suitable for raw water for domestic water supply.
3) Any king of toxic substances in raw water can be technically and theoretically removed by using iron-exchange method. However, the iron-exchange method is developed for producing highly purified industrial water, such as IC industry, and thus it is not economically feasible for drinking water. On the other hand, the raw water containing toxic heavy metals or chemicals is involved in high risk that such polluted water might be supplied to household unexpectedly when the water purification facilities are malfunctioning.
4) It is recommended to conduct a water quality investigation that aims to trace variation of the content of toxic materials in the process of water treatment including sedimentation process (SS).
5) Mercury is recommended to be included in the monitoring items of water quality.
6) Trivalent chromium in raw water can be removed by the conventional coagulation-sedimentation process. On the other hand, the former process can not remove hexavalent chromium, but it can be technically removed by a special method with a reduction process. However it requires a complex pH control process (raising/ lowering) during the reduction process. Therefore pH control is not recommendable from the standpoint of safety control.
7) Removal of cyanide also can be technically possible by a special method with oxidation process including pH control, but it is also dangerous and not recommendable.
8) BOD (Biological Oxygen Demand), generally less than 5 mg/l upstream of La Atarjea, is acceptable range in spite of industrial and domestic sewerage.

Heavy chlorination has been applied for disinfection of water supply with extra cost of chlorine. Heavy metals, that might cause degradation of public health in long term, will not be able to be eliminated by normal water treatment plant with reasonable cost. Excessive dosage of chlorination yields by-product such as trihalomethane, and it might also cause degradation of public health.

3.3.2 Study for Alternative Measures

Bases on the identified water quality issues the Study Team suggests SEDAPAL to study the following measures as a hint to resolve present problems:

a. Monitoring Water Quality and Aquatic Ecology

- To make inventory of aquatic species and fish population
- To assess the fish fauna and fish population dynamics
- To introduce artificial reproduction of endemic fish with ecological and/ or economic interest
- To assess the aquatic environment through the use of bio indicators: integrated monitoring approach using benthic organisms, zooplakton toxicity tests, and fish liver tissues to evaluate pollution effects, and correlate with chemical and metal analysis at specified areas,
- To conduct water quality test for selected pesticide and toxic chemicals
- To conduct water quality test for mercury (not included in SEDAPAL's list)

b. Institutional Arrangement

- Institutional arrangement to regulate point source control of industrial waste water discharge in particular mining industry
- Enhancement of cleaner production among the industries: it aims to enhance technology to reduce the content of toxic chemical materials contained in sewage and solid waste in the production process, and to reduce the use of the toxic chemical materials in quantity including recycle and reuse technology
- Enactment of polluter's pay principle

c. Alternative Structural Measures

- Installation of specific treatment plants for toxic chemicals and metals (costly)
- Relocation of the existing SEDAPAL intake facilities from La Atarjea to appropriate upstream site including bypass pipeline

3.3.3 Integrated Management of Surface Water and Groundwater

Comprehensive and quantitative river basin management under the concept of hydrological cycle management will be required for the Rímac River basin in the future. The management will aim to establish sustainable development and environment of the basin by improving:

(1) the national or regional institutional framework for water resources development and management;

(2) the organizational and financial framework for basin management;

(3) the regional water quality management regulatory institutions and implementation;

(4) irrigation management policy, institutions and regulations;

An example is shown below.

Legal and Institutional Arrangement: Legal and institutional framework that enables the anticipated management framework,

Monitoring System: Integrated monitoring and management of surface water and ground water, and water quantity and quality, and

Public Involvement: Establishment of autonomous (public-private) organization to monitor and improve the river environment by participatory approach.

3.4 Water Loss Due to Hydrogeological Condition

3.4.1 Infiltration Calculated by SEDAPAL

Based on the information on maximum and minimum water levels recorded in 19 observation wells (piezometers) and 30 extraction-recharge wells of the pilot project, SEDAPAL obtained the answer for the water level recovering produced between October 1998 and March 1999, due to the induced recharge effect.

The obtained data determined that the water volume filtered into the pilot project service area, between Huachipa Bridge and La Atarjea, was 4.12 MCM during that period, equivalent to 0.317 m^3/sec during the 5 observation months or 0.130 m^3/sec for one year.

3.4.2 Theoretical Infiltration Calculated by Morits Equation

To quantify the infiltration theoretically, considering the constant permeability conditions in the covered area, the Moritz equation has been used. (see Annex III)

As a result of this equation, an average infiltration of 1.49 m^3/sec for the 6-km area between Huachipa Bridge and La Atarjea is obtained. The average velocity (1.11 m/sec) and the average flow (26.93 m^3/sec) are obtained from the measurements carried out by the JICA Study Team at the 1B point, 200 m upstream of La Atarjea intake.

3.4.3 Other Infiltration Values Obtained from Investigation

According to investigations developed by several consultants in the Rímac river Valley aquifer, the infiltration values do not show the same magnitude rate.

3.4.4 Direct Measurement by JICA

The infiltration between 1B and 3B sites was approximately estimated to be 2.0 m^3/sec by the JICA Study Team based on the water flow measurement by use of current meters during August 27 to September 19, 2001.

3.4.5 Binnie & Partners (1980)

A balance performed by B & P considers that the infiltrations between Chosica and Callao are 4.72 m^3/sec. The infiltrations downstream La Atarjea are 1/3 of the total infiltration between Chosica and Callao; and La Atarjea flows have been calculated from the Chosica flow minus the 2/3 of infiltration losses produced between Chosica and Callao.

The infiltrations considered in the different studies on the Rímac River are shown in the following table:

Infiltration Rates in Different Studies

	Date	Distances (km aprox.).	Infiltration (m^3/sec)	Infiltration (m^3/s/km)	Scope
SEDAPAL	1999	6	0.13	0.02	Huachipa -La Atarjea
Morits Equation	2001	6	1.49	0.25	Huachipa- La Atarjea
JICA	1981	6	2.0	0.33	Vitarte – La Atarjea
B&P	1980	22	3.15	0.14	Chosica –La Atarjea

3.4.6 Conclusions:

(1) According to the obtained information, it was not possible to get a definitive conclusion about the infiltration produced between Huachipa Bridge and La Atarjea. In addition, the flow measurements carried out by the JICA Study Team between August and September, 2001, in the above-mentioned area, do not show the existence of significant infiltrations in the area.

(2) The discrepancies between SEDAPAL and the mentioned consultants require a future investigation.

CHAPTER 4 REVIEW OF 1998 WATER SUPPLY MASTER PLAN

4.1 Water Demand

4.1.1 Domestic and Non-Domestic Water Demand

(1) Projection of Future Population of Metropolitan Lima and Huarochiri Districts in Rímac River Basin

Metropolitan Lima is constituted by 43 districts of Lima Province and 6 districts of Callao Province. Besides those above districts in Rímac River Basin there are 19 districts which belong to the Huarochirí province. In Figure 4.1.1 are shown all districts as well as SEDAPAL water supply areas. Total population in Metropolitan Lima as 1993 census was 6,434,323 which is 28.4% of the total population of Perú. In Table 4.1.1 shows the future population of Metropolitan Lima as estimated by SEDAPAL M/P, BLASA and INEI. For the planning horizon of 2030 such population projected ranges between 11.5 to 11.75 millions. Regarding population in Rímac river basin other than Metropolitan Lima has been estimated to be 73,597 in year 2030. A summary is given below

Metropolitan Lima Population

	1993	1998	2000	2005	2010	2020	2030
MASTER PLAN	6,434,323	7,130,008	7,505,802	8,233,031	8,934,224	10,266,351	11,751,197
Annual Growth Rate (%)		2.07	2.60	1.87	1.65	1.40	1.36
BLASA			7,400,352	8,083,627	8,768,901	10,133,451	11,500,000
Annual Growth Rate (%)				1.78	1.64	1.46	1.27
INEI			7,500,542	8,187,398	8,881,228	10,267,751	11,713,832
Annual Growth Rate (%)				1.77	1.64	1.46	1.33

Huarochiri Districts Population

	1993	1998	2000	2005	2010	2020	2030
JICA Study Team			50,569	54,789	58,890	66,518	73,597
Annual Growth Rate (%)				1.62	1.45	1.23	1.02

(2) Water Demand

Domestic and non-domestic water demand for Lima Metropolitan Area which includes 49 districts has been calculated by four (4) methods, they are:

* SEDAPAL Master Plan (1998)

* BLASA (Revised water demand, 2001)

* BLASA/Master Plan (It is BLASA approach applying to it population given by SEDAPAL Master Plan)

* BLASA/INEI (It is BLASA approach applying to it population forecasted by National Institute of Statistics)

BLASA in April 2001 under contract with SEDAPAL revised water demand calculated by SEDAPAL Master Plan in 1998 because unbilled potable water(*) instead to decrease was increasing from 35% in 1997 to 44% in year 2000 notwithstanding that unit water consumption for same period decreased from 319 l/p/d to 290 l/p/d, thus basically targeted water demand forecasted by SEDAPAL Master Plan did not accomplish.

Main differences between Master Plan and BLASA are as follows:

* BLASA forecasted population is less than that one of SEDAPAL Master Plan

* BLASA present metered water consumption is larger than that one of SEDAPAL Master Plan

* BLASA considered some little unit water consumption for those non-connected population and SEDAPAL Master Plan did not consider any

* BLASA coverage is a little less than that of SEDAPAL Master Plan

* Water supply efficiency (1-loss ratio) were settled as follows:

Water Supply Efficiency

Year	SEDAPAL Master Plan	BLASA
2000	65 %	70 %
2005	70 %	75 %
2010 - 2030	75 %	75 %

Metered and non-metered unit domestic water consumption per head in l/p/d were settled as follows:

(*) Unbilled potable water (UPW) means the sum of physical and no physical water loss plus no identified water loss.

Unit Domestic Water Consumption in l/p/d

Year	Social Category	BLASA		Master Plan	
		Metered	Non-metered	Metered	Non-metered
From 1998 to 2001	A	405	520	360	520
	B	260	400	250	400
	C	230	330	180	330
	D	160	165	125	165
From 2002 to 2004	A	405	520	360	-
	B	260	400	250	-
	C	230	330	180	-
	D	160	165	125	-
From 2005 to 2030	A	360	-	360	-
	B	250	-	250	-
	C	180	-	180	-
	D	125	-	125	-

For non-domestic consumption all methods adopted what was settled in SEDAPAL Master Plan.

For the four (4) methods above mentioned total water demand was calculated as shown in Table 4.1.2 as well as in Figure 4.1.2. For year 2000, 2005, 2010, 2020 and 2030 total water demand is shown as follows.

Methods	2000	2005	2010	2020	2030
Water Demand Master Plan (m^3/sec)	27.80	29.67	30.64	35.54	40.68
Water Demand BLASA (m^3/sec)	32.09	26.34	29.13	35.17	40.17
Water Demand BLASA/PM (m^3/sec)	32.46	26.72	29.56	35.54	40.87
Water Demand BLASA/INEI (m^3/sec)	32.45	26.61	29.42	35.54	40.77

For year 2030 differences among each method are only 2% and this difference is due to the population natural increment.

For the purpose of this supplementary study and in order to carry out water balance BLASA approach was selected.

4.1.2 Water for Agricultural Uses

(1) General Aspects

It should be taken into account that there is not a significant agricultural activity in the high zone of the Rímac river basin, starting from Ricardo Palma, since the land exploitation has already reached the maximum level allowed by the land surface. It is recommendable to carry out a study on the water demand without considering the water use for agricultural activities in this area. Therefore, the studies were categorized from Chosica to La Atarjea intake.

The geographic condition of the Rímac River is complex in respect to topography and climate. Particularly, the altitude varies from the seacoast (0.00 m.a.s.l.) to the source of the river (about 5,100 m.a.s.l.); and the climate varies from 0° C to 25°C as average. This is why many of the potential cropping areas are located in the middle and low area of the basin, where the rainfall is insufficient or non-existent, according to the climate data reported by the La Molina Agrarian University Station.

(2) Present Agriculture and Irrigation Conditions

(a) Present Agriculture Condition

The agricultural fields of the study area are located nearby both Rímac riverbanks, particularly from Huachipa to Callao.

The Board of Users of the Rímac Irrigation District has carried out an inventory of the areas (Year 2000), which is shown in the following table:

Irrigation Sub-sector	No. of Users	Irrigated Area (Has)	Discharge Regulated ATDR (m^3/sec)
Cumbe (San Mateo)	445	159.42	0.16
Tapicaraucro	381	294.20	0.29
Lanca	342	79.56	0.08
Comité Parca (Santa Eulalia)	113	99.60	0.10
Ricardo Palma	198	299.58	0.30
Chosica Vieja Los Cóndores	140	196.18	0.25
Chaclacayo	176	102.05	0.13
La Estrella	339	361.28	0.41
Chacrasana	80	133.36	0.40
Ñaña	155	498.06	0.71
Carapongo	276	202.98	0.48
Nievería	324	324.26	0.51
Huachipa	541	765.15	0.84
Ate	127	685.35	0.50
Surco	79	1,009.69	0.52
San Agustín (Callao)	144	472.28	0.47
Total	3,860	5,683.00	6.15

The cropping pattern of these 5,683 irrigated hectares is divided as follows:

21% vegetables

26% corncob and yellow maize

13% coast potato

11% sweet potato and beans

29% orchard and pasture

The remaining 26,555 Has of the valley are constituted by urban areas and/or private or public properties that are not appropriate for agricultural activities, because they are located above the riverbed.

(b) Present Water Demand Estimation

The present water demand estimation is based on the potential evapotranspiration (Eto) established according to the PENMAN(*) method,

(*) Source: The Irrigation, Volume I, 1992, National Agrarian University
FAO Irrigation and Drainage Study N° 24

whose cropping pattern effect regarding the water requirements is given by the cropping coefficient (Kc), which represents the relation between the cropping evapotranspiration (ETcrop) and the potential evapotranspiration (ETP) or ETcrop = Kc.Eto. Assuming that the global irrigation efficiency is of 50% and, according to the cropping pattern (Figure 4.1.3), the total water demand for agricultural activities in an area of 5,683 Has is 74,47 MCM, while the pick monthly demand is 12.2 MCM or 4.71 m^3/sec for a efficiency of 50%. If we compare this data with the valley irrigation water of about 6.83 m^3/sec (Fig. 2.3.2, Chapter 2.3), there will be losses due to the inappropriate water management and/or the excessive use of 2.12 m^3/seg.

The present irrigation water demand has been calculated for four alternatives, which are shown in Table 4.1.3 and summarized as follows:

Present Irrigation Water Demand

Alternative	Area (has)	Irrigation Efficiency by Conveyance (%)	Irrigation Efficiency by Distribution (%)	Irrigation Efficiency (%)	Irrigation Water Loss (%)	Total Demand (MCM)	Scope
1A	5,683	75	67	50	50	74.47	All the Irrigation District (San Mateo-Callao)
1B	5,683	70	60	42	58	89.42	All the Rímac Irrigation District (San Mateo-Callao)
2A	4,751	75	67	50	50	62.42	From Ricardo Palma to Callao
2B	4,751	70	60	42	58	74.42	From Ricardo Palma to Callao

The best alternative for the evaluation of the water loss and water use conditions for agricultural activities would be the 2A, because this area shows the greatest agricultural development of the Rímac river valley; therefore, it will allow characterizing the most representative water demands.

Total irrigation water losses due to water conveyance and water distribution have been assumed to be 50 % and 58 % respectively, a percentage of these losses will be infiltrated and be part of the ground water, nevertheless with the information which is available for this study it is not possible to determine which percentage become ground water.

4.2 Progress of Water Saving Measures

4.2.1 Unbilled Water and Water Losses

In accordance with SEDAPAL yearbook 2000, water consumption per capita (Produced water/Served inhabitant) has decreased during the period 1997-2000 from 319.4 l/day to 288.9 l/day.

Based on information provided by SEDAPAL in Table 4.2.1 is shown the structure of the unbilled water up to April 2001. Unbilled water is 43% which is breaking down in 30% as water supply system losses and 13% as unrecorded losses. System losses are taken into account for the purpose of calculating water production requirements and the balance would be the efficiency of the whole system for the intake, production and distribution of potable water; then, as of April 2001 it can be said in round numbers that the efficiency of the system managed by SEDAPAL is 70%, which is quite close to values being handled in the large capital cities of South America.

4.2.2 Micrometering

The house connections and number of installed meters has evolved favorably in the period 1997-2000, as shown below:

Year	1997	1998	1999	2000
Installed connections	839,337	871,723	940,325	971,130
Metered connections	308,544	352,485	488,011	631,263

In reviewing these figures it is observed that as of year 2000, despite a significant effort by SEDAPAL, there still is 35% of installed house connections without meter.

4.2.3 Current Network and Rehabilitation of Potable Water Network

The evolution of the potable water network as well as its rehabilitation are shown below:

Year	1997	1998	1999	2000	2001
Potable water network (km)	8,158	8,464	8,652	8,751	
Cumulative rehabilitated Network (km)	156.13	198.99	337.67	435.93	440.29

4.2.4 Saved Water due to Micrometering and Network Rehabilitation

According to data furnished by SEDAPAL's Micrometering and Records Team, water savings due to the combined effects of the increase in micrometering, network rehabilitation and leakage control, amounted to an average of 5.6 m^3/sec as of August 2001.

This potable water savings has been reflected in an improvement of service to the supplied population, i.e. bigger amount of water, higher pressures and better service continuity; however, it has not been reflected in achieving the target service coverage due to the lack of new distribution networks that enter in operation as the population increases.

4.3 Water Demand and Supply Balance

4.3.1 Annual Water Balance

(1) SEDAPAL´s Method

Water balance carried out by SEDAPAL Master Plan in 1998 following procedure was applied:

* Projection of active water demand (D/I, commercial, state use and park and gardens) from 1998-2030. Active water demand means the water demand which occurs in future if MIO program is implemented (institutional and operational improvement program)

* Assessment of surface and groundwater source present and future

* Water production required taking in consideration total water loss (physical and no-physical). Loss were assessed as 35% in period 1998-2000, 30% in 2005 and 25% from 2010 to 2030.

* Loss in Rímac river upstream La Atarjea during dry season (May-November) was assessed as 5% of the average discharge in same period

* Irrigation water demand in Rímac and Lurín valley

* Reuse of sewerage treated water in gardening and agriculture

Water balance was carried annually and monthly for four (4) alternatives (1, 1a, 2 and 3). For year 2030 monthly water balance are shown in Tables 4.3.1 and 4.3.2 for alternatives 1a and 2. Annual water balance including potable water treatment plant as well as projects to be implemented in order to fulfill water demand in dry season (May-November) are shown in Tables 4.3.3 and 4.3.4. Alternatives 1a and 2 include to bring $5m^3$/sec either from Cañete or Mantaro River Basin. Alternative 2 was finally selected by SEDAPAL Master Plan.

Based upon average daily water demand in Figure 4.3.1 the proposed expansion system of SEDAPAL Master Plan is presented.

It was assumed that all domestic and non-domestic water demand of Lima Metropolitan area is taken at La Atarjea where intakes and potable water treatment plant are located. Water balance was calculated as water offer (surface and groundwater) minus water demand.

4.3.2 Water Demand and Supply Balance Analysis

(1) Balance Model by Monthly Discharge

The water balance point is set at SEDAPAL's intake site at La Atarjea. The available surface water flow at La Atarjea intake is assumed to be the discharge at Chosica minus the aggregate water loss between La Atarjea and Chosica. The aggregate water loss between La Atarjea and Chosica is assumed to be the sum of the irrigation demand and other water losses consisting of riparian water uses, infiltration and evaporation in the stretch.

It is assumed that all domestic and industrial water demand of the Lima Metropolitan area is withdrawn at La Atarjea. The net D/I water supply demand is balance of the total D/I water supply demand minus the total groundwater supply.

In short the water balance is calculated by:

$Q_{BL,t} = Q_{C,t} - (D_{IR,t} + L_{AC,t}) - (D_{WS,t} - Q_{G,t}) + Q_{Ri,t}$

$= Q_{C,t} - D_{IR,t} - L_{AC,t} - D_{WS,t} + Q_{G,t} + Q_{Ri,t}$

Where,

$Q_{BL,t}$: Demand and supply balance at year t (m^3/sec)

$Q_{C,t}$: Surface flow discharge at Chosica (SENAMHI Station) at year t (m^3/sec)

$D_{IR,t}$: Irrigation water demand between La Atarjea and Chosica at year t (m^3/sec)

$L_{AC,t}$: Water loss in the stretch between Atarjea and Chosica at year t (m^3/sec)

$D_{WS,t}$: D/I Water supply demand of Lima Metropolitan area at year t (m^3/sec)

$Q_{G,t}$: Groundwater Supply for Lima Metropolitan area at year t (m^3/sec)

$Q_{Ri,t}$: Regulated flow from reservoirs and diversion at year t (m^3/sec)

(2) Flow Condition

The monthly mean discharge record of 20 years at Chosica from 1979 to 1998 is used as the surface discharge at Chosica.

The discharge during the period was modified by the regulated flow by the Marca I Project facilities commissioned in 1962 and the Yuracmayo Project commissioned in 1996, but it is treated as the existing natural flow, i.c., without project.

(3) Calculation Case and Result

The water demand and supply balance is done for the following category, where Marca I and Yuracmayo Projects are treated as the existing condition:

Cases for Water Balance Calculation

Category	Dam & Water Transfer	D/I Water Demand	Water Loss
A	Without Project	2000, 2005, 2010, 2020, 2030	6.0 m^3/sec
B	With Project Marca III, Marca II	2005 ~ 2030	0.67 m^3/sec
C	With Project Marca III, Marca II, Huascacocha, Mantaro-Carispacha (or Cañete) Max. 16.5 m^3/sec	2005 ~ 2030	6.0 m^3/sec (Irrigation, Factory, Infiltration, Evaporation, etc.)

Alternative cases for the water balance and corresponding conditions are shown in Table 4.3.5. The summary of the calculation results is shown in Table 4.3.6.

Figure 4.3.2 shows the monthly mean discharge from 1978 to 1989 and a pattern of projected total water supply and irrigation demand from the year 2000 to the year 2030. Figure 4.3.3 shows the distribution of deficit during the 20 year period.

These results infer the following prospect:

(a) During the last two decades the most severe drought occurred in 1989-1992 period. It continued four years, and the reservoirs and lagoons in the upstream of the Rímac River were completely emptied due to little rainfall during the rainy season.

(b) If the same event occurred, even the lowest water supply demand projected in 2005 will not be fulfilled even if Marca II is commissioned by 2005. The hydrological reliability of 'With Marca II system' is assessed to be less than 80% (4/20). That is, input of Marca II will not be sufficient even for the event of 1994-1995 draught (4/20) in 2005 even considering the optimistic water loss in the Chosica-La Atarjea stretch being only 0.67 m^3/sec instead of 6.0 m^3/sec.

(c) SEDAPAL's present planning method of water demand and supply based on the annual mean analysis is assessed to be very optimistic. Introduction of an elaborated quantitative water demand and supply balance method considering seasonal variation of discharge and water demand by use of at least monthly mean discharge records will be necessary in order to manage the reliable water supply system for the Lima metropolitan area.

4.3.3 Review of SEDAPAL's Expansion Plan

As presented in Figure 4.3.1 above, SEDAPAL Master Plan had considered following project be under operation in order to supply raw water during dry season in average as follows:

Marca III (Surface water) in year 1999: Q= 3.0m^3/sec

Chillón Project (surface and ground water) in year 2001: Q= 0.71 m^3/sec

Marca II (Surface water) in year 2003: Q= 6.5 m^3/sec

Huascacocha (Surface water) in year 2015: 2.5 m^3/sec

Cañete or Mantaro (Surface water) in year 2020: 5.0 m^3/sec (or 2.5 m^3/sec each in years 2021 and 2025)

SEDAPAL's Master Plan took into account 5% (0.67 m^3/sec) of the average dry season discharge as infiltration in the Rímac river upstream of La Atarjea water intake.

In case counting the Rímac water loss (Irrigation water intake, infiltration and others) be 6.0 m^3/sec, then situation is completely different from that forecasted by SEDAPAL Master Plan because total water sources available (surface and ground water) has to be reduced in the same amount of loss.

Based on what has been stated above Figure 4.3.4 was prepared in order to show how loss in 6 m^3/sec affects the SEDAPAL expansion plan but still keeping that Marca II has to be under operation in year 2003 as it was planed by Master Plan. Main conclusions are:

- Huascacocha project in the amount of 2.5 m^3/sec has to get early into operation in year 2007 instead 2015
- Mantaro-Carispacha project in the amount of 5 m^3/sec has to get early into operation in year 2012 instead 2020, and
- A new source of surface water in the amount of 5.4 m^3/sec has to get into operation in year 2020

Regarding actual situation of SEDAPAL implementation are as follows:

- Marca III (3m^3/sec): under operation since 1999 as scheduled
- Chillón ground water project in the amount of 0.8 m^3/sec went into operation in June 2001
- Marca II is delayed. Construction has been scheduled to start in 2004 and operation in 2007.

Taking into consideration those above facts then Huascacocha project and Marca II have to be under operation in year 2007 in the total amount of 9.0 m^3/sec as shown in Figure 4.3.5. The location of these projects in the Mantaro River basin is shown in Figure 4.3.6.

4.4 Preliminary Economic Evaluation

4.4.1 Introduction

(1) Background

In the SEDAPAL's 1998 Water Supply Master Plan (hereinafter referred to the "M/P"), four alternatives for expansion supplying raw water to meet the future water demand in the Metropolitan Lima were studied with a long-term time frame up to 2030, and as a result of the M/P, the Alternative 2 as titled in the M/P was recommended for its implementation. The Alternative 2 consists of four projects including one short-term, two middle-term and one long-term projects, and the Mantaro-Carispaccha Scheme is the long-term project to supply 5m^3/s of raw water, which technically and economically competes with other proposed projects of the Canete Scheme with Multi-Purpose Dams (two multi-purpose dams planned under "Case 3.1" and "Case 3.3" in the IT/R[1]) supplying the same amount of raw water as the Mantaro-Carispaccha Scheme.

Further, it was found during the supplemental investigation that the Concon-Topara Irrigation Project, being planned along the Canete River and promoted by a private

1: Interim Report

sector, is planned to be implemented in the near future, so that the Cañete River may not be able to provide 5m^3/s of raw water planned to be supplied for the Metropolitan Lima if another single-purpose dam for water supply proposed as Cañete Scheme with Single-Purpose Dam (single-purpose dam only for water supply planned in the IT/R) is not constructed.

(2) Objective

Under review of the M/P in the P/R (2)[2], a preliminary economic evaluation (hereinafter referred to the "Evaluation") of the Mantaro-Carispaccha Scheme was carried out with the Cañete Scheme with Multi-Purpose Dams and Cañete Scheme with Single-Purpose Dam in order to objectively see economic viability of the above four alternative schemes and identify which alternative scheme would be recommended as the economically lowest-cost scheme option for its implementation in the M/P.

4.4.2 Evaluation Methodology

(1) Applied Evaluation Method

To achieve the objective of the Evaluation, a least-cost analysis method was applied in order to compare economic costs of mutually independent and technically feasible three alternative schemes and identify the one with the lowest present value of economic costs by estimating a unit value of average incremental economic costs (hereinafter referred to the "AIEC") of raw water for each of the three alternative schemes and selecting the one with the lowest unit value of AIEC.

(2) Assumptions Made for the Evaluation

Following assumptions were made in order to carry out the Evaluation.

- In the Evaluation, construction period and project life were assumed to be 5 years and 45 years, respectively.

- A unit value of AIEC of raw water for each of the three alternative schemes was calculated with economic opportunity costs of capital rated at 12% which was applied by the similar projects of SEDAPAL as well as by the economic evaluation conducted in the IT/R.

- Factors used for converting financial costs of the four alternative schemes to economic costs were 0.83 for investment costs and 0.78 for O&M costs, which were applied in the IT/R. Further, the estimated financial investment costs were assumed to be composed of 80% for local and 20% for foreign portions.

- Benefits that the four alternative schemes produce were assumed to be same, which are to supply 5m^3/s of raw water to the Metropolitan Lima.

- Regarding the Cañete Scheme with Multi-Purpose Dams, the applied cost-sharing ratio to water supply sector was 26% for Case 3.1 and 22% for Case 3.3.

2: Progress Report (2)

4.4.3 Analysis and Results of the Evaluation

(1) Adjusted Financial Costs of the Four Alternative Schemes

The financial costs of the four alternative schemes estimated in the IT/R are shown in a cash flow presented in Table 4.4.1. Further, breakdown of financial costs of the Canete Scheme with Single-Purpose Dam and Canete Schemes with Multi-purpose Dams (Case 3.1 and Case 3.3) are also shown in Table 4.4.2, Table 4.4.3 and Table 4.4.4, respectively. The summary of the financial costs is also given in the table below.

Summary of Adjusted Financial Costs for the Four Alternative Schemes

(Unit: Million US$)

Alternative Schemes		Investment Costs	Annual O&M Costs
Mantaro-Carispaccha Scheme	-	**217.946**	**6.176**
Canete Scheme with Single-Purpose Dam (Morro de Arica Dam Only)	Single-Purpose Dam	142.910	0.530
	Water Conveyance	294.970	0.840
	Total Costs	**437.880**	**1.370**
Canete Scheme with Multi-Purpose Dams (Case 3.1: San Jeronimo and Morro de Arica Dams)	Multi-Purpose Dams	709.210	2.610
	Water Conveyance	294.970	0.840
	Total Costs	**1,004.180**	**3.450**
Canete Scheme with Multi-Purpose Dams(Case 3.3: Paucarcocha, Morro de Arica Dams & New Ground Water)	Multi-Purpose Dams	211.800	0.750
	Water Conveyance	294.970	0.840
	New Ground Water	12.110	0.610
	Total Costs	**518.880**	**2.200**

(2) Estimated Economic Costs of the Three Alternative Schemes

Based on the financial costs of the four alternative schemes, the economic costs were estimated by applying the conversion factors assumed in the Evaluation and are shown in a cash flow presented in Table 4.4.1. Further, breakdown of economic costs of the Canete Scheme with Single-Purpose Dam and Canete Schemes with Multi-purpose Dams (Case 3.1 and Case 3.3) are also shown in Table 4.4.2, Table 4.4.3 and Table 4.4.4, respectively. The summary of the estimated economic costs is also given in the table below.

Summary of Estimated Economic Costs for the Four Alternative Schemes

(Unit: Million US$)

Alternative Schemes		Investment Costs	Annual O&M Costs
Mantaro-Carispaccha Scheme	-	**188.305**	**4.817**
Canete Scheme with Single-Purpose Dam (Morro de Arica Dam Only)	Single-Purpose Dam	123.474	0.413
	Water Conveyance	254.854	0.655
	Total Costs	**378.328**	**1.069**
Canete Scheme with Multi-Purpose Dams (Case 3.1: San Jeronimo and Morro de Arica Dams)	Multi-Purpose Dams	612.757	2.036
	Water Conveyance	254.854	0.655
	Total Costs	**867.612**	**2.691**
Canete Scheme with Multi-Purpose Dams(Case 3.3: Paucarcocha, Morro de Arica Dams & New Ground Water)	Multi-Purpose Dams	40.259	0.129
	Water Conveyance	254.854	0.655
	New Ground Water	10.463	0.476
	Total Costs	**305.576**	**1.260**

(3) Results of the Evaluation

With the economic costs estimated, AIEC of raw water produced by the four alternative schemes was calculated on the basis of incremental water to be supplied and are shown in a cash flow presented in Table 4.4.5. The unit values of AIEC were further estimated and used for comparing and then identifying the lowest-cost scheme among the four alternative schemes. The estimated unit values of AIEC are presented in the table below.

Estimated Unit Value of AIEC

(Unit: US$/$m^3$)

Mantaro-Carispaccha Scheme	**Canete Schemes**		
	Single-Purpose Dam	**Multi-Purpose Dam (Case: 3.1)**	**Multi-Purpose Dam (Case: 3.3)**
0.119	**0.208**	**0.478**	**0.170**

Source: JICA Study Team

The results given in the above table show that the unit value of AIEC for the Mantaro-Carispaccha Scheme was identified to be the lowest among the four alternatives, which indicates that the Mantaro-Carispaccha Scheme was found to be the lowest-cost scheme option among the four alternative schemes and would be economically justifiable for its implementation in the M/P.

CHAPTER 5 IMPLEMENTATION SCHEDULE OF CANETE RIVER WATER RESOURCES DEVELOPMENT PLAN

5.1 Alternative Scenario

Coupled with the water balance analysis, 3 Scenarios including total 7 cases were examined as alternatives for the Cañete river water resources development in the study for the IT/R, as shown on the Table 4.2.3 in IT/R and reproduced herein as attached Table 5.1.1, where:

- Scenario-1 places first priority on the D/I water supply, in particular, high weight on the water conveyance to the south of Lima metropolitan area, while,
- Scenario-2 places high weight on irrigation (agricultural) development, and
- Scenario-3 places equal weight on the D/I water supply and irrigation (agricultural) development.

The economic and financial analysis indicated that all the alternative cases are viable except for the Scenario-1/Case 1.2, economic IRR of which is 11.3% slightly lower than the opportunity cost of capital in Peru, 12%.

5.2 Implementation Schedule

Cementos Lima (private firm in Lima) is currently proceeding a project named 'EL PLATANAL INTEGRATED PROJECT' for the development of total 270 MW power production and total 27,000 ha irrigation, with construction of a storage named Moro de Arica dam in the upstream stretch of the Cañete river. The details of the Project are presented in the following page.

Periods for the construction of the works and sales of the irrigation lots are assumed to be 4 years and 10 years respectively. Preparatory works including access roads are being proceeded. Social settlement in the project related area including Cañete and Yauyos provinces were started in April 2001.

This development has dimensions (in water demand, dams, power stations, groundwater development, water conveyance and irrigation facilities) similar to those of the Scenario-2/Case 2.1 on the Table 5.1.1. It is however noted that the Case 2.1 assumes construction of Paucarcocha reservoir but the above project assumes the reservoir construction as a possibility in future.

Such being the current status of the Cañete river water development, it is necessary to implement some additional facility to yield new water for the purpose to transfer the Cañete river water to Lima.

Option for the additional facility to yield new 5 m^3/sec water is deemed to be:

- Construction of a storage named San Jerónimo in the midstream, equivalent to the Scenario-3/Case 3.1,or,

- Construction of the Paucarcocha dam at upstream glacial lakes and 3 m^3/sec groundwater wells in the downstream coastal area, equivalent to the Scenario-3/Case 3.3.

As examined in the foregoing Section 4.5, economic comparison of the alternatives for yielding 5 m^3/sec water between the above Cañete basin facility and the Mantaro basin facility (Mantaro-Carispacha scheme) shows that the latter is preferred. Further, it would be the case that the transfer of Cañete river water to other basin, namely to Lima, invites serious objection by the people in the Cañete basin.

"EL PLATANAL" INTEGRATED PROJECT

I. PRINCIPAL DIMENSIONS

1. Project Reservoirs

a) Morro de Arica Reservoir

This reservoir takes advantage of a creek formed by the river in the town of Morro de Arica, located among the communities of Anta and Llapay.

Location:	Morro de Arica
Elevation:	3000 m.a.s.l
Storage capacity:	244 MCM
Purpose:	seasonal primary regulation
Type of dam:	CFRD
Height:	220 m
Fetch:	8 km

b) Capillucas Reservoir

Location:	Capillucas
Elevation:	1,525 m.a.s.l
Storage capacity:	5 MCM
Purpose:	hourly regulation
Type of dam:	CFRD
Height:	37 m
Fetch:	1 km

c) Paucarcocha Reservoir (only as a possibility in future)

Location:	Tanta
Elevation:	4,220 m.a.s.l
Storage capacity:	55 MCM
Purpose:	seasonal secondary regulation

2. Tunnel between Capillucas Reservoir and the Main Powerhouse

Location:	between Capillucas and San Juan
Total length:	13.40 km
Diameter:	4.2 – 4.8 m
Design discharge:	43 m^3/sec.

3. Powerhouses

a) Main Powerhouse (G1)

Location:	San Juan

Elevation: 900 m.a.s.l
Gross Head: 655 m
Design discharge: 42 m^3/sec.
Type of Turbine: Pelton
Power: 2 x 110 MW 220 MW
Tail Water Reservoir:
Elevation: 892 m.a.s.l
Storage capacity: 600,000 m^3

b) Morro de Arica Powerhouse (G2)

Location: at the base of Morro de Arica dam
Gross Head: 221 m
Design discharge: 44,3 m^3/sec
Type of Turbine: Francis
Power: 50 MW

4. Transmission Lines

Two 220 kV single-wire transmission lines.

5. Pampas de Concon-Topara Irrigation Intake

Location 500 m downstream from Socsi, at 303 m.a.s.l
Design capacity 20 m^3/sec
Effective discharge 12 m^3/sec
Sand-trap 3 x 60 m long chambers

6. Diversion Channel between Intake Works and Pampas de Concon-Topará

Type: rectangular shape
Length: 31 km
Design Discharge: 20 m^3/sec
Effective Discharge: 12 m^3/sec
Main channel going to Pampas de Concon-Topara
Type: Trapezoidal shape
Length: 45 km
Design discharge: 20 to 2.5 m^3/sec
Effective discharge: 12 to 1.5 m^3/sec

II. Benefits

1. Hydroelectric Power

Main Powerhouse (G1)
Firm power 220 MW
Output 1,100,000 MWh/year
Plant factor 57%
Morro de Arica Powerhouse (G2)
Installed capacity 50 MW
Output 132,000 MWh/year
Plant factor 30%

2. Agriculture

Irrigation area 27,000 ha
Agricultural products 600,000 tos/year

III. Investment and Project Schedule

1. **Investment**

Investment Amount For Hydroelectric Aspects	=	US$ 270 million
Investment Amount For the Irrigation of Concon-Topara	=	US$ 70 million
Total Amount	=	US$ 340 million
Investors' Contribution	=	US$ 140 million.
Investors	=	International and National Private Investors led by Cementos Lima
Amount of External Financing	=	US$ 200 million
Period of External Financing	=	14 years: 4 years' grace and 10 years amortization

2. **Project Schedule**

Estimated Time of Execution	=	4 years
Estimated Time for the Sale of Concon-Topara lots	=	10 years

TABLES

Table 2.1.1 Lithology Units

UNIT I	**QUATERNARY DEPOSITS**	
UNIT II	**VOLCANIC ROCKS**	
	II An	ANDESITE
	II rda	RHYOLITE
	II Ta	TRAQUYANDESITE
	II br	BRECCIA
UNIT III	**VOLCANIC – SEDIMENTARY ROCKS**	
	III A	VOLCANIC CONGLOMERATE, ANDESITIC EXTRUSIVES, SILT AND SANDSTONE
	III B	TUFF, TUFFACEAS SANDSTONE AND LIMESTONE
	III AB	INCLUDE ROCKS OF III A AND III B
	III C	SANDSTONE, ANDESITE AND CONGLOMERATE
	III D	TUFF, SANDSTONE AND SILSTONE
	III E	ANDESITE EXTRUSIVE
	III	ANDESITIC LAVAS, MUDSTONE, MARL CHERT
UNIT IV	**SEDIMENTARY ROCKS**	
	IV A	LIMESTONE
	IV B	SHALE, SANDSTONE, QUARZITE, SILSTONE
	IV C	SANDSTONE, SILSTONE, SHALE, CONGLOMERATE
	IV D	LIMESTONE, SILSTONE
UNIT V	**INTRUSIVE ROCKS**	
	V gr	GRANITE
	V Tgd	TONALITE – GRANODIORITE
	V MZ-gd	MONZONITE – GRANODIORITE
	V di	DIORITE
	V gd	GRANODIORITE
	V Tdi	TONALITE – DIORITE
	V gb-di	GABRO DIORITE

Table 2.2.1 Mean Monthly Rainfall

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Period
Rimac river basin														
Ticlio	95	125	103	58	30	9	10	19	44	66	54	87	701	1957-67
La Pirhua	127	136	147	62	27	8	17	14	39	57	47	92	875	1970-80
Quisha	115	117	134	73	20	9	12	13	35	48	49	79	730	1969-96
San Cristobal	133	146	149	76	27	13	9	16	41	67	85	107	898	1952-92
Mina Colqui	115	146	147	55	15	3	4	13	24	48	57	86	706	1969-94
Canchalloc	119	125	141	88	18	6	12	16	48	65	47	127	776	1969-74
Milloc	140	146	148	70	26	12	11	17	44	74	81	121	888	1967-95
Casapalca	112	130	120	52	22	10	8	12	40	53	60	89	703	1947-95
Chalilla	80	83	125	16	1	0	0	1	2	8	15	35	366	1969-83
Bellavista	120	133	123	46	17	3	2	5	20	40	55	82	624	1945-70
San Jose de Parac	102	121	117	38	8	4	2	4	12	41	40	78	603	1965-96
Carampoma	90	85	83	24	3	0	1	2	8	17	25	45	345	1965-96
Tamboraque	101	79	100	26	5	0	0	2	18	19	17	71	468	1970-74
Matucana	63	76	75	21	2	0	0	1	1	10	17	42	316	1984-96
Santa Eulalia	12	18	23	0	0	0	0	0	1	1	0	5	57	1964-96
La Cantuta	15	7	2	0	0	0	0	0	0	1	0	3	35	1973-96
Mantaro river basin (1)														
Cazapatos	107	114	98	50	26	12	7	15	37	59	60	88	676	1953-95
Junin	155	133	115	66	28	20	11	22	48	81	79	109	861	1969-92
Carhuacayan	137	166	145	65	29	10	13	23	51	79	87	102	907	1969-81
Hueghue	156	135	117	68	28	18	12	30	48	79	83	107	878	1969-95
Atocsaico	110	116	106	60	28	22	14	27	50	72	81	96	785	1952-95
Corpacancha	124	133	119	80	37	17	19	31	63	82	79	103	890	1956-95
Marcapomacocha	194	201	213	113	45	23	19	35	71	115	124	155	1,308	1969-95
Yantac	107	130	129	64	36	17	10	17	46	62	63	83	755	1957-93
Oroya	91	89	87	41	24	15	10	19	38	52	58	75	599	1943-92
Morococha	127	132	126	72	36	18	17	26	58	72	73	98	850	1947-95
Huascacocha	113	123	116	59	32	15	13	20	50	65	73	91	769	1955-95
Pachacayo	99	116	120	54	19	11	7	14	33	58	64	85	694	1966-96
Mantaro	100	110	114	49	13	9	6	11	30	56	68	98	657	1963-96
Yahuricocha	139	142	150	81	22	10	8	14	41	62	66	96	900	1965-96
Huaytapallana	146	139	136	54	23	15	5	13	42	70	79	106	801	1965-96
Mantaro river basin (2)														
Quiulacocha	121	130	120	76	32	16	14	18	46	78	96	108	855	1953-92
Upamayo	137	145	135	70	37	19	10	21	54	78	88	117	909	1952-92
Shelby	125	125	120	69	28	11	7	18	41	77	82	108	810	1956-92
Carhuamayo	121	120	100	56	28	13	8	18	53	69	70	93	749	1952-92
La Cima	105	112	92	50	28	18	10	24	51	67	61	92	709	1953-92
Malpaso	126	119	102	59	36	20	15	28	61	71	76	101	819	1940-92
Pucara	90	95	83	47	23	9	10	16	32	49	53	71	578	1953-92
Pachachaca	99	107	108	54	27	15	12	20	45	61	63	82	695	1947-92
Pomacocha	105	122	126	61	25	12	8	14	35	56	63	90	717	1953-92
Huallacocha Baja	117	148	143	71	24	10	8	13	32	63	67	102	808	1953-92
Mayupampa	87	79	78	38	18	12	9	20	38	52	58	62	555	1956-92
Curipata	86	95	95	43	19	13	9	17	35	54	54	72	587	1953-92
Quiulla	83	98	96	46	15	8	5	10	28	50	59	75	572	1957-92
Porvenir	111	110	97	43	14	7	6	15	36	58	68	84	654	1950-92
Jacayhuanca	90	92	85	42	24	18	14	20	41	54	53	78	619	1957-92
Chillon river basin														
Canta	70	77	91	27	2	1	0	1	4	14	18	40	369	1944-95
Huamantanga	60	82	97	23	6	0	0	0	1	9	21	28	346	1963-96
Huaros	73	81	118	44	5	0	1	1	5	19	27	55	428	1965-95
Lachaqui	111	169	154	44	6	0	0	2	6	30	36	69	616	1965-95
Pariancancha	125	130	129	56	20	3	4	9	23	52	58	89	702	1968-95

Source:	Rimac river basin	
	Mantaro river basin (1)	-do-
	Mantaro river basin (2)	Actualizacion de Estudios de Fuentes de Agua para Lima (1992, SEDAPAL)
	Chillon river basin	Estudio de Factibilidad del Desarrollo para el Aprovechamiento Optimo de las Agus Superficiales y Subterraneas del Rio Chillon (1998, SEDAPAL)

Table 2.2.2 Mean Monthly Temperature

(unit : mm)

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean	Period
Hipólito Unanue*	21.4	22.4	22.0	20.4	19.4	18.0	16.6	16.3	16.5	17.4	18.9	20.3	19.1	1961-71
Limatambo*	21.1	22.0	21.7	20.0	18.0	16.1	15.3	15.1	15.2	16.2	17.5	19.4	18.1	1950-62
Campo de Marte*	21.8	22.7	22.2	20.6	18.3	16.5	15.6	15.3	15.5	16.5	18.0	19.8	18.6	1937-82
A Von Humboldt*	20.9	22.0	21.6	19.8	17.5	15.8	14.7	14.6	15.1	15.9	17.3	19.2	17.9	1966-72
La Molina*	21.8	22.6	22.2	20.3	17.6	15.7	14.9	15.0	15.4	16.3	17.7	19.6	18.3	1930-67
Ñaña*	21.3	22.2	22.3	22.2	18.6	17.4	15.3	15.2	15.8	16.8	17.7	16.6	18.5	1964-84
Chosica*	22.2	23.2	23.2	21.7	19.1	17.0	16.1	17.2	18.0	19.1	20.0	20.8	19.8	1948-54
Matucana*	14.3	14.2	14.1	14.4	14.5	14.2	14.2	14.3	14.5	14.5	15.2	15.0	14.5	1964-71
Matucana	16.0	16.0	16.0	15.7	15.8	15.4	15.3	15.6	16.1	15.8	15.7	16.1	15.8	1990-00
Milloc*	4.5	4.7	5.0	5.5	5.5	4.8	5.4	5.7	4.9	4.4	4.5	4.8	5.0	1969-71
Aerop.Inter.*	22.1	22.5	22.2	20.6	18.7	17.5	16.7	16.4	16.5	17.3	18.7	20.6	19.2	1961-86
Chucuito*	21.6	22.1	22.0	20.6	18.8	18.1	17.2	16.8	16.8	17.6	19.0	20.6	19.3	1978-86
Santa Eulalia	15.3	15.2	15.2	15.5	15.4	14.8	15.0	15.2	15.6	15.7	15.5	15.5	15.3	1965-71
Canta	13.4	13.2	13.1	13.5	14.1	13.8	14.1	14.0	14.1	13.8	13.5	13.3	13.7	1964-71
Marcapomacocha	5.0	5.5	5.3	4.8	4.3	3.7	2.9	3.4	4.0	5.0	4.9	5.3	4.5	1970-00

Source :* Master Plan Study on th Disaster Prevention Project in the Rimac River Basin (JICA, 1988)

Table 2.2.3 Mean Monthly Relative Humidity

(unit : %)

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean	Period
Campo de Marte*	83	82	83	84	85	86	87	88	88	86	84	83	85	1971-82
Matucana*	74	77	78	73	64	60	57	60	61	63	64	70	67	1964-85
Ñaña*	83	81	80	81	87	89	90	89	88	87	86	85	86	1964-84
Hipólito Unanue*	86	85	87	88	87	88	88	88	88	87	85	85	87	1969-72
Limatambo*	82	81	81	82	84	86	87	88	88	85	83	82	84	1950-62
A Von Humboldt*	82	80	80	82	85	88	88	89	88	86	84	82	85	1966-72
La Molina*	82	81	83	86	89	89	89	89	82	85	82	85	85	1930-67
Chosica*	71	70	70	73	74	73	71	69	69	69	70	70	71	1948-54
Santa Eulalia	77	78	79	72	58	48	42	50	54	57	56	66	61	1965-72
Canta	79	82	83	75	59	50	46	50	54	61	61	70	64	1964-71
Mean	80	80	80	80	77	76	75	76	76	77	76	78	79	

Source : * Master Plan Study on th Disaster Prevention Project in the Rimac River Basin (JICA, 1988)

Table 2.2.4 Wind Velocity and Direction

(unit : km/hour)

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean	Period
Hipólito Unanue*	S	S	S	S	S	S	S	S	S	S	S	S	S	1969-72
	10.8	10.8	14.4	10.8	10.8	7.2	7.2	7.2	7.2	7.2	10.8	10.8	9.6	
Limatambo*	S	S	S	S	S	S	S	S	S	S	S	S	S	1950-62
	20.4	13.0	13.0	13.0	11.1	11.1	11.1	11.1	11.1	13.0	11.1	13.0	12.7	
Campo de Marte*	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	1961-72
	14.8	13.0	13.0	11.1	11.1	11.1	11.1	9.3	9.3	11.1	11.1	11.1	11.4	
A. Von Humbolt*	W	W	W	W	W	W	W	W	W	W	W	W	W	1966-72
	10.3	8.3	9.8	5.2	5.4	4.8	5.0	5.1	5.9	6.3	6.4	6.4	6.6	
Matucana*	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	1964-71
	16.0	15.0	13.0	15.2	13.2	13.0	16.0	4.0	15.8	16.0	15.8	17.2	14.2	

Source : * Master Plan Study on th Disaster Prevention Project in the Rimac River Basin (JICA, 1988)

Table 2.2.5 Sunshine Duration

(unit : hour)

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Period
Hipólito Unanue*	151	181	211	145	78	30	25	19	28	47	92	132	1139	1962-72
Campo de Marte*	198	205	225	211	129	51	34	30	36	71	114	165	1469	1955-72
A. Von Humbolt*	183	193	222	213	142	73	81	71	99	118	134	183	1712	1966-72
La Molina*	180	193	228	228	158	70	60	64	94	135	162	187	1759	1930-50
Mean	178	193	222	199	127	56	50	46	64	93	126	167	1520	

Source : * Master Plan Study on th Disaster Prevention Project in the Rimac River Basin (JICA, 1988)

Table 2.2.6 Mean Monthly Evaporation

(unit : mm)

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Period
Hipólito Unanue*	48.3	47.6	52.2	42.4	47.4	36.4	36.5	34.0	33.0	38.6	48.2	51.1	515.7	1969-72
Campo de Marte*	83.6	78.7	82.3	68.6	52.0	39.3	38.4	37.2	38.6	51.9	65.6	74.7	710.9	1929-72
A. Von Humbolt*	121.6	128.4	127.7	99.3	74.4	53.0	53.3	49.3	56.3	68.7	85.1	111.5	1028.6	1966-72
La Molina*	116.6	110.7	112.5	97.5	70.0	51.5	50.5	53.4	60.3	78.7	90.8	102.9	995.4	1930-67
Ñaña*	97.8	88.7	101.5	91.7	74.5	60.5	53.6	61.0	63.8	74.9	76.9	75.8	920.7	1964-84
Matucana*	98.2	77.9	76.5	97.5	143.4	165.9	189.5	186.9	183.5	169.4	164.8	136.6	1690.1	1964-85
Canta	59.1	42.1	43.7	62.8	113.1	144.9	177.7	155.2	131.1	112.8	108.1	82.0	1232.6	1964-71
Mean	89.3	82.0	85.2	80.0	82.1	78.8	85.6	82.4	80.9	85.0	91.4	90.7	1013.4	

Source : * Master Plan Study on th Disaster Prevention Project in the Rimac River Basin (JICA, 1988)

Table 2.2.7 Major Reservoirs and Lagoons

River Baisn	Effective Storage	River Baisn	Effective Storage
Sta. Eulalia River Basin		**Mantaro River Basin**	
Quisha	8.70	Antacoto	120.00
Carpa	17.80	Marcacocha	10.70
Huasca	6.30	Marcapomacocha	14.80
Sacsa	16.20	Sangrar	8.80
Quiula	1.90	Tucto	2.75
Piticuli	6.50		
Huampar	3.30		
Huachua	5.10		
Chiche	2.30		
Pucro	2.00		
Misha	0.70		
Canchis	2.10		
Huallunca	1.60		
Pirhua	0.90		
Manca	1.60		
Sub-Total in Sta.Eulalia Basin	77.00		
Rimac River Basin			
Yuracmayo	48.30		
Total of Rimac River Basin	**125.30**	**Total of Mantaro River Basin**	**157.05**

Source : Datos proporcionados por EDEGEL

Table 2.4.1 Analytical Methods Used by SEDAPAL Laboratory

PARAMETERS	ANALYTICAL METHODS
PH	Potenciometer
TURBIDITY	Nephelometer
ELECTRIC CONDUCTIVITY	Potenciometer
TEMPERATURE	Thermometer
DISSOLVED OXYGEN	Oxygen Meter – Specific Ions
TOTAL SOLIDS	Gravity Meter
DISSOLVED SOLIDS	Gravity Meter
SUSPENDED SOLIDS	Gravity Meter
IRON	Spectrophotometry of Atomic Absortion
MANGANESUM	Spectrophotometry of Atomic Absortion
LEAD	Spectrophotometry of Atomic Absortion
CADMIUM	Spectrophotometry of Atomic Absortion
COPPER	Spectrophotometry of Atomic Absortion
ZINC	Spectrophotometry of Atomic Absortion
ALUMINUM	Spectrophotometry of Atomic Absortion
BARIUM	Spectrophotometry of Atomic Absortion
ARSENIC	Atomic Absortion – Hydride generation
CYANID	Colorimetry - Barbituric Acid
ORGANIC CARBON	Carbon Analyzer – Nondispersive Infrared Combustion
INORGANIC CARBON	Carbon Analyzer – Nondispersive Infrared Combustion
TRIHALOMETHANES	Gas Chromatography – Liquid Extraction

Table 2.4.2 Summary of Rímac River Annual Aerage Water Quality Test (1993 – 1996)

PARAMETERS	UNITS	MONITORING STATIONS													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
PH	Units	7.76	8.46	8.46	8.26	7.72	8.40	8.39	8.20	8.29	8.27	8.17	8.24	8.18	8.28
TURBIDITY	U.N.T/U.J	9.79	31.90	158.00	42.60	33.80	36.50	21.68	38.78	185.00	16.64	36.34	39.00	45.53	49.00
ELECTRIC CONDUCTIVITY	μmhos/cm	869.00	684.00	703.00	687.00	382.00	633.00	614.00	726.00	743.00	455.00	517.00	486.00	505.00	521.00
TEMPERATURE	°C	19.36	16.94	16.96	16.60	13.56	15.51	19.50	22.37	22.45	19.60	21.00	17.90	19.42	20.37
DISSOLVED OXYGEN	Mg/lt	6.64	7.69	7.78	7.79	8.32	7.81	7.73	7.64	7.69	8.68	7.99	8.21	8.32	7.88
TOTAL SOLIDS	Mg/lt	737.00	558.00	570.00	571.00	394.00	514.00	534.00	673.00	640.00	420.00	547.00	407.00	438.00	431.00
DISSOLVED SOLIDS	Mg/lt	562.00	427.00	435.00	435.00	217.00	363.00	380.00	454.00	443.00	278.00	350.00	290.00	341.00	333.00
SUSPENDED SOLIDS	Mg/lt	32.00	41.50	59.00	52.80	49.00	38.00	23.30	26.80	21.83	59.00	61.30	36.80	38.80	34.50
IRON	Mg/lt	0.891	3.250	25.087	4.826	6.709	4.572	2.296	3.203	2.420	0.949	3.154	3.857	4.235	4.176
MANGANESUM	Mg/lt	0.171	0.270	2.270	0.362	0.590	4.899	0.215	0.150	0.124	0.085	0.173	0.211	0.202	0.190
LEAD	Mg/lt	0.087	0.470	2.507	0.533	0.132	0.463	0.144	0.358	0.215	0.090	0.177	0.217	0.181	0.203
CADMIUM	Mg/lt	0.0056	0.0100	0.0230	0.0076	0.0237	0.0130	0.0074	0.0089	0.0077	0.0034	0.0055	0.0048	0.0348	0.0044
CHROMIUM	Mg/lt	0.0057	0.0100	0.0219	0.0160	0.0053	0.0124	0.0058	0.0017	0.0071	0.0064	0.0021	0.0023	0.0073	0.0078
COPPER	Mg/lt	0.065	0.210	0.634	0.249	0.313	0.246	0.090	0.096	0.052	0.046	0.441	0.117	0.072	0.071
ZINC	Mg/lt	1.381	1.520	4.615	1.906	4.290	2.205	0.956	0.887	0.372	0.333	0.481	0.700	0.588	0.530
ALUMINUM	Mg/lt	0.512	1.080	2.539	1.221	1.206	0.988	0.474	1.095	1.004	0.662	1.446	1.249	1.574	1.526
BARIUM	Mg/lt	0.160	0.140	0.145	0.144	0.114	0.140	0.129	0.314	0.195	0.113	0.176	0.123	0.125	0.134
ARSENIC	Mg/lt	0.030	0.040	0.688	0.080	0.469	0.175	0.074	0.060	0.038	0.025	0.038	0.046	0.044	0.038
CYANID	Mg/lt	<0.0025	<0.0025	0.029	0.011	<0.0025	0.015	0.002	0.002	0.015	<0.0020	0.004	<0.0025	0.001	0.001
TOTAL CARBON	Mg/lt	43.73	32.75	32.89	32.38	8.66	27.08	26.74	25.79	30.03	24.29	27.45	24.37	26.10	26.28
INORGANIC CARBON	Mg/lt	42.00	31.20	30.95	30.63	6.33	24.76	24.34	23.31	26.89	21.56	21.38	22.29	22.93	22.82
ORGANIC CARBON	Mg/lt	1.71	1.57	1.86	1.53	2.35	1.57	2.42	2.49	3.13	3.06	6.08	4.95	3.15	2.86
TRIHALOMETHANES	μg/lt	2.22	2.21	1.88	4.65	2.70	2.39	3.46	3.42	4.13	2.69	13.93	3.13	4.32	6.80

1) GRATHON TUNNEL; 2) TAMBORAQUE III BRIDGE; 3) EFFLUENTS FROM TAMBORAQUE MINING FACILITIES; 4) TAMBORAQUE II BRIDGE;
5) ARURI RIVER; 6) TAMBORAQUE INTAKE; 7) SURCO BRIDGE; 8) CORCONA; 9) RICARDO PALMA BRIDGE; 10) SANTA EULALIA RIVER;
11) LOS ANGELES BRIDGE; 12) ÑAÑA BRIDGE; 13) HUACHIPA BRIDGE; 14) LA ATARJEA INTAKE

Prepared by Marco Antonio Meza Alvarez, January 1997

Source: Physic-Chemical Laboratory. SEDAPAL Sub-Management Office for Plants

Table 2.4.3 Limits of Potentially Hazardous Substances based on the Classification of Water cources (General Water Law)

PARAMETERS	EXPRESSED IN	WATERCOURSES			
		I	II	III	IV
ALUMINUM	Mg/lt as Al				1.0
ARSENIC	Mg/lt as As*****	0.1	0.1	0.2	1.0
BARIUM	Mg/lt as Ba	0.1	0.1		0.5
CADMIUM	Mg/lt as Cd*****	0.01	0.01	0.05	
CYANID	Mg/lt as CN*****	0.2	0.2	1.0	
COBALT	Mg/lt as Co				0.2
COPPER	Mg/lt as Cu*****	1.0	1.0	0.5	3.0
FECAL COLIFORMS	N.M.P / 100 ml	0.0	4000	1000	
TOTAL COLIFORMS	N.M.P / 100 ml	8.8	20000	5000	
COLOR	Units Pt/Co	0	10	20	30
CHROMIUM	Mg/lt as Cr*****	0.05	0.05	1.0	5.0
DISSOLVED OXYGEN	Mg/lt as DO	>3.0	>3.0	>3.0	>3.0
BOD	Mg/lt as BOD	5.0	5.0	15.0	10.0
PHENOLS	Mg/lt as Phenol	0.0005	0.001	0.001	
FLUORIDES	Mg/lt as F	1.5	1.5	2.0	
FATS	Mg/lt	1.5	1.5	0.5	0.0
IRON	Mg/lt as Fe	1.5	0.3	0.3	1.0
LITIUM	Mg/lt as Li				
MAGNESIUM	Mg/lt as Mg			150	
MANGANESIUM	Mg/lt as Mn	0.1	0.1	0.5	
MERCURY	Mg/lt as Hg*****	0.002	0.002	0.01	
NITRATUM	Mg/lt as N*****	0.01	0.01	0.1	
NICKEL	Mg/lt as Ni*****	0.002	0.002	0.002	0.5
PH	Units	5 – 9	5 – 9	5 – 9	5 – 9
SILVER	Mg/lt as Ag	0.05	0.05	0.05	
LEAD	Mg/lt as Pb*****	0.05	0.05	0.1	
PCB	Mg/lt as PBC*****	0.001	0.001	0.001	
SELENIUM	Mg/lt as Se	0.01	0.01	0.05	0.05
SUSPENDED SOLIDS	Mg/lt	0	0	0	**
SULPHATES	Mg/lt as SO_4			4	
SULPHIDES	Mg/lt as S	0.001	0.002	0.005	
ZINC	Mg/lt as Zn	5.0	5.0	25.0	

***** : Potentially hazardous substances
****** : little quantity
I : water supply for domestic use, with basic disinfection
II : water supply for domestic use, undergoing treatment equivalent to a combined process of mixing and coagulation, sedimentation, filtration and chlorinating.
III : water for the irrigation of crops (vegetables) to be eaten on raw state and animal drinking.
IV : water from recreational areas (toilets and other similar)
Prepared by Marco Antonio Meza Alvarez, January 1997
SOURCE: General Law on Waters, Law Decree No. 17752 and amendments to regulations of titles I, II and III (Supreme Decree No. 007-83-SA) classification of continental watercourses

Table 2.4.4 Environmental Quality Standard in Japan (1971) Concerning Protection of Human Health

Item	Standard value
Cadmium	less than 0.01 mg/l
Cyanide	Non-detection
Lead	less than 0.01 mg/l
Hexavalent Chromium	less than 0.05 mg/l
Arsenic	less than 0.01 mg/l
Mercury	less than 0.0005 mg/l
Alkyl Mercury	Non-detection
PCB	Non-detection
Dichloromethane	less than 0.02 mg/l
Carbon Tetrachloride	less than 0.002 mg/l
1,2-dichloroethane	less than 0.004 mg/l
1,1-dichloroethylene	less than 0.02 mg/l
cis-1,2-dichloroethylene	less than 0.04 mg/l
1,1,1-trichloroethane	less than 1.0 mg/l
1,1,2-trichloroethane	less than 0.006 mg/l
Trichloroethane	less than 0.03 mg/l
Tetrachloroethylene	less than 0.01 mg/l
1,3-dichloropropene	less than 0.002 mg/l
Thiuram	less than 0.006 mg/l
Simazine	less than 0.003 mg/l
Tiobencarb	less than 0.02 mg/l
Benzene	less than 0.01 mg/l
Selenium	less than 0.01 mg/l
Nitrate Nitrogen / Nitrite Nitrogen	less than 10.0 mg/l
Fluorine	less than 0.8 mg/l
Boron	less than 1.0 mg/l

Note:

1. Standard value show the annual average value except Cyanide.
   Standard value for Cyanide show the maximum value.
2. Non-detection means that the test result done by the specified measurement method shall be less than the allowable limit.
3. Fluorine and Boron shall not apply to the ocean area.

Table 2.4.5 Environment Water Quality Standard for River Concerning Conservation of the Living Environment

Item / Class	Suitability for Water Use (River excluding lakes)	Standard Value				
		Hydrogen Ion Concentration (pH)	Biochemical Oxygen Demand (BOD)	Suspended Solid (SS)	Dissolved Oxygen (DO)	Number of Total Coliforms
AA	1st class water for water supply, Water for conservation of the natural environment and Lower A class water use	6.5～8.5	< 1 mg/l	< 25 mg/l	> 7.5 mg/l	< 500MPN/ 100 ml
A	2nd class water for water supply, 1st class water for fishery water, Water bathing and Lower B class water use	6.5～8.5	< 2 mg/l	< 25 mg/l	> 7.6 mg/l	< 1,000MPN/ 100 ml
B	3rd class water for water supply, 2nd class water for fishery water and Lower C class water use	6.5～8.5	< 3 mg/l	< 25 mg/l	> 5 mg/l	< 5,000MPN/ 100 ml
C	3rd class water for fishery water, 1st class water for industrial water and Lower than D class water use	6.5～8.5	< 5 mg/l	< 50 mg/l	> 5 mg/l	—
D	2nd class water for industrial water, Agricultural water and Lower than E class water use	6.5～8.5	< 8 mg/l	< 100 mg/l	> 2 mg/l	—
E	3rd class water for industrial water and Water for conservation of living environment	6.5～8.5 (6.0～7.5)	< 10 mg/l	Non-waste found	> 2 mg/l (> 5 mg/l)	—

Note:

1. Standard value show the daily average
2.
3. Classification of water use is shown below.

(1) Conservation of natural environment: Conservation of natural resources for sightseeing etc.

(2) 1st class water for water supply: Water treated by primary treatment method as filtration

2nd class water for water supply:
process

3rd class water for water supply:
process with pretreatment

(3) 1st class water for fishery water: Water for fishes living in the oligosaprobic water such as a trout and fishes living in 2nd and 3rd class water

2nd class water for fishery water: Water for fishes living in the oligosaprobic water such as a salmon and fishes living in 3rd class water

3rd class water for fishery water: Water for fishes living in the β-mesosaprobic water such as a carp

(4) 1st class water for industry water: Water treated by common treatment method as sedimentation

2nd class water for industry water: Water treated by advanced treatment method as chemical feeding

3rd class water for industry water: Water treated by special treatment method

(5) Conservation of living environment:

Table 3.1.1 Probable Annual Rainfall in Rímac and Mantaro River Basin

Observation Station			Probable Annual Rainfall (mm)							
			1/2	1/3	1/5	1/10	1/20	1/50	1/100	Related Project
Station Name	Altitude (m)	Sample number	50 %	67 %	80 %	90 %	95 %	98 %	99 %	(*)
1. Rimac river basin										
Quisha	4,650	21	649	503	388	285	215	148	110	Santa Eulalia
Milloc	4,400	29	839	753	683	621	577	535	511	-do-
Casapalca	4,191	48	690	620	558	495	446	394	361	Rimac river
San Jose de Parac	3,800	18	602	522	450	378	322	262	224	Yuracmayo
Average 1.	4,260		695	599	520	445	390	335	301	
2. Mantaro river basin										
Hueghue	4,150	26	864	792	728	664	614	562	529	Marca III
Corpacacancha	4,150	34	865	816	776	740	715	690	676	Marca I
Marcapomacocha	4,600	27	1245	1040	865	698	573	447	371	Marca III
Morococha	4,522	47	846	788	734	678	632	583	550	Marca II
Huascacocha	4,500	40	758	705	657	610	574	536	512	Marca II
Pomacocha	4,300	40	707	655	609	562	525	487	462	Marca II
San Cristobal	4,625	35	875	791	718	648	595	541	507	Marca II
Average 2.	4,407		880	798	727	657	604	549	515	

Note: Legalistic Normal Distribution is applicable to estimate probable rainfall.
(*) Percentage means the reliability of rainfall occurrence.

Table 3.2.1 Hourly River Discharge Data observed at Chosica (SENAMHI)

(unit : m³/sec)

Date / Time	Jul.23	Jul.24	Jul.25	Jul.26	Jul.27	Jul.28	Jul.29	Jul.30	Jul.31	Aug.1	Aug.2	Aug.3	Aug.4	Aug.5	Aug.6	Aug.7	Aug.8	Aug.9	Aug.10	Aug.11	Aug.12	Aug.13	Aug.14	Aug.15	Aug.16
0:00	n.a.	29.098	33.181	28.377	29.510	25.886	n.a.	26.303	29.098	30.023	32.825	28.549	29.002	24.105	22.945	31.745	27.200	29.607	27.649	32.053	26.012	27.499	33.212	28.624	30.443
1:00	29.098	29.098	32.166	27.653	28.170	25.677	n.a.	23.893	27.550	34.379	32.670	29.002	29.607	24.542	27.649	31.899	26.754	29.759	27.499	31.438	26.012	27.798	32.284	28.624	30.291
2:00	30.330	28.377	29.612	27.446	26.615	25.573	n.a.	26.095	27.860	30.672	33.756	28.248	30.063	25.275	26.308	30.672	26.605	28.700	26.308	32.515	25.717	27.948	29.531	28.173	28.624
3:00	30.330	28.274	28.893	27.550	25.573	24.104	n.a.	26.511	27.342	29.759	32.825	27.798	29.002	26.012	26.160	30.520	25.717	28.098	26.457	32.361	25.717	29.153	27.873	27.873	27.873
4:00	30.330	26.823	27.446	26.927	24.314	24.314	n.a.	26.719	27.031	29.911	31.284	26.605	27.499	25.422	27.798	32.515	22.801	25.865	26.160	31.131	22.945	29.455	27.574	28.173	28.926
5:00	29.098	26.719	25.677	27.031	23.998	30.023	n.a.	27.031	26.407	28.098	29.153	24.250	30.825	26.457	28.399	29.304	21.654	24.542	24.835	30.825	23.234	29.759	26.086	27.275	25.643
6:00	27.860	25.782	25.154	26.407	23.471	28.790	n.a.	27.757	25.677	26.457	25.865	23.523	30.825	26.754	27.499	28.098	23.523	25.570	26.308	30.672	22.513	29.002	23.596	25.643	25.791
7:00	26.615	25.677	25.468	23.788	22.093	26.719	n.a.	25.677	23.577	25.865	25.865	22.513	27.798	23.379	26.902	27.499	22.083	24.396	24.982	27.798	20.519	25.570	25.496	25.202	24.762
8:00	25.468	26.511	25.259	23.048	23.682	26.303	n.a.	24.104	22.942	24.835	23.959	21.940	27.051	25.422	21.940	27.948	22.370	23.959	25.570	28.098	22.226	22.011	26.234	25.055	24.032
9:00	25.468	25.468	25.259	21.666	22.093	24.944	n.a.	22.730	22.199	22.657	24.105	22.801	26.457	26.012	19.676	27.948	21.369	20.097	23.959	25.570	26.012	29.987	25.643	24.032	23.741
10:00	24.104	24.524	25.154	24.630	21.880	23.471	n.a.	23.471	24.630	24.396	26.160	24.689	22.801	25.865	21.085	25.422	21.085	22.370	23.814	25.865	24.835	29.380	29.077	20.873	21.298
11:00	23.682	25.677	25.363	25.468	21.666	24.314	n.a.	23.048	22.942	26.605	25.422	23.523	25.570	26.902	23.089	27.499	21.797	23.959	23.089	26.902	23.814	28.926	26.679	21.726	20.167
12:00	22.942	24.209	25.259	22.624	23.893	21.880	n.a.	22.305	22.836	25.422	25.422	22.945	25.422	26.457	24.689	26.012	20.237	21.797	21.940	27.200	23.234	29.531	26.383	22.585	20.449
13:00	26.511	24.419	24.735	23.365	25.154	22.836	n.a.	23.893	24.839	24.542	27.649	22.226	25.275	25.128	26.754	25.717	21.085	24.982	24.105	26.308	24.982	26.828	25.643	25.055	26.383
14:00	26.095	25.259	22.942	16.904	24.944	22.518	n.a.	25.782	26.199	23.089	25.422	25.275	25.717	25.865	26.457	23.668	20.802	24.689	25.865	25.865	25.128	28.323	23.451	23.306	26.383
15:00	25.782	25.886	22.730	21.453	26.719	23.682	n.a.	26.719	26.511	22.801	24.542	29.304	26.754	25.128	23.234	25.570	21.227	23.668	24.689	21.797	25.128	28.624	23.306	23.451	24.323
16:00	24.314	22.199	28.377	22.730	26.511	22.412	n.a.	26.511	25.468	20.378	37.530	29.153	26.754	21.085	24.982	27.051	22.945	22.083	28.248	24.835	25.275	28.023	25.055	28.323	24.323
17:00	26.823	22.412	30.739	27.239	26.927	23.365	n.a.	26.615	24.735	23.668	34.379	30.367	28.248	20.802	27.649	29.607	26.605	20.378	31.899	26.160	27.200	30.443	26.531	28.474	26.531
18:00	27.342	25.573	31.454	27.757	26.303	25.573	n.a.	26.719	25.782	29.002	30.672	29.607	28.098	21.654	28.549	26.902	27.200	27.649	31.591	26.308	27.051	31.668	26.828	28.173	27.574
19:00	28.790	25.677	32.776	25.886	27.757	26.719	n.a.	30.433	26.615	28.851	29.759	30.063	28.851	21.512	27.798	27.499	27.798	29.153	30.367	26.308	27.798	31.976	28.926	27.126	28.323
20:00	28.790	26.615	32.674	27.550	27.239	26.615	n.a.	30.433	26.615	30.367	29.304	29.002	28.399	25.128	26.902	28.098	27.798	29.607	31.745	26.308	29.002	34.614	28.926	25.791	28.926
21:00	28.790	26.615	31.250	27.446	28.170	26.823	n.a.	29.920	26.615	32.980	29.911	28.549	28.549	25.128	30.672	25.570	29.759	30.520	32.053	26.605	29.607	33.057	29.380	29.077	30.596
22:00	29.201	30.330	30.228	29.510	27.031	26.615	n.a.	29.612	25.259	32.207	28.549	31.899	29.153	26.160	31.745	23.668	29.759	27.798	33.290	27.499	24.396	32.593	28.173	29.835	29.987
23:00	29.098	33.384	28.996	29.612	26.927	26.095	n.a.	29.818	24.839	32.825	30.215	31.438	27.200	26.308	32.515	25.275	29.455	26.605	33.290	27.499	27.499	33.834	27.873	30.291	30.139
Max.	30.330	33.384	33.181	29.612	29.510	30.023	n.a.	30.433	29.098	34.379	37.530	31.899	30.825	26.902	32.515	32.515	29.759	30.520	33.290	32.515	29.607	34.614	33.212	30.291	30.596
Min.	22.942	22.199	22.730	16.904	21.666	21.880	n.a.	22.305	22.199	20.378	23.959	21.940	22.801	20.802	19.676	23.668	20.237	20.097	21.940	21.797	20.519	22.011	23.306	20.873	20.167
Average	27.255	26.442	27.950	25.503	25.443	25.219	n.a.	26.337	25.565	27.491	29.052	26.803	27.705	24.854	26.308	27.738	24.485	25.660	27.321	27.830	25.244	29.417	27.240	26.365	26.480

Date / Time	Aug.17	Aug.18	Aug.19	Aug.20	Aug.21	Aug.22	Aug.23	Aug.24	Aug.25	Aug.26	Aug.27	Aug.28	Aug.29	Aug.30	Aug.31	Sep.1	Sep.2	Sep.3	Sep.4	Sep.5	Sep.6	Sep.7	Sep.8	Sep.9
0:00	29.987	29.987	26.531	24.615	29.002	33.134	28.248	30.215	30.978	31.438	29.153	29.674	30.739	31.211	28.953	29.207	28.363	26.730	28.850	30.970	30.060	32.200	32.980	28.540
1:00	28.624	27.424	27.424	23.886	28.549	30.063	28.399	30.063	30.672	29.759	29.153	28.869	30.063	30.739	28.953	31.254	27.230	25.570	34.692	30.215	37.054	33.290	32.515	27.649
2:00	28.775	26.234	27.574	26.531	25.570	28.851	25.570	29.911	29.607	30.215	29.153	28.152	28.953	30.483	28.953	30.184	28.068	24.689	35.476	29.607	34.536	31.284	32.361	27.051
3:00	27.723	23.596	26.234	26.383	26.160	28.399	23.668	28.851	29.153	28.851	30.063	26.480	34.242	30.483	28.658	29.886	28.068	25.570	32.980	26.902	28.851	28.248	30.825	27.350
4:00	28.173	22.441	25.202	26.383	24.982	29.153	23.814	29.759	26.457	24.835	29.153	24.952	31.425	28.363	28.447	28.447	27.858	25.570	30.520	25.865	26.902	27.350	27.649	27.051
5:00	28.323	23.162	26.234	25.939	23.959	26.160	21.654	28.098	27.499	23.668	27.350	24.747	27.565	25.859	27.439	25.487	29.080	24.689	29.002	26.308	27.200	26.308	25.275	27.200
6:00	25.791	24.323	25.349	24.323	21.227	24.835	23.234	27.499	24.835	27.649	27.350	23.605	26.231	24.665	23.971	25.735	28.700	23.814	27.350	25.275	26.160	23.814	23.814	24.542
7:00	25.496	24.908	22.873	23.162	18.840	19.536	15.303	25.422	25.128	26.902	25.570	22.594	25.158	24.379	23.889	25.487	24.542	20.378	24.250	24.689	23.668	23.234	24.105	26.160
8:00	23.886	23.162	22.729	22.083	19.536	21.512	18.011	23.814	24.982	25.570	23.402	22.312	22.513	23.605	21.472	26.772	28.784	22.083	25.275	23.668	20.519	24.542	20.943	26.902
9:00	21.583	24.908	23.017	26.308	22.226	26.308	26.457	22.801	24.250	26.160	20.283	19.536	21.552	23.118	24.583	25.735	25.446	23.668	24.982	23.523	22.083	22.083	19.956	24.835
10:00	23.596	24.615	20.731	25.422	21.369	25.865	25.865	22.657	24.689	27.499	24.297	23.402	21.631	23.321	24.542	24.747	25.240	23.668	25.570	22.945	23.089	25.128	24.105	21.797
11:00	24.615	22.729	19.886	27.649	21.369	26.308	25.717	25.275	24.982	29.002	24.379	24.093	23.118	22.916	23.118	24.461	25.570	23.668	25.128	23.234	22.226	23.959	22.370	19.118
12:00	25.349	25.791	22.011	26.012	24.982	24.835	28.549	26.308	23.523	25.570	24.297	25.446	24.379	22.031	22.795	22.152	24.952	25.128	25.717	20.519	22.083	24.250	21.654	24.689
13:00	28.023	27.275	22.154	25.128	22.801	24.689	26.160	25.865	23.523	26.902	27.649	25.859	24.542	21.193	22.916	22.594	25.570	26.457	25.570	20.802	26.457	23.089	22.657	22.801
14:00	28.023	27.873	22.298	25.865	24.542	24.542	26.308	23.234	21.512	25.275	28.068	24.297	23.767	23.118	26.564	23.402	26.356	26.902	26.902	24.250	27.798	22.513	24.105	23.959
15:00	28.173	29.683	21.156	29.304	24.542	26.160	26.605	22.945	24.105	24.396	28.447	24.379	24.788	23.808	26.730	23.971	25.652	25.422	26.308	25.275	27.649	21.797	26.012	22.801
16:00	29.531	26.977	21.868	27.499	25.422	27.948	25.275	26.902	26.160	24.250	28.489	22.433	24.175	26.772	27.272	27.942	25.735	25.128	27.051	25.865	27.798	21.797	25.570	23.523
17:00	29.380	26.828	22.441	27.649	25.717	26.754	29.455	27.948	28.399	24.542	28.700	21.831	24.461	28.363	26.231	30.184	26.356	26.605	26.902	24.542	29.153	22.370	26.457	26.754
18:00	29.380	27.275	21.726	28.700	28.700	26.012	30.215	29.304	28.399	26.457	29.589	20.796	26.273	28.278	27.063	30.099	25.240	26.902	27.948	26.308	28.700	27.649	30.215	26.902
19:00	29.683	27.275	21.726	27.649	29.607	25.128	30.215	29.759	32.670	27.649	29.886	24.747	26.730	29.207	28.996	28.953	27.942	27.350	28.851	27.798	28.851	29.002	31.899	27.200
20:00	29.380	27.275	25.349	27.649	28.700	27.499	30.825	29.153	32.825	27.499	30.014	27.481	27.230	28.278	32.071	29.080	29.292	27.350	27.350	30.825	30.520	29.304	32.515	29.911
21:00	29.835	28.323	25.349	28.248	26.754	27.948	30.978	28.851	32.980	27.499	29.886	27.732	27.984	25.487	32.373	30.227	28.996	29.153	30.978	31.131	32.980	29.304	34.379	32.515
22:00	29.683	27.275	25.643	28.700	29.607	26.754	30.520	29.759	33.134	27.948	29.971	31.640	26.938	27.147	32.287	31.726	30.014	30.215	28.098	31.284	33.445	31.284	34.849	32.361
23:00	29.228	26.383	24.177	26.605	32.670	27.200	30.672	29.911	32.515	27.051	29.080	32.071	30.398	29.292	30.911	32.157	27.565	28.851	30.367	29.304	31.899	30.978	30.063	28.700
Max.	29.987	29.987	27.574	29.304	32.670	33.134	30.978	30.215	33.134	31.438	30.063	32.071	34.242	31.211	32.373	32.157	30.014	30.215	35.476	31.284	37.054	33.290	34.849	32.515
Min.	21.583	22.441	19.886	22.083	18.840	19.536	15.303	22.657	21.512	23.668	20.283	19.536	21.552	21.193	21.472	22.152	24.542	20.378	24.250	20.519	20.519	21.797	19.956	19.118
Average	27.593	26.072	23.737	26.321	25.285	26.483	26.322	27.263	27.624	26.941	27.641	25.297	26.452	26.338	27.049	27.495	27.109	25.648	28.172	26.296	27.903	26.449	27.386	26.263

Source : SENAMHI

Note: n.a. (not available)

Table 3.2.2 Hourly Intake Discharge Data observed at La Atarjea Intake (SEDAPAL)

(unit : m^3/sec)

Date / Time	Jul.23	Jul.24	Jul.25	Jul.26	Jul.27	Jul.28	Jul.29	Jul.30	Jul.31	Aug.1	Aug.2	Aug.3	Aug.4	Aug.5	Aug.6	Aug.7	Aug.8	Aug.9	Aug.10	Aug.11	Aug.12	Aug.13	Aug.14	Aug.15	Aug.16
0:00	n.a.	17.261	16.400	16.736	17.949	16.567	n.a.	13.020	14.442	15.321	15.369	15.528	17.143	14.937	7.984	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	13.982	18.439	17.563	18.944
1:00	12.478	15.767	16.148	14.811	16.805	12.224	n.a.	12.916	14.723	14.654	15.276	14.427	15.211	14.096	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	12.290	16.883	16.668	16.743
2:00	12.415	16.083	16.494	14.770	15.846	12.290	n.a.	13.034	14.580	15.178	15.430	14.541	14.732	11.423	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	12.153	16.993	16.445	15.887
3:00	12.254	15.810	16.590	14.627	15.707	12.376	n.a.	13.383	14.577	14.574	15.181	14.430	14.675	11.535	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	12.426	16.962	15.974	15.745
4:00	12.506	15.295	16.597	14.520	14.923	11.919	n.a.	13.168	14.513	14.513	15.284	14.434	14.734	11.101	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	12.412	16.913	15.909	16.048
5:00	12.521	14.985	14.340	13.853	14.211	11.929	n.a.	12.946	13.877	14.364	15.001	14.152	14.417	11.309	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	12.206	16.244	15.999	15.892
6:00	12.632	15.119	14.205	14.274	13.588	13.996	n.a.	13.096	13.657	14.408	15.336	14.416	14.370	11.379	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	22.922	16.104	16.088	16.035
7:00	15.818	14.920	16.033	17.076	17.125	14.108	n.a.	13.050	13.753	14.437	15.809	14.199	14.326	12.893	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	22.087	16.059	16.098	16.809
8:00	15.045	14.638	14.611	15.090	16.017	13.722	n.a.	13.225	13.572	14.813	15.422	14.640	14.748	12.701	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	20.953	15.738	15.927	16.630
9:00	14.818	14.952	14.604	14.349	16.961	14.777	n.a.	13.710	14.510	14.975	15.251	15.156	15.581	14.439	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	18.613	15.714	17.105	16.806
10:00	14.066	15.273	14.476	14.528	15.472	14.403	n.a.	13.961	15.203	14.429	14.429	14.645	16.603	15.081	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	18.193	15.333	16.500	17.934
11:00	14.166	13.946	14.580	15.021	13.995	14.661	n.a.	13.519	14.934	14.365	14.646	14.314	16.670	16.495	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	14.927	15.485	16.915	17.592
12:00	14.745	13.400	14.246	12.430	14.815	15.082	n.a.	13.435	14.591	14.083	14.185	14.516	16.764	15.946	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	15.060	15.981	17.107	16.142
13:00	14.648	13.348	13.323	13.039	13.300	14.924	n.a.	13.621	14.544	14.037	13.975	13.890	17.301	16.196	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	13.406	13.849	12.102	15.448
14:00	14.830	13.504	13.388	12.055	14.116	14.071	n.a.	13.507	13.786	14.237	13.701	13.809	17.426	16.403	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	13.406	15.459	15.154	16.600
15:00	13.939	13.471	14.230	13.265	13.958	12.874	n.a.	12.958	13.828	14.601	14.175	13.935	17.247	16.802	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	16.739	16.705	14.609	15.592
16:00	13.235	13.607	14.770	13.849	15.064	12.996	n.a.	12.992	14.386	14.811	13.799	14.104	17.669	16.718	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	17.174	17.614	15.207	15.796
17:00	12.600	13.649	14.714	13.467	15.570	13.391	n.a.	12.326	14.502	15.457	14.457	13.964	16.877	14.287	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	18.503	18.225	15.596	15.983
18:00	13.356	13.632	14.588	12.784	15.306	14.592	n.a.	12.310	15.489	15.438	14.907	14.664	16.709	14.232	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	17.177	18.431	17.464	16.195
19:00	14.410	14.369	14.617	12.286	15.480	14.693	n.a.	12.678	16.851	15.300	15.733	15.313	16.790	14.396	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	18.291	18.254	16.972	16.537
20:00	17.561	16.173	14.927	12.680	15.443	15.188	n.a.	12.730	17.801	15.276	19.376	15.758	15.116	13.725	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	19.476	18.315	16.735	17.015
21:00	16.697	16.231	18.259	16.330	15.660	14.935	n.a.	12.736	18.198	15.803	18.594	16.892	15.170	13.663	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	20.697	18.602	17.868	16.702
22:00	16.999	16.180	18.575	17.992	16.169	14.896	n.a.	14.129	16.918	15.906	19.402	16.847	14.609	13.225	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	20.656	19.474	19.385	18.630
23:00	17.823	16.442	17.443	18.370	16.376	15.598	n.a.	14.338	15.281	15.166	16.751	17.052	14.787	13.273	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	19.092	19.512	19.560	18.930
Max.	17.823	17.261	18.575	18.370	17.949	16.567	n.a.	14.338	18.198	15.906	19.402	17.052	17.669	16.802	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	22.922	19.512	19.560	18.944
Min.	12.254	13.348	13.323	12.055	13.300	11.919	n.a.	12.310	13.572	14.037	13.701	13.809	14.326	11.101	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	12.153	13.849	12.102	15.448
Average	14.329	14.919	15.340	14.508	15.411	14.009	n.a.	13.200	14.938	14.839	15.479	14.818	15.820	14.011	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	16.785	16.970	16.456	16.693

Date / Time	Aug.17	Aug.18	Aug.19	Aug.20	Aug.21	Aug.22	Aug.23	Aug.24	Aug.25	Aug.26	Aug.27	Aug.28	Aug.29	Aug.30	Aug.31	Sep.1	Sep.2	Sep.3	Sep.4	Sep.5	Sep.6	Sep.7	Sep.8	Sep.9
0:00	18.764	14.778	17.460	17.033	16.601	17.524	16.999	19.178	15.307	15.766	17.273	18.260	19.029	18.560	16.884	19.539	18.883	13.322	20.767	18.425	17.275	16.599	19.947	17.234
1:00	16.193	14.547	16.246	14.502	16.220	16.259	16.078	18.321	15.718	15.758	15.863	16.160	18.508	16.243	15.090	19.539	19.204	13.828	17.099	14.455	17.588	16.321	18.087	17.158
2:00	15.510	14.664	16.503	14.594	16.041	16.210	15.519	18.472	15.747	15.854	15.975	16.461	18.797	16.203	15.121	22.380	19.233	14.638	17.552	13.510	17.421	15.811	18.263	17.253
3:00	15.523	14.490	16.434	14.587	16.163	16.113	15.378	18.066	15.501	16.039	16.075	16.340	18.862	16.108	14.288	20.653	19.199	14.712	17.377	13.509	17.584	15.806	18.123	16.829
4:00	14.506	14.615	16.263	14.532	15.961	16.280	15.712	17.968	15.468	15.853	16.006	16.097	17.257	15.715	14.152	20.575	18.993	14.282	16.513	13.562	17.374	15.317	18.183	16.652
5:00	13.673	14.581	16.361	14.390	16.429	16.273	15.638	18.081	15.463	15.894	16.210	16.035	17.528	15.811	14.111	17.084	18.968	14.766	16.062	13.525	16.884	17.478	18.529	16.575
6:00	13.618	17.195	16.271	14.535	16.350	16.498	15.597	17.887	15.359	15.702	16.197	16.241	17.295	15.689	14.727	15.758	18.958	15.549	15.667	16.173	18.343	16.001	19.042	17.105
7:00	15.518	17.040	17.914	16.849	16.572	17.870	15.568	18.359	16.867	19.259	16.847	17.517	17.439	16.044	15.176	13.359	19.398	16.270	15.103	18.203	17.742	15.856	16.996	17.058
8:00	15.460	16.864	17.729	16.933	16.639	17.559	15.355	17.722	17.154	18.842	16.898	16.988	16.004	16.181	14.784	15.641	19.147	16.188	15.539	17.598	17.910	15.580	15.778	16.639
9:00	15.460	17.072	17.122	17.193	16.632	17.200	16.063	19.057	16.427	19.052	16.514	17.126	16.338	16.134	16.273	15.473	19.250	17.693	15.718	17.010	17.100	16.678	14.802	14.722
10:00	16.418	16.554	16.352	17.107	17.068	17.074	15.566	18.811	16.310	18.936	16.923	16.409	16.564	15.708	16.040	16.321	19.254	7.510	16.068	15.514	17.364	16.388	14.634	14.564
11:00	15.955	17.290	15.515	16.884	16.786	16.734	15.414	18.336	17.514	17.071	18.154	15.584	16.230	15.473	15.525	16.245	18.696	14.711	15.751	15.339	15.786	14.789	14.548	15.385
12:00	17.323	17.376	14.872	15.411	15.871	16.112	14.708	18.123	17.534	16.421	16.674	14.758	13.538	15.746	15.478	16.444	18.534	13.642	15.802	14.416	14.339	14.474	14.510	15.385
13:00	17.228	16.934	14.154	15.254	13.692	13.818	12.809	17.438	17.179	15.625	15.957	13.968	13.299	15.762	15.427	16.444	18.608	13.753	15.622	13.626	13.922	11.987	14.308	15.280
14:00	15.676	16.934	14.466	14.914	14.662	15.403	13.819	16.087	18.029	14.830	15.754	13.913	13.274	15.952	15.612	17.461	18.044	14.268	15.660	13.453	13.064	13.724	14.839	10.178
15:00	14.733	17.471	13.867	15.938	15.977	16.314	13.819	15.995	17.374	14.535	15.640	13.676	13.179	15.734	15.504	16.755	17.863	14.351	15.334	13.589	13.535	15.496	15.800	16.198
16:00	16.543	17.480	13.925	15.628	15.335	17.780	15.126	16.108	17.722	14.535	15.508	15.198	13.814	15.759	15.307	16.275	17.897	14.834	14.714	12.990	13.897	14.750	15.834	16.647
17:00	17.252	18.046	13.818	16.357	16.301	17.089	15.660	18.245	18.277	14.535	15.631	15.528	15.006	15.465	17.536	16.320	18.202	15.054	14.967	13.756	14.061	14.708	16.532	17.948
18:00	18.814	17.996	13.964	14.405	17.652	17.439	17.538	18.338	18.403	20.145	16.808	17.408	16.681	16.278	17.576	16.756	16.561	16.680	18.218	14.384	16.160	15.854	16.575	17.248
19:00	19.389	19.202	14.585	16.073	17.326	17.483	18.829	17.889	18.264	19.578	17.620	17.267	17.486	16.210	18.359	19.736	17.620	17.416	18.383	16.679	17.829	16.050	16.618	17.116
20:00	20.211	19.993	14.790	17.457	16.831	17.378	19.953	19.268	18.693	19.175	17.775	17.114	18.971	16.489	18.870	20.304	17.676	16.728	18.711	17.945	17.656	16.901	16.783	17.108
21:00	19.543	20.636	15.520	17.451	19.456	17.201	18.787	19.683	17.276	19.276	18.121	17.305	19.057	16.866	18.766	19.378	17.081	18.400	18.697	17.768	17.517	17.268	16.889	18.112
22:00	18.826	17.412	16.656	17.301	18.308	16.870	19.033	19.112	17.346	16.585	18.245	17.413	18.874	17.060	19.383	19.041	13.817	20.861	19.624	17.045	19.048	19.218	16.998	18.619
23:00	14.594	17.417	17.164	18.558	18.503	17.583	19.164	19.612	15.793	17.281	18.266	17.774	18.106	17.157	19.539	18.883	13.472	20.239	18.619	17.748	17.704	19.936	17.226	15.593
Max.	20.211	20.636	17.914	18.558	19.456	17.870	19.953	19.683	18.693	20.145	18.266	18.260	19.057	18.560	19.539	22.380	19.398	20.861	20.767	18.425	19.048	19.936	19.947	18.619
Min.	13.618	14.490	13.818	14.390	13.692	13.818	12.809	15.995	15.307	14.535	15.508	13.676	13.179	15.465	14.111	13.359	13.472	7.510	14.714	12.990	13.064	11.987	14.308	10.178
Average	16.530	16.941	15.748	15.995	16.557	16.753	16.172	18.173	16.864	16.939	16.706	16.273	16.714	16.181	16.230	17.765	18.107	15.404	16.815	15.426	16.546	15.958	16.660	16.359

Source : SEDAPAL

Note: n.a. (not available)

Table3.2.3 Intake Capacity of Industrial and Irrigation Intakes

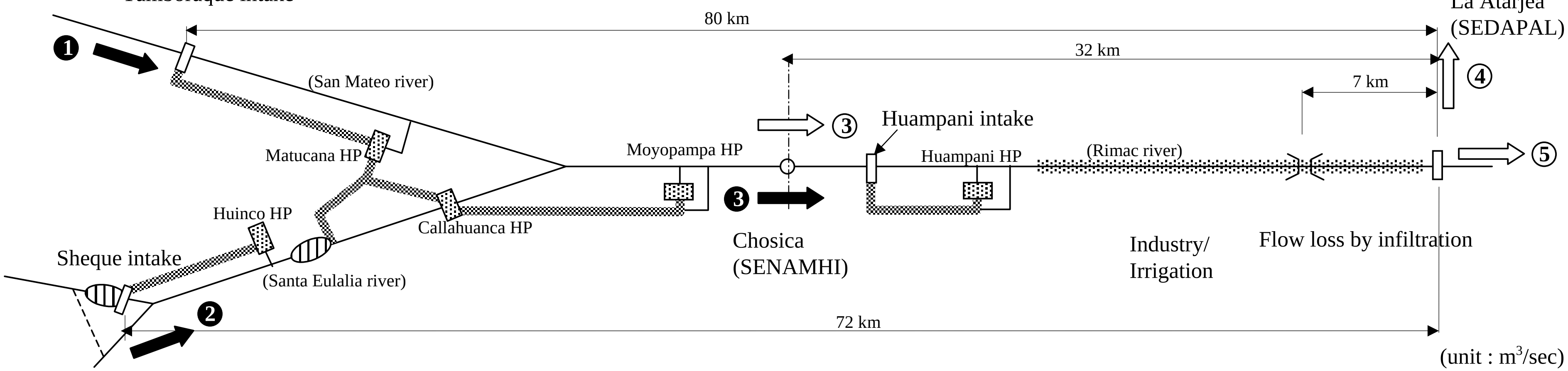
No.	Name	Type	Location: Rimac river	Location: Sta. Eulalia river	Altitude	Intake Discharge (Aug. 25-Sep. 4, 2001)	Discharge requested to ATDR
1	San Agustin	(Premitive)	Right		70	0.7	---
2	La Atarjea	Concrete	Left		---	---	---
3	Surco	(Premitive)	Left		346	1.00	0.52
4	Laguna 1	Concrete	Left		---	0.15	0.15
5	Laguna 2	Concrete	Left		---	0.15	0.15
6	Ate	(Premitive)	Left		421	0.50	0.50
7	Huachipa	(Premitive)	Right		433	1.00	0.84
8	Nieveria	(Premitive)	Right		464	0.75	0.51
9	Carapongo	(Premitive)	Right		537	0.60	0.48
10	La Estrella	(Premitive)	Left		605	0.70	0.41
11	Castrillejo	(Premitive)	Left		622	0.15	0.14
12	Nana Bajo	(Premitive)	Right		637	0.12	0.21
13	Nana Medio	Concrete	Right		677	0.50	0.23
14	Pte. Los Angeles	(Premitive)	Left		---	0.15	0.13
15	Nana Alto	(Premitive)	Left		748	0.25	0.27
16	Santa Ines	(Premitive)	Left		804	0.16	0.21
17	Chacrasana	Concrete	Right		885	0.40	0.40
18	Chosica Vieja Los Condores	(Premitive)	Left		963	0.00	---
19	Chosica Vieja Los Condores Actual	Concrete		Left	959	0.25	0.25
	Total					6.83	5.40

Table 3.2.4 Surface Water Measurement

	Aug. 29					Aug. 30					Aug. 31					Sep. 1					Sep. 2					Sep. 3				
	1B	2B	3B	4B	1A	1B	2B	3B	4B	1A	1B	2B	3B	4B	1A	1B	2B	3B	4B	1A	1B	2B	3B	4B	1A	1B	2B	3B	4B	1A
5:00																														
5:30													29.8					30.1						30.0						
6:00											30.5												29.7							
6:30								31.8								38.1														
7:00																														
9:00																														
9:30																														
10:00																														
10:30																														
11:00																														
11:30													25.5					28.7												
12:00									30.3								27.7							30.1		23.2		22.1		
12:30								29.1															28.4							
13:00											26.3					25.5														
13:30																										23.1		23.9		
14:00									31.6																					
14:30																														
15:00																														
15:30																														
16:00																														
16:30																														
17:00			25.9																											
17:30																														
18:00			26.0																											
18:30																														
19:00	26.3																													
19:30																														

	Sep. 4					Sep. 5					Sep. 6					Sep. 12					Sep. 13					Sep. 19				
	1B	2B	3B	4B	1A	1B	2B	3B	4B	1A	1B	2B	3B	4B	1A	1B	2B	5B	4B	1A	1B	2B	3B	4B	1A	1B	2B	5B	4B	1A
5:00																														
5:30																														
6:00																														
6:30																														
7:00																														
9:00																														
9:30															20.7															
10:00														29.2																
10:30															21.1															
11:00			27.4																											
11:30														30.5	20.7													14.5		
12:00																22.3		18.7							21.9			14.9		
12:30			27.9																											
13:00	26.2																							22.6	22.0					
13:30	28.5																	16.9								16.2				
14:00																23.2								25.0	21.5	16.6				
14:30										23.5																				
15:00									23.6															25.8						
15:30																														
16:00									31.7																					
16:30																														
17:00																														
17:30										21.8																				
18:00																														
18:30										23.0																				
19:00																														
19:30																														

Table 3.2.5 Flow Balance in Rimac River Basin



(unit : m³/sec)

	❶	❷	❶+❷	❸-❶-❷	❸ , ③	Industry / Irrigation	Infiltration	Others	Total	④	⑤
Monthly average (Jul.- Sep., 1991-92)	6.1 (EDEGEL)	8.4 (EDEGEL)	14.5	-0.3 -0.4	14.2 (SENAMHI) 14.1 (EDEGEL)	-1.6 -1.5	-2.0	---	-3.6 -3.5	10.6 *1 (SEDAPAL)	0.0 0.0
Monthly average (Jul.- Sep., 1993-95)	6.8 (EDEGEL)	12.1 (EDEGEL)	18.9	+0.5 -1.7	19.4 (SENAMHI) 17.2 (EDEGEL)	-4.3 -2.1	-2.0	---	-6.3 -4.1	13.1 *1 (SEDAPAL)	0.0 0.0
Monthly average (Jul.- Sep., 1996-97)	5.7 (EDEGEL)	10.0 (EDEGEL)	15.7	+5.3 +1.9	21.0 (SENAMHI) 17.6 (EDEGEL)	-7.1 -3.7	-2.0	---	-9.1 -5.7	11.9 *1 (SEDAPAL)	0.0 0.0
Daily average in Aug. 27 - Sep. 9, 2001	11.3 (JICA)	13.0 (JICA)	24.3	+2.5	26.8 (SENAMHI)	-6.8 *3	-2.0	---	-8.8	16.5 *2 (SEDAPAL)	1.5

Source: *1 Production of Plant No. 1 and 2, La Atarjea (SEDAPAL)
*2 Discharge at Sediment trap basin (Desarenadores) No. 1 and 2 (SEDAPAL)
*3 Discharge measurement in Sep. 12 - 14, 2001 by JICA
Discharge data of EDEGEL at Chosica is observed at the Huampani intake. There is no intake between Chosica SENAMHI station and Huampani intake.

Note: ⑤ Overflow discharge at La Atarjea intake was assumed to be negligible in the dry season from 1991 to 1997 because discharge observed at Chosica of 20.0 m³/sec might diverted all for potable water production. While daily average discharge of 1.5 m³/sec (or 6.0 m³/sec presuming 6 hours overflow time) of overflow from flood gates was observed during Aug. 27 to Sep. 9, 2001.

Table 3.2.6 Discharge Records at Sheque and Tamboraque Intakes by EDEGEL

Date \ Time	Discharge at Sheque Intake (EDEGEL) 7:00	12:00	17:00	Average	(JICATeam)	Discharge at Tamboraque Intake (EDEGEL) 7:00	12:00	17:00	Average	(JICATeam)
Aug. 1, 2001	12.6	12.6	12.3	12.5		10.1	10.1	10.1	10.1	
Aug. 2	12.8	12.8	12.8	12.8		10.0	10.0	9.8	9.9	
Aug. 3	12.6	12.6	13.6	12.9		9.9	10.0	9.8	9.9	
Aug. 4	12.7	12.7	12.7	12.7		9.8	9.8	9.8	9.8	
Aug. 5	12.6	12.5	12.4	12.5		9.7	9.7	9.7	9.7	
Aug. 6	12.4	12.4	12.0	12.3		10.1	10.1	10.1	10.1	
Aug. 7	13.0	13.0	12.8	12.9		10.0	10.0	10.0	10.0	
Aug. 8	12.8	12.8	12.8	12.8		10.2	10.2	10.2	10.2	
Aug. 9	12.8	12.8	12.8	12.8		10.0	10.0	10.0	10.0	
Aug. 10	12.8	12.8	12.8	12.8		10.0	10.0	10.0	10.0	
Aug. 11	12.8	12.6	12.6	12.7		10.0	10.0	9.9	10.0	
Aug. 12	12.7	12.7	12.7	12.7		8.8	8.9	8.9	8.9	
Aug. 13	12.8	12.6	12.6	12.7		9.9	9.8	9.8	9.8	
Aug. 14	13.1	13.1	13.0	13.1		9.8	9.8	9.8	9.8	
Aug. 15	13.1	13.1	13.1	13.1		9.8	9.8	9.8	9.8	
Aug. 16	13.1	13.1	12.8	13.0		9.7	9.7	10.2	9.9	
Aug. 17	12.8	12.8	12.8	12.8		9.9	10.1	9.8	9.9	
Aug. 18	12.8	12.8	12.3	12.6		10.1	10.1	9.8	10.0	
Aug. 19	12.5	12.5	12.2	12.4		9.0	9.0	8.8	8.9	
Aug. 20	12.1	12.0	13.6	12.6		8.8	8.8	9.7	9.1	
Aug. 21	12.6	12.6	12.6	12.6		9.7	9.7	10.2	9.9	
Aug. 22	12.6	12.8	12.8	12.7		10.2	10.2	10.3	10.2	
Aug. 23	13.0	12.8	12.8	12.9		10.1	10.1	10.3	10.2	
Aug. 24	12.8	12.8	12.8	12.8		10.3	10.4	10.0	10.2	
Aug. 25	13.0	13.0	12.9	13.0		10.3	10.3	10.5	10.4	
Aug. 26	12.7	12.6	12.6	12.6		9.0	8.8	8.8	8.9	
Aug. 27	12.8	12.6	12.6	12.7		9.8	9.9	9.9	9.9	
Aug. 28	12.8	12.6	12.6	12.7		9.9	9.9	9.9	9.9	
Aug. 29	12.8	12.6	12.6	12.7		10.7	10.7	10.2	10.5	
Aug. 30	12.8	12.6	13.6	13.0		10.2	10.2	10.3	10.2	
Aug. 31	12.8	12.8	12.6	12.7		10.3	10.3	10.4	10.3	
Sep. 1, 2001	12.8	12.6	12.8	12.7		10.2	10.2	10.2	10.2	
Sep. 2	11.8	14.0	13.8	13.2		9.1	9.1	9.2	9.1	
Sep. 3	13.5	13.5	13.4	13.5		10.4	10.4	9.8	10.2	
Sep. 4	13.0	13.0	13.0	13.0		9.8	9.8	9.8	9.8	
Sep. 5	13.2	13.2	13.2	13.2		9.8	9.8	9.8	9.8	
Sep. 6	13.5	13.2	12.8	13.2		9.9	9.9	9.9	9.9	
Sep. 7	12.8	12.9	12.9	12.9	13.0 (*1)	9.8	9.8	9.8	9.8	11.3 (*2)
Sep. 8	13.0	13.0	12.8	12.9		9.8	9.8	9.8	9.8	
Sep. 9	12.8	12.8	13.0	12.9		9.0	9.0	8.9	9.0	
Average				12.8					9.9	

	Discharge at Sheque Intake (JICA Team)					Discharge at Tamboraque Intake (JICA Team)				
Sep. 7, 2001	2A					4A				
	14:30	15:30	16:00	Average		11:00	12:00	12:30	Average	
	9.18	9.06	9.09	9.1		11.51	11.34	11.31	11.3	(*2)
	3A									
	10:00	10:30	12:30	Average						
	3.85	3.89	3.90	3.9						

(*1) : 9.1 (2A)+3.9 (3A) = 13.0 m^3/sec

Table 4.1.1 Metropolitan Lima Population Projection

Year	MASTER PLAN	BLASA	INEI
1998	7,130,008		7,224,609
1999	7,313,907		7,362,668
2000	7,505,802	7,400,352	7,500,542
2001	7,651,248	7,537,007	7,637,967
2002	7,796,694	7,673,662	7,775,138
2003	7,942,140	7,810,317	7,912,274
2004	8,087,586	7,946,972	8,049,619
2005	8,233,031	8,083,627	8,187,398
2006	8,373,270	8,220,682	8,325,615
2007	8,513,509	8,367,737	8,464,115
2008	8,653,747	8,494,791	8,602,892
2009	8,793,986	8,631,846	8,741,931
2010	8,934,224	8,768,901	8,881,228
2011	9,066,548	8,903,558	9,021,093
2012	9,198,872	9,040,211	9,161,545
2013	9,331,195	9,170,866	9,302,085
2014	9,463,519	9,313,521	9,442,231
2015	9,595,842	9,450,176	9,581,487
2016	9,726,346	9,586,831	9,720,296
2017	9,858,624	9,723,486	9,858,979
2018	9,992,701	9,860,141	9,996,884
2019	10,128,602	9,996,796	10,133,357
2020	10,266,351	10,133,451	10,267,751
2021	10,405,973	10,270,106	(*)10,403,929
2022	10,547,495	10,406,761	(*)10,541,915
2023	10,690,941	10,543,415	(*)10,681,733
2024	10,836,337	10,680,070	(*)10,823,406
2025	10,983,073	10,816,725	(*)10,966,961
2026	11,133,090	10,953,380	(*)11,112,421
2027	11,284,500	11,090,035	(*)11,259,812
2028	11,437,969	11,226,690	(*)11,409,161
2029	11,593,526	11,363,345	(*)11,560,492
2030	11,751,197	11,500,000	(*)11,713,832

(*) Calculated by JICA Study Team applying INEI growt rate between 2019-2020 for Lima (1.34%) and Callao (1.20%) respectively.

Table 4.1.2 Total Water Demand (m^3/s)

Year	Water Demand Master Plan	Water Demand BLASA	Water Demand BLASA/PM	Water Demand BLASA/INEI
1998	32.29			
1999	30.05			
2000	27.80	32.09	32.46	32.45
2001	27.46	31.26	31.64	31.60
2002	28.08	30.27	30.66	30.59
2003	28.78	29.13	29.52	29.43
2004	29.48	27.82	28.21	28.10
2005	29.67	26.34	26.72	26.61
2006	29.86	26.90	27.29	27.17
2007	30.06	27.46	27.83	27.70
2008	30.25	28.01	28.42	28.29
2009	30.45	28.57	28.99	28.86
2010	30.64	29.13	29.56	29.42
2011	31.12	29.70	30.13	30.01
2012	31.60	30.29	30.70	30.61
2013	32.09	30.87	31.30	31.22
2014	32.57	31.47	31.87	31.81
2015	33.05	32.07	32.46	32.42
2016	33.55	32.69	33.07	33.05
2017	34.05	33.31	33.68	33.68
2018	34.54	33.93	34.29	34.30
2019	35.04	34.55	34.91	34.92
2020	35.54	35.17	35.54	35.54
2021	36.04	35.67	36.04	36.04
2022	36.54	36.16	36.55	36.54
2023	37.05	36.66	37.07	37.04
2024	37.55	37.16	37.59	37.56
2025	38.05	37.65	38.12	38.07
2026	38.58	38.16	38.66	38.60
2027	39.10	38.66	39.20	39.13
2028	39.63	39.16	39.75	39.67
2029	40.15	39.67	40.31	40.22
2030	40.68	40.17	40.87	40.77

Table 4.1.3 Monthly Irrigation Water Demands for 4 Alternatives

Alternative	Area (ha)	Irrigation Efficiency %	Irrigation Water Demand (m^3/sec)												Total	
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	m^3/sec	MCM
1A	5,683	50	2.64	4.50	4.71	2.58	2.15	1.63	1.61	1.36	1.94	2.22	2.25	1.14	28.73	74.47
1B	5,683	42	3.15	5.36	5.60	3.07	2.56	1.94	1.91	1.62	2.31	2.64	2.98	1.36	34.50	89.42
2A	4,751	50	2.20	3.78	3.94	2.10	1.80	1.38	1.36	1.12	1.66	1.90	1.92	0.92	24.08	62.42
2B	4,751	42	2.63	4.50	4.69	2.50	2.15	1.65	1.62	1.33	1.97	2.27	2.30	1.10	28.71	74.42

Table 4.2.1 Structure of Unbilled Water (*)

Breakdown by Loss Origin	Cumulative January, February, March & April 2001			
	Total (m3)	% UB	System losses (%)	Not Reg. losses(%)
I. Physical Lossess (leakage and operation losses)				
1. Detectable leakages in Primary Networks	1,657,755	0.71	0.71	
2. Detectable leakages in Secondary Networks	1,246,079	0.53	0.53	
3. Detectable leakage in House Connections	5,796,754	2.47	2.47	
4. Spillovers from Reservoirs	17,728	0.01	0.01	
5. Firefighting use	55,094	0.02		0.02
6. Clean-up of water and sewerage piping	82,366	0.04		0.04
7. Reservoir Clean-up	67,617	0.03		0.03
8. Tank truck supply in managed areas	104,859	0.04		0.04
9. Hydraulic Testing in distribution and collection systems	243	0.00		0.00
10.Water loss in supply faucets	1,254,850	0.53	0.53	
Sub-total Physical Losses (I)	**10,283,345**	**4.38**	**4.24**	**0.13**
II.Not physical losses (clandestine and commercial)				
11. Inaccurate reading of water meters	6,966,857	2.96		2.96
12. Underbilling-Commercial Subventions	4,596,627	1.96		1.96
13. Misuse of fire hydrants	80,405	0.03	0.03	
14.Misuse of outlets for public lawns irrigation	15,717,888	6.69	6.69	
15. Underbilling of users with water meters	13,180,932	5.61		5.61
16.Clandestine connections (divertions, connections,, by-pass and pools)	450,712	0.19	0.19	
Divertions	173,530	0.07	0.07	
Connections	212,346	0.09	0.09	
House By-pass connections	21,947	0.01	0.01	
Public fountains	45,961	0.02	0.02	
17. Tampered meters	1,277,337	0.54		0.54
18. Meter seal breakage	458,364	0.20		0.20
19. Inaccurate record due to adjustment of consumption to minimum flows	2,656,788	1.13		1.13
20. Consumption from not incorporated sectors	39,966	0.02		0.02
21.Unreasonable use in sectors with restricted supply	1,717,160	0.73		0.73
Sub-total Not Physical Losses (II)	**47,143,036**	**20.06**	**6.91**	**13.15**
III. Losses of unknown origin (III) (C)				
22. Deduction by difference between production and physical losses	**43,658,264**	**18.58**	**18.58**	
Total Unbilled Water (UB) (I+II+III)	**101,084,645**	**43.01**	**29.74**	**13.28**
Total Billed Water m3	**133,922,006**	**56.99**		**56.99**
Potable Water Production (executed) m3	**235,006,651**	**100.00**		**100.00**
% UB (as a percentage of production)		**43.01%**		

(*) Table based on the data provided by the Developmente and Investigation Manager of SEDAPAL
UB= Unbilled Water

Table 4.3.1 Water Demand and Supply Balance for Year 2030 (*)

Alternative 1a

Item	Imp. Date	Probable Discharge	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Average	Dry Season	Wet Season
Rimac River Basin																	
Rimac River at 90% 1/		22.22	28.94	45.73	50.27	31.14	16.88	12.32	11.46	11.38	11.97	12.83	14.25	19.42	22.22	13.01	35.10
Yuracmayo		2.50					2.00	2.00	2.00	2.00	2.00	2.00	2.00		1.17	2.00	0.00
Marca III 2/	2001	3.10					5.31	5.31	5.31	5.31	5.31	5.31	5.31		3.10	5.31	0.00
Marca II 3/	2002	3.95					6.00	6.00	6.00	6.00	6.00	6.00	6.00		3.50	6.00	0.00
Loss		-5.00%					(0.67)	(0.67)	(0.67)	(0.67)	(0.67)	(0.67)	(0.67)		-0.39	-0.67	0.00
Total Rimac River Basin			28.94	45.73	50.27	31.14	29.52	24.96	24.10	24.02	24.61	25.47	26.89	19.42	29.59	25.65	35.10
Chillón River Basin																	
Chillón River(- Irrigation Water Demand)		1.00	1.30	1.80	1.90	1.70	1.00	1.30	0.80	0.30	0.30	0.30	0.30	1.00	1.00	0.61	1.54
Chillón Extraction/Recharge	2000	0.53						0.10	0.10	0.10	0.10	0.10	0.20		0.06	0.10	0.00
Huascacocha Reservoir	2010	1.92	1.10	1.10	1.10	1.10	2.50	2.50	2.50	2.50	2.50	2.50	2.50	1.10	1.92	2.50	1.10
Total Chillón River Basin			2.40	2.90	3.00	2.80	3.50	3.90	3.40	2.90	2.90	2.90	3.00	2.10	2.98	3.21	2.64
Lurín River Basin																	
Lurín River at 90%		2.28	2.13	8.77	10.84	4.41	0.30	0.15	0.05	0.02	0.02	0.01	0.04	0.65	2.28	0.08	5.36
Lurín River Basin New Wells	2002	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Total Lurín River Basin			2.43	9.07	11.14	4.71	0.60	0.45	0.35	0.32	0.32	0.31	0.34	0.95	2.58	0.38	5.66
Cañete River Basin	2021	7.50	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Wells		5.00	3.70	3.70	3.70	3.70	6.52	6.52	6.52	6.52	6.52	6.52	6.52	3.70	5.35	6.52	3.70
Total Sources			**42.47**	**66.40**	**73.11**	**47.35**	**45.14**	**40.83**	**39.37**	**38.76**	**39.35**	**40.20**	**41.75**	**31.17**	45.49	40.77	52.10
Total Produced Water Required (**)			42.03	42.03	42.03	42.03	42.03	42.03	42.03	42.03	42.03	42.03	42.03	42.03	42.03	42.03	42.03
Seasonal Factor			1.03	1.07	1.09	1.05	1.00	0.98	0.95	0.98	0.96	0.92	0.97	0.99	1.00	0.97	1.05
Monthly Produced Water Required			43.32	45.01	45.85	44.17	42.06	41.22	39.96	41.22	40.38	38.70	40.80	41.64	42.03	40.62	44.00
Superavit (Déficit) Potable Water			-0.85	21.39	27.26	3.18	3.08	-0.39	-0.59	-2.46	-1.03	1.50	0.95	-10.47	3.46	0.15	8.10

(*) Numbers to make this table were taken from "Master Plan of Drinking Water and Sewerage Systems of Lima and Callao", SEDAPAL 1998.

(**) Total produced required water with 100% of coverage and including unaccounter water

1/ Natural discharge of Marca I are included as part of natural discharge of Rímac River

2/ In accordance with D/D carried out by GMI S.A. Consulting Engineers in 1997, average discharge to be transferred to Rimac River is 3.0 m^3/s with a maximum of 6.2 m^3/s; SEDAPAL Master Plan adopted to transfer 5.31 m^3/s during dry season and 0 m^3/s during rainy season which convey to 3.1 m^3/s in average

3/ In accordance with D/D carried out by Salzgitter Gmbh discharge to be transferred to Rimac River in dry season in 6.5 m^3/s in average; Master Plan adopted 6.0 m^3/s which is fine

Table 4.3.2 Water Demand and Supply Balance for Year 2030 (*)

Alternative 2

Item	Imp. Date	Probable Discharge	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Average	Dry Season	Wet Season
Rimac River Basin																	
Rimac River at 90%		22.22	28.94	45.73	50.27	31.14	16.88	12.32	11.46	11.38	11.97	12.83	14.25	19.42	22.22	13.01	35.10
Yuracmayo		2.50					2.00	2.00	2.00	2.00	2.00	2.00	2.00		1.17	2.00	0.00
Marca III	2001	3.10					5.31	5.31	5.31	5.31	5.31	5.31	5.31		3.10	5.31	0.00
Marca II	2002 1/	3.95					6.00	6.00	6.00	6.00	6.00	6.00	6.00		3.50	6.00	0.00
Loss		-5.00%					(0.67)	(0.67)	(0.67)	(0.67)	(0.67)	(0.67)	(0.67)		-0.39	-0.67	0.00
Total Rimac Basin Project			28.94	45.73	50.27	31.14	29.52	24.96	24.10	24.02	24.61	25.47	26.89	19.42	29.59	25.65	35.10
Mantaro (Carispacha) water Transfer	2021	6.20					5.00	5.00	5.00	5.00	5.00	5.00	5.00		2.92	5.00	0.00
Total Rimac River Basin			28.94	45.73	50.27	31.14	34.52	29.96	29.10	29.02	29.61	30.47	31.89	19.42	32.51	30.65	35.10
Chillón River Basin																	
Chillón River(- Irrigation Water Demand)		1.00	1.30	1.80	1.90	1.70	1.00	1.30	0.80	0.30	0.30	0.30	0.30	1.00	1.00	0.61	1.54
Chillón Extraction/Recharge	2001	0.53						0.10	0.10	0.10	0.10	0.10	0.20		0.06	0.10	0.00
Huascacocha Reservoir	2013	1.92	1.10	1.10	1.10	1.10	2.50	2.50	2.50	2.50	2.50	2.50	2.50	1.10	1.92	2.50	1.10
Total Chillón River Basin			2.40	2.90	3.00	2.80	3.50	3.90	3.40	2.90	2.90	2.90	3.00	2.10	2.98	3.21	2.64
Lurín River Basin																	
Lurín River at 90%		2.28	2.13	8.77	10.84	4.41	0.30	0.15	0.05	0.02	0.02	0.01	0.04	0.65	2.28	0.08	5.36
Lurín River Basin New Wells	2002	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Total Lurín River Basin			2.43	9.07	11.14	4.71	0.60	0.45	0.35	0.32	0.32	0.31	0.34	0.95	2.58	0.38	5.66
Wells		5.00	3.70	3.70	3.70	3.70	6.52	6.52	6.52	6.52	6.52	6.52	6.52	3.70	5.35	6.52	3.70
Total Sources			**37.47**	**61.40**	**68.11**	**42.35**	**45.14**	**40.83**	**39.37**	**38.76**	**39.35**	**40.20**	**41.75**	**26.17**	43.41	40.77	47.10
Total Produced Water Required (**)			42.03	42.03	42.03	42.03	42.03	42.03	42.03	42.03	42.03	42.03	42.03	42.03	42.03	42.03	42.03
Seasonal Factor			1.03	1.07	1.09	1.05	1.00	0.98	0.95	0.98	0.96	0.92	0.97	0.99	1.00	0.97	1.05
Monthly Produced Water Required			43.32	45.01	45.85	44.17	42.06	41.22	39.96	41.22	40.38	38.70	40.80	41.64	42.03	40.62	44.00
Superavit (Déficit) Potable Water			-5.85	16.39	22.26	-1.82	3.08	-0.39	-0.59	-2.46	-1.03	1.50	0.95	-15.47	1.38	0.15	3.10

(*) Numbers to make this table were taken from "Master Plan of Drinking Water and Sewerage Systems of Lima and Callao", SEDAPAL 1998.

(**) Total produced required water with 100% of coverage and including unaccounter water

1/ Commissioning of Marca II project was scheduled for year 2002, however at present year 2001 still its construction has not started which means he is delayed

Table 4.3.3 Demand and Supply Balance for Dry Season (*)
Alternative 1a

Year	**1998**	**2000**	**2001**	**2002**	**2003**	**2005**	**2006**	**2007**	**2008**	**2010**	**2011**	**2012**	**2013**	**2015**	**2016**	**2017**	**2018**	**2020**	**2021**	**2022**	**2023**	**2025**	**2026**	**2027**	**2028**	**2030**
Cañete River Water Transmission	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.50	2.50	2.50	5.00	5.00	5.00	5.00
Huascacocha Reservoir	-	-	-	-	-	-	-	-	-	-	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Chillón River Development	-	-	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
Marca II 1/	-	-	-	-	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78
Marca III	-	-	-	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09
Yuracmayo	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78
Lurín River 90%	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Rimac River 90%	10.22	11.12	11.72	12.22	13.01	13.01	13.01	13.01	13.01	13.01	13.01	13.01	13.01	13.01	13.01	13.01	13.01	13.01	13.01	13.01	13.01	13.01	13.01	13.01	13.01	13.01
Lurín River New Wells	-	-	-	-	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Wells	11.51	9.74	8.85	7.46	6.08	5.30	5.17	5.13	5.09	5.01	2.27	2.72	3.17	4.09	4.54	4.99	5.44	6.36	6.85	4.84	5.34	6.35	4.37	4.89	5.41	6.49
Total Sources	**23.59**	**22.72**	**22.53**	**26.73**	**32.22**	**31.44**	**31.31**	**31.27**	**31.23**	**31.15**	**31.52**	**31.97**	**32.42**	**33.34**	**33.79**	**34.24**	**34.69**	**35.61**	**36.10**	**36.59**	**37.09**	**38.10**	**38.62**	**39.14**	**39.66**	**40.74**
Lima South Plant Stage 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.50	2.50	2.50	2.50
Lima South Plant Stage 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Chillon Plant Stage 2	-	-	-	-	-	-	-	-	-	-	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80
Chillon Plant Stage 1	-	-	-	-	-	-	0.10	0.10	0.10	0.10	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Huachipa Plant Stage 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Huachipa Plant Stage 1	-	-	-	-	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
W/S upper Rimac	-	-	-	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Atarjea Plant	12.00	12.90	13.50	14.00	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50
Lurin River New Wells	-	-	-	-	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Wells	11.51	9.74	8.85	7.46	6.08	5.30	5.17	5.13	5.09	5.01	2.27	2.72	3.17	4.09	4.54	4.99	5.44	6.36	6.85	4.84	5.34	6.35	4.37	4.89	5.41	6.49
Total Drinking Water Supply	**23.51**	**22.64**	**22.35**	**23.46**	**31.88**	**31.10**	**31.07**	**31.03**	**30.99**	**30.91**	**31.37**	**31.82**	**32.27**	**33.19**	**33.64**	**34.09**	**34.54**	**35.46**	**35.95**	**36.44**	**36.94**	**37.95**	**38.47**	**38.99**	**39.51**	**40.59**
Water Demand 100% cov. + UNW	**27.45**	**24.80**	**24.08**	**26.16**	**31.62**	**31.10**	**31.07**	**31.03**	**30.99**	**30.91**	**31.37**	**31.82**	**32.27**	**33.19**	**33.64**	**34.09**	**34.54**	**35.46**	**35.95**	**36.44**	**36.94**	**37.95**	**38.47**	**38.99**	**39.51**	**40.59**
Superavit(Deficit) of Drinking Water	**(3.94)**	**(2.16)**	**(1.73)**	**(2.7)**	**0.26**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

(*) Numbers to make this table were taken from "Master Plan of Drinking Water and Sewerage Systems of Lima and Callao", SEDAPAL 1998.

UNW= unaccounted water

1/ Marca II project and Huachipa potable water treatment plan are related; Huachipa plant depends upon discharge coming from Marca II project, nevertheless construction of Marca II still does not start, then operation of these two projects scheduled for year 2003 is not feasible

Table 4.3.4 Demand and Supply Balance for Dry Season (*)
Alternative 2

Year	1998	1999	2000	2002	2003	2004	2005	2006	2007	2008	2009	2011	2012	2013	2014	2015	2016	2017	2019	2020	2021	2022	2023	2024	2025	2026	2028	2029	2030
Mantaro (Carispacha) Water Transmission	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.94	2.94	2.94	2.94	5.00	5.00	5.00	5.00
Huascacocha Reservoir	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Chillón River Development	-	-	-	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
Marca II 1/	-	-	-	-	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78
Marca III	-	-	-	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09
Yuracmayo	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78
Lurín River 90%	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Rimac River 90%	10.22	10.52	11.12	12.22	13.01	13.01	13.01	13.01	13.01	13.01	13.01	13.01	13.01	13.01	13.01	13.01	13.01	13.01	13.01	13.01	13.01	13.01	13.01	13.01	13.01	13.01	13.01	13.01	13.01
Lurín River New Wells	-	-	-	-	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Wells	11.30	10.20	9.10	7.00	5.11	4.69	4.59	4.55	4.52	4.48	4.44	4.85	5.31	5.76	3.63	4.09	4.54	4.99	5.90	6.36	6.85	4.14	4.64	5.14	5.65	4.17	5.21	5.75	6.29
Total Sources	**23.38**	**22.58**	**22.08**	**26.88**	**31.86**	**31.44**	**31.34**	**31.30**	**31.27**	**31.23**	**31.19**	**31.60**	**32.06**	**32.51**	**32.88**	**33.34**	**33.79**	**34.24**	**35.15**	**35.61**	**36.10**	**36.33**	**36.83**	**37.33**	**37.84**	**38.42**	**39.46**	**40.00**	**40.54**
Huachipa Plant Stage 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.00	2.00	2.00	2.00
Huachipa Plant Stage 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20
Lima South Plant	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chillon Plant Stage 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80
Chillon Plant Stage 1	-	-	-	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Huachipa Plant Stage 1	-	-	-	-	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
W/S upper Rimac	-	-	-	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Atarjea Plant	12.00	12.30	12.90	14.00	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50
Lurin River New Wells	-	-	-	-	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Wells	11.30	10.20	9.10	7.00	5.11	4.69	4.59	4.55	4.52	4.48	4.44	4.85	5.31	5.76	3.63	4.09	4.54	4.99	5.90	6.36	6.85	4.14	4.64	5.14	5.65	4.17	5.21	5.75	6.29
Total Drinking Water Supply	23.30	22.50	22.00	23.71	31.62	31.20	31.10	31.06	31.03	30.99	30.95	31.36	31.82	32.27	32.73	33.19	33.64	34.09	35.00	35.46	35.95	36.44	36.94	37.44	37.95	38.47	39.51	40.05	40.59
Water Demand 100% cov. + UNW	27.45	26.09	24.80	26.16	31.62	31.20	31.10	31.07	31.03	30.99	30.95	31.37	31.82	32.27	32.73	33.19	33.64	34.09	35.00	35.46	35.95	36.44	36.94	37.44	37.95	38.47	39.51	40.05	40.59
Superavit(Deficit) of Drinking Water	(4.15)	(3.59)	(2.80)	(2.45)	0.00	0.00	0.00	(0.01)	0.00	0.00	0.00	(0.01)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

(*) Numbers to make this table were taken from "Master Plan of Drinking Water and Sewerage Systems of Lima and Callao", SEDAPAL 1998.

UNW= unaccounted water

1/ Marca II project and Huachipa potable water treatment plan are related; Huachipa plant depends upon discharge coming from Marca II project, nevertheless construction of Marca II still does not start, then operation of these two

Table 4.3.5 Alternative Cases for Water Balance Analysis

	Without Project	With Project Without Irrigation & Loss		With Project With Loss & Irrigation
	Case A1	Case B1	Case B2	Case C1
Water Demand 1) D/I Water supply(*) 2000 ~ 2030	2000, 2005, 2010 2020, 2030	2005	2010, 2030	2005, 2010, 2020, 2030
2) Irrigation, losses & other demand, Assumed constant	6.0 m^3/s	0.67 m^3/s	0.67 m^3/s	6.0 m^3/s
3) Groundwater Supply	no	7.68 m^3/s	7.68 m^3/s	5.0 m^3/s
Dam & Water Transfer	no	Marca III (3.0 m^3/s)	Marca III + II (9.5 m^3/s)	Marca III + II, Huascacocha, Mantaro (16.5 m^3/s)

Notes,

(1) Marca I Project and Yuracmayo Project are treated as the existing condition.

(2) Marca III (3.0 m^3/s), Marca II (6.5 m^3/s), Huascacocha (2.5 m^3/s), Mantaro - Carispacha or Cañete(5.0 m^3/s) are treated as future projects.

Table 4.3.6 Result of Water Balance Analysis

Category	Case	Target Year	Total Demand (m^3/s)	Peak Deficit(*) (m^3/s)	Annual Deficit (MCM) 1/20	Annual Deficit (MCM) 2/20	Annual Deficit (MCM) 4/20	Occurence Year 1/20	Occurence Year 2/20	Occurence Year 4/20	Remarks
A	A1	2000	32.09	27.69	1152.94	1151.93	714.36	1991-1992	1989-1990	1994-1995	
		2005	26.34	21.53	827.19	818.41	284.70	1991-1992	1989-1990	1979	
		2010	29.13	24.52	982.38	978.54	357.97	1991-1992	1989-1990	1979	
		2020	35.17	30.99	1338.67	1337.10	513.45	1991-1992	1989-1990	1997	
		2030	40.17	36.34	1641.39	1637.70	1134.88	1991-1992	1989-1990	1994-1995	
B	B1	2000	32.09	14.50	328.97	305.46	70.18	1991-1992	1989-1990	1979	
		2005	26.34	8.34	80.72	87.87	4.41	1991-1992	1989-1990	1980	
		2010	29.13	11.33	185.91	164.59	26.37	1991-1992	1989-1990	1979	
		2020	35.17	17.80	494.62	477.77	120.30	1991-1992	1989-1990	1979	
		2030	40.17	23.15	773.27	769.51	260.65	1991-1992	1989-1990	1997	
	B2	2000	32.09	14.50	189.06	199.01	42.38	1991-1992	1989-1990	1993	
		2005	26.34	8.34	71.77	60.30	13.28	1991-1992	1989-1990	1997	
		2010	29.13	11.33	122.91	107.61	27.85	1991-1992	1989-1990	1993	
		2020	35.17	17.80	303.79	316.17	74.14	1991-1992	1989-1990	1995	
		2030	40.17	23.15	565.19	565.99	177.64	1991-1992	1989-1990	1995	
C	C1	2000	32.09	22.69	381.29	416.69	145.39	1991-1992	1989-1990	1995	
		2005	26.34	16.53	233.09	236.68	56.22	1991-1992	1989-1990	1997	
		2010	29.13	19.52	301.40	314.25	99.48	1991-1992	1989-1990	1995	
		2020	35.17	25.99	516.82	532.45	203.86	1991-1992	1989-1990	1995	
		2030	40.17	31.34	800.11	801.59	334.89	1991-1992	1989-1990	1995	

(*) Peak Deficit : Maximum deficit in specified year.

Table 4.4.1 (1) Financial Costs of the Canete Scheme with Multi-Purpose Dams Adjusted by Cost Allocation
(Case 3.3: Paucarcocha Dam & Morro de Arica Dam)

Year	Financial Costs (1,000 US$)									Adjusted Financial Costs by Cost Allocation (1,000 US$)									
	Annual Investment Costs				Annual O&M Costs				Total Annual Costs	Annual Investment Costs				Annual O&M Costs				Total Annual Costs
	Multi-Purpose Dams	Water Conveyrance	New Ground Water	Total Costs	Multi-Purpose Dams	Water Conveyrance	New Ground Water	Total Costs		Multi-Purpose Dams	Water Conveyrance	New Ground Water	Total Costs	Multi-Purpose Dams	Water Conveyrance	New Ground Water	Total Costs	
1	6,354	8,850	363	15,567					15,567	2,224	8,850	363	11,437					11,437
2	52,950	73,740	3,027	129,717					129,717	18,533	73,740	3,027	95,300					95,300
3	74,130	103,240	4,238	181,608					181,608	25,946	103,240	4,238	133,424					133,424
4	63,540	88,490	3,633	155,663					155,663	22,239	88,490	3,633	114,362					114,362
5	14,826	20,650	848	36,324					36,324	5,189	20,650	848	26,687					26,687
6					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
7					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
8					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
9					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
10					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
11					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
12					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
13					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
14					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
15					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
16					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
17					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
18					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
19					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
20					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
21					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
22					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
23					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
24					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
25					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
26					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
27					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
28					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
29					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
30					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
31					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
32					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
33					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
34					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
35					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
36					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
37					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
38					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
39					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
40					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
41					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
42					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
43					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
44					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
45					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
46					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
47					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
48					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
49					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
50					900	1,000	605	2,505	2,505					315	1,000	605	1,920	1,920
Total	**211,800**	294,970	12,110	518,880	40,500	45,000	27,247	112,747	631,627	**74,130**	294,970	12,110	381,210	14,175	45,000	27,247	86,422	467,632

Table 4.4.1 (2) Economic Costs of the Canete Scheme with Multi-Purpose Dams Adjusted by Cost Allocation
(Case 3.3: Paucarcocha Dam & Morro de Arica Dam)

Year	Adjusted Financial Costs by Cost Allocation (1,000 US$)									Adjusted Economic Costs (1,000 US$)								
	Annual Investment Costs				Annual O&M Costs				Total	Annual Investment Costs				Annual O&M Costs				Total
	Multi-Purpose Dams	Water Conveyrance	Ground Water	Total Costs	Multi-Purpose Dams	Water Conveyrance	Ground Water	Total Costs	Annual Costs	Multi-Purpose Dams	Water Conveyrance	Ground Water	Total Costs	Multi-Purpose Dams	Water Conveyrance	Ground Water	Total Costs	Annual Costs
1	2,224	8,850	363	11,437					11,437	1,921	7,646	314	9,882					9,882
2	18,533	73,740	3,027	95,300					95,300	16,012	63,711	2,616	82,339					82,339
3	25,946	103,240	4,238	133,424					133,424	22,417	89,199	3,662	115,278					115,278
4	22,239	88,490	3,633	114,362					114,362	19,214	76,455	3,139	98,809					98,809
5	5,189	20,650	848	26,687					26,687	4,483	17,842	732	23,057					23,057
6					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
7					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
8					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
9					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
10					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
11					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
12					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
13					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
14					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
15					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
16					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
17					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
18					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
19					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
20					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
21					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
22					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
23					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
24					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
25					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
26					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
27					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
28					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
29					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
30					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
31					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
32					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
33					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
34					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
35					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
36					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
37					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
38					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
39					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
40					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
41					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
42					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
43					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
44					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
45					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
46					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
47					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
48					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
49					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
50					315	1,000	605	1,920	1,920					246	780	472	1,498	1,498
Total	**74,130**	294,970	12,110	381,210	14,175	45,000	27,247	86,422	467,632	64,048	254,854	10,463	329,365	11,057	35,100	21,253	67,409	396,775

Table 4.4.2 (1) Estimated Financial and Economic Costs (1,000 US$)

- Mantaro-Carispaccha Scheme -

Year	Financial Costs			Economic Costs		
	Annual Investment Costs	Annual O&M Costs	Total Annual Costs	Annual Investment Costs	Annual O&M Costs	Total Annual Costs
1	10,160		10,160	8,778		8,778
2	84,640		84,640	73,129		73,129
3	118,500		118,500	102,384		102,384
4	101,570		101,570	87,756		87,756
5	23,700		23,700	20,477		20,477
6		7,810	7,810		6,092	6,092
7		7,810	7,810		6,092	6,092
8		7,810	7,810		6,092	6,092
9		7,810	7,810		6,092	6,092
10		7,810	7,810		6,092	6,092
11		7,810	7,810		6,092	6,092
12		7,810	7,810		6,092	6,092
13		7,810	7,810		6,092	6,092
14		7,810	7,810		6,092	6,092
15		7,810	7,810		6,092	6,092
16		7,810	7,810		6,092	6,092
17		7,810	7,810		6,092	6,092
18		7,810	7,810		6,092	6,092
19		7,810	7,810		6,092	6,092
20		7,810	7,810		6,092	6,092
21		7,810	7,810		6,092	6,092
22		7,810	7,810		6,092	6,092
23		7,810	7,810		6,092	6,092
24		7,810	7,810		6,092	6,092
25		7,810	7,810		6,092	6,092
26		7,810	7,810		6,092	6,092
27		7,810	7,810		6,092	6,092
28		7,810	7,810		6,092	6,092
29		7,810	7,810		6,092	6,092
30		7,810	7,810		6,092	6,092
31		7,810	7,810		6,092	6,092
32		7,810	7,810		6,092	6,092
33		7,810	7,810		6,092	6,092
34		7,810	7,810		6,092	6,092
35		7,810	7,810		6,092	6,092
36		7,810	7,810		6,092	6,092
37		7,810	7,810		6,092	6,092
38		7,810	7,810		6,092	6,092
39		7,810	7,810		6,092	6,092
40		7,810	7,810		6,092	6,092
41		7,810	7,810		6,092	6,092
42		7,810	7,810		6,092	6,092
43		7,810	7,810		6,092	6,092
44		7,810	7,810		6,092	6,092
45		7,810	7,810		6,092	6,092
46		7,810	7,810		6,092	6,092
47		7,810	7,810		6,092	6,092
48		7,810	7,810		6,092	6,092
49		7,810	7,810		6,092	6,092
50		7,810	7,810		6,092	6,092
Total	338,570	351,450	690,020	292,524	274,131	566,655

- Canete Scheme with Single-Purpose Dam -

(Case 3.1: San Jeronimo Dam Only)

Year	Financial Costs			Economic Costs		
	Annual Investment Costs	Annual O&M Costs	Total Annual Costs	Annual Investment Costs	Annual O&M Costs	Total Annual Costs
1	24,244		24,244	20,947		20,947
2	202,023		202,023	174,547		174,547
3	282,836		282,836	244,370		244,370
4	242,429		242,429	209,459		209,459
5	56,569		56,569	48,876		48,876
6		2,890	2,890		2,254	2,254
7		2,890	2,890		2,254	2,254
8		2,890	2,890		2,254	2,254
9		2,890	2,890		2,254	2,254
10		2,890	2,890		2,254	2,254
11		2,890	2,890		2,254	2,254
12		2,890	2,890		2,254	2,254
13		2,890	2,890		2,254	2,254
14		2,890	2,890		2,254	2,254
15		2,890	2,890		2,254	2,254
16		2,890	2,890		2,254	2,254
17		2,890	2,890		2,254	2,254
18		2,890	2,890		2,254	2,254
19		2,890	2,890		2,254	2,254
20		2,890	2,890		2,254	2,254
21		2,890	2,890		2,254	2,254
22		2,890	2,890		2,254	2,254
23		2,890	2,890		2,254	2,254
24		2,890	2,890		2,254	2,254
25		2,890	2,890		2,254	2,254
26		2,890	2,890		2,254	2,254
27		2,890	2,890		2,254	2,254
28		2,890	2,890		2,254	2,254
29		2,890	2,890		2,254	2,254
30		2,890	2,890		2,254	2,254
31		2,890	2,890		2,254	2,254
32		2,890	2,890		2,254	2,254
33		2,890	2,890		2,254	2,254
34		2,890	2,890		2,254	2,254
35		2,890	2,890		2,254	2,254
36		2,890	2,890		2,254	2,254
37		2,890	2,890		2,254	2,254
38		2,890	2,890		2,254	2,254
39		2,890	2,890		2,254	2,254
40		2,890	2,890		2,254	2,254
41		2,890	2,890		2,254	2,254
42		2,890	2,890		2,254	2,254
43		2,890	2,890		2,254	2,254
44		2,890	2,890		2,254	2,254
45		2,890	2,890		2,254	2,254
46		2,890	2,890		2,254	2,254
47		2,890	2,890		2,254	2,254
48		2,890	2,890		2,254	2,254
49		2,890	2,890		2,254	2,254
50		2,890	2,890		2,254	2,254
Total	808,100	130,050	938,150	698,198	101,439	799,637

- Canete Scheme with Multi-Purpose Dams -

(Case 3.3: Paucarcocha Dam & Morro de Arica Dam)

Year	Financial Costs			Economic Costs		
	Annual Investment Costs	Annual O&M Costs	Total Annual Costs	Annual Investment Costs	Annual O&M Costs	Total Annual Costs
1	11,437		11,437	9,882		9,882
2	95,300		95,300	82,339		82,339
3	133,424		133,424	115,278		115,278
4	114,362		114,362	98,809		98,809
5	26,687		26,687	23,057		23,057
6		1,920	1,920		1,498	1,498
7		1,920	1,920		1,498	1,498
8		1,920	1,920		1,498	1,498
9		1,920	1,920		1,498	1,498
10		1,920	1,920		1,498	1,498
11		1,920	1,920		1,498	1,498
12		1,920	1,920		1,498	1,498
13		1,920	1,920		1,498	1,498
14		1,920	1,920		1,498	1,498
15		1,920	1,920		1,498	1,498
16		1,920	1,920		1,498	1,498
17		1,920	1,920		1,498	1,498
18		1,920	1,920		1,498	1,498
19		1,920	1,920		1,498	1,498
20		1,920	1,920		1,498	1,498
21		1,920	1,920		1,498	1,498
22		1,920	1,920		1,498	1,498
23		1,920	1,920		1,498	1,498
24		1,920	1,920		1,498	1,498
25		1,920	1,920		1,498	1,498
26		1,920	1,920		1,498	1,498
27		1,920	1,920		1,498	1,498
28		1,920	1,920		1,498	1,498
29		1,920	1,920		1,498	1,498
30		1,920	1,920		1,498	1,498
31		1,920	1,920		1,498	1,498
32		1,920	1,920		1,498	1,498
33		1,920	1,920		1,498	1,498
34		1,920	1,920		1,498	1,498
35		1,920	1,920		1,498	1,498
36		1,920	1,920		1,498	1,498
37		1,920	1,920		1,498	1,498
38		1,920	1,920		1,498	1,498
39		1,920	1,920		1,498	1,498
40		1,920	1,920		1,498	1,498
41		1,920	1,920		1,498	1,498
42		1,920	1,920		1,498	1,498
43		1,920	1,920		1,498	1,498
44		1,920	1,920		1,498	1,498
45		1,920	1,920		1,498	1,498
46		1,920	1,920		1,498	1,498
47		1,920	1,920		1,498	1,498
48		1,920	1,920		1,498	1,498
49		1,920	1,920		1,498	1,498
50		1,920	1,920		1,498	1,498
Total	381,210	86,422	467,632	329,365	67,409	396,775

Table 4.4.2 (2) Breakdown of Financial and Economic Costs of the Canete Scheme with Single-Purpose Dam by Component
(Case 3.1: San Jeronimo Dam Only)

Year	Financial Costs (1,000 US$)							Adjusted Economic Costs (1,000 US$)						
	Annual Investment Costs			Annual O&M Costs			Total Annual Costs	Annual Investment Costs			Annual O&M Costs			Total Annual Costs
	Single-Purpose Dams	Water Conveyrance	Total Costs	Single-Purpose Dams	Water Conveyrance	Total Costs		Single-Purpose Dams	Water Conveyrance	Total Costs	Single-Purpose Dams	Water Conveyrance	Total Costs	
1	15,394	8,850	24,244				24,244	13,300	7,646	20,947				20,947
2	128,283	73,740	202,023				202,023	110,836	63,711	174,547				174,547
3	179,596	103,240	282,836				282,836	155,171	89,199	244,370				244,370
4	153,939	88,490	242,429				242,429	133,003	76,455	209,459				209,459
5	35,919	20,650	56,569				56,569	31,034	17,842	48,876				48,876
6				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
7				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
8				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
9				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
10				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
11				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
12				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
13				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
14				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
15				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
16				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
17				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
18				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
19				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
20				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
21				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
22				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
23				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
24				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
25				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
26				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
27				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
28				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
29				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
30				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
31				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
32				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
33				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
34				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
35				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
36				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
37				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
38				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
39				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
40				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
41				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
42				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
43				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
44				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
45				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
46				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
47				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
48				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
49				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
50				1,890	1,000	2,890	2,890				1,474	780	2,254	2,254
Total	**513,130**	294,970	808,100	85,050	45,000	130,050	938,150	443,344	254,854	698,198	66,339	35,100	101,439	799,637

Table 4.4.3 Estimated Average Incremental Economic Costs (AIEC) and Water Supplied (1,000 US$)

- Mantaro-Carispaccha Scheme -

Year	Incremental Economic Costs			Incremental Water Supplied	
	Annual Investment Costs	Annual O&M Costs	Total Annual Costs	Incremental Water Supplied (m3/s)	Incremental Water Supplied (1,000m3/year)
1	8,778		8,778		
2	73,129		73,129		
3	102,384		102,384		
4	87,756		87,756		
5	20,477		20,477		
6		6,092	6,092	5	157,680
7		6,092	6,092	5	157,680
8		6,092	6,092	5	157,680
9		6,092	6,092	5	157,680
10		6,092	6,092	5	157,680
11		6,092	6,092	5	157,680
12		6,092	6,092	5	157,680
13		6,092	6,092	5	157,680
14		6,092	6,092	5	157,680
15		6,092	6,092	5	157,680
16		6,092	6,092	5	157,680
17		6,092	6,092	5	157,680
18		6,092	6,092	5	157,680
19		6,092	6,092	5	157,680
20		6,092	6,092	5	157,680
21		6,092	6,092	5	157,680
22		6,092	6,092	5	157,680
23		6,092	6,092	5	157,680
24		6,092	6,092	5	157,680
25		6,092	6,092	5	157,680
26		6,092	6,092	5	157,680
27		6,092	6,092	5	157,680
28		6,092	6,092	5	157,680
29		6,092	6,092	5	157,680
30		6,092	6,092	5	157,680
31		6,092	6,092	5	157,680
32		6,092	6,092	5	157,680
33		6,092	6,092	5	157,680
34		6,092	6,092	5	157,680
35		6,092	6,092	5	157,680
36		6,092	6,092	5	157,680
37		6,092	6,092	5	157,680
38		6,092	6,092	5	157,680
39		6,092	6,092	5	157,680
40		6,092	6,092	5	157,680
41		6,092	6,092	5	157,680
42		6,092	6,092	5	157,680
43		6,092	6,092	5	157,680
44		6,092	6,092	5	157,680
45		6,092	6,092	5	157,680
46		6,092	6,092	5	157,680
47		6,092	6,092	5	157,680
48		6,092	6,092	5	157,680
49		6,092	6,092	5	157,680
50		6,092	6,092	5	157,680
Total	292,524	274,131	566,655	225	7,095,600
NPV	206,400	50,455	235,030	41	1,305,987
Estimated Unit Value of AIEC (US$/m3) =					**0.180**

- Canete Scheme with Single-Purpose Dam -

(Case 3.1: San Jeronimo Dam Only)

Year	Incremental Economic Costs			Incremental Water Supplied	
	Annual Investment Costs	Annual O&M Costs	Total Annual Costs	Incremental Water Supplied (m3/s)	Incremental Water Supplied (1,000m3/year)
1	20,947		20,947		
2	174,547		174,547		
3	244,370		244,370		
4	209,459		209,459		
5	48,876		48,876		
6		2,254	2,254	5	157,680
7		2,254	2,254	5	157,680
8		2,254	2,254	5	157,680
9		2,254	2,254	5	157,680
10		2,254	2,254	5	157,680
11		2,254	2,254	5	157,680
12		2,254	2,254	5	157,680
13		2,254	2,254	5	157,680
14		2,254	2,254	5	157,680
15		2,254	2,254	5	157,680
16		2,254	2,254	5	157,680
17		2,254	2,254	5	157,680
18		2,254	2,254	5	157,680
19		2,254	2,254	5	157,680
20		2,254	2,254	5	157,680
21		2,254	2,254	5	157,680
22		2,254	2,254	5	157,680
23		2,254	2,254	5	157,680
24		2,254	2,254	5	157,680
25		2,254	2,254	5	157,680
26		2,254	2,254	5	157,680
27		2,254	2,254	5	157,680
28		2,254	2,254	5	157,680
29		2,254	2,254	5	157,680
30		2,254	2,254	5	157,680
31		2,254	2,254	5	157,680
32		2,254	2,254	5	157,680
33		2,254	2,254	5	157,680
34		2,254	2,254	5	157,680
35		2,254	2,254	5	157,680
36		2,254	2,254	5	157,680
37		2,254	2,254	5	157,680
38		2,254	2,254	5	157,680
39		2,254	2,254	5	157,680
40		2,254	2,254	5	157,680
41		2,254	2,254	5	157,680
42		2,254	2,254	5	157,680
43		2,254	2,254	5	157,680
44		2,254	2,254	5	157,680
45		2,254	2,254	5	157,680
46		2,254	2,254	5	157,680
47		2,254	2,254	5	157,680
48		2,254	2,254	5	157,680
49		2,254	2,254	5	157,680
50		2,254	2,254	5	157,680
Total	698,198	101,439	799,637	225	7,095,600
NPV	492,636	18,670	503,230	41	1,305,987
Estimated Unit Value of AIEC (US$/m3) =					**0.385**

- Canete Scheme with Multi-Purpose Dams -

(Case 3.3: Paucarcocha Dam & Morro de Arica Dam)

Year	Incremental Economic Costs			Incremental Water Supplied	
	Annual Investment Costs	Annual O&M Costs	Total Annual Costs	Incremental Water Supplied (m3/s)	Incremental Water Supplied (1,000m3/year)
1	9,882		9,882		
2	82,339		82,339		
3	115,278		115,278		
4	98,809		98,809		
5	23,057		23,057		
6		1,498	1,498	5	157,680
7		1,498	1,498	5	157,680
8		1,498	1,498	5	157,680
9		1,498	1,498	5	157,680
10		1,498	1,498	5	157,680
11		1,498	1,498	5	157,680
12		1,498	1,498	5	157,680
13		1,498	1,498	5	157,680
14		1,498	1,498	5	157,680
15		1,498	1,498	5	157,680
16		1,498	1,498	5	157,680
17		1,498	1,498	5	157,680
18		1,498	1,498	5	157,680
19		1,498	1,498	5	157,680
20		1,498	1,498	5	157,680
21		1,498	1,498	5	157,680
22		1,498	1,498	5	157,680
23		1,498	1,498	5	157,680
24		1,498	1,498	5	157,680
25		1,498	1,498	5	157,680
26		1,498	1,498	5	157,680
27		1,498	1,498	5	157,680
28		1,498	1,498	5	157,680
29		1,498	1,498	5	157,680
30		1,498	1,498	5	157,680
31		1,498	1,498	5	157,680
32		1,498	1,498	5	157,680
33		1,498	1,498	5	157,680
34		1,498	1,498	5	157,680
35		1,498	1,498	5	157,680
36		1,498	1,498	5	157,680
37		1,498	1,498	5	157,680
38		1,498	1,498	5	157,680
39		1,498	1,498	5	157,680
40		1,498	1,498	5	157,680
41		1,498	1,498	5	157,680
42		1,498	1,498	5	157,680
43		1,498	1,498	5	157,680
44		1,498	1,498	5	157,680
45		1,498	1,498	5	157,680
46		1,498	1,498	5	157,680
47		1,498	1,498	5	157,680
48		1,498	1,498	5	157,680
49		1,498	1,498	5	157,680
50		1,498	1,498	5	157,680
Total	467,632	329,365	67,409	225	7,095,600
NPV	232,394	12,407	239,434	41	1,305,987
Estimated Unit Value of AIEC (US$/m3) =					**0.183**

Table 5.1.1 Water Resources Development Scenarios and Alternative Cases

	Scenario-1		Scenario-2		Scenario-3		
	Case 1.1	Case 1.2	Case 2.1	Case 2.2	Case 3.1	Case 3.2	Case 3.3
Water Demand:							
1)D/I Water Supply	CB+L5	CB+L10	CB	CB	CB+L5	CB+L5	CB+L5
2)Irrigation Demand	CV	CV+CLC	CV+CTP	CV+CTP5	CV+CLC+CTP	CV+CTP5	CV+CTP
3)Maintenance Flow	Mf4.3	Mf4.3	Mf4.3	Mf4.3	Mf4.3	Mf4.3	Mp1.0
4)Total Demand (MCM)	667.7	855.55	861.4	685.73	1049.28	843.41	915.05
Dam: Active Storage							
1)Morro de Arica (MCM)	205	245	245	205	245	245	245
2)Paucarcocha (MCM)	Not Applicable	55	55	Not Applicable	Not Applicable	55	55
3)Capillucas (MCM)	2.8	2.8	2.8	2.8	2.8	2.8	2.8
4)San Jeronimo (MCM)	Not Applicable	Not Applicable	Not Applicable	Not Applicable	280	Not Applicable	Not Applicable
Power Station:							
1)Morro de Arica (MW)	46	50	50	46	50	50	50
2)El. Platanal (MW)	200	220	220	200	220	220	220
3)San Jeronimo (MW)	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable
New Ground Water							3m3/s(94.6MCM)
Water Conveyance	L5=5m3/s	L10=10m3/s	Not Applicable	Not Applicable	L5=5m3/s	L5=5m3/s	L5=5m3/s
Irrigation Facilities	Not Applicable	Not Applicable	CTP Full Scale	CTP Half Scale	CTP Full Scale	CTP Half Scale	CTP Full Scale

Notes

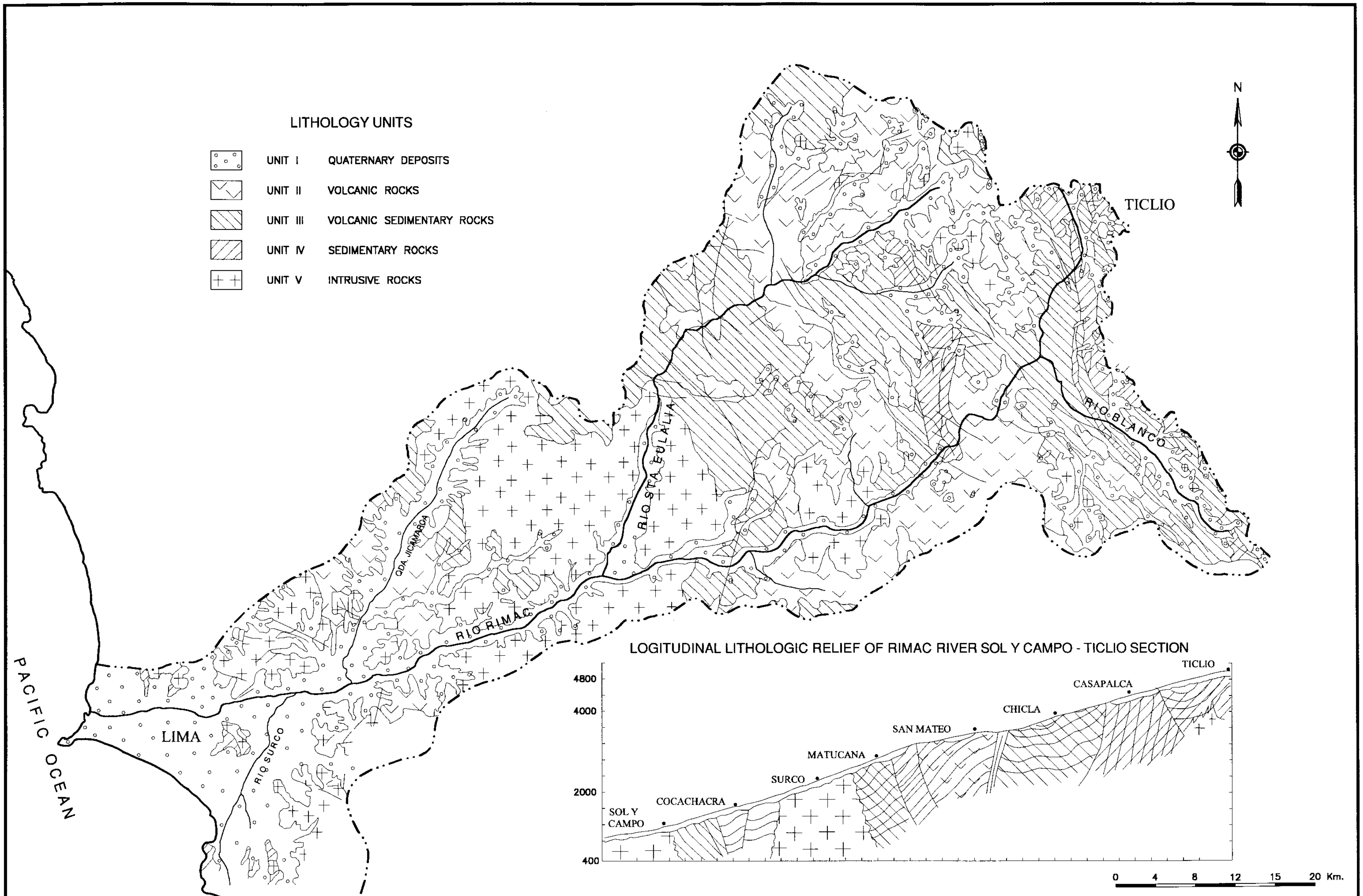
CB: D/I Water in Canete River Basin(34.22MCM), L5: Lima D/I Water Supply 5m3/s(157.68MCM), L10: Lima D/I Water Supply 10 m3/s(315.36MCM),

CV: Canete Valley Irrigation(340.20MCM), CLC: Alto Imperial Irrigation(30.17MCM), CTP: Concon-Topara Irrigation (Full Scale 351.41MCM),

CTP5: Concon-Topara Irrigation (Half Scale 175.71MCM)

Mf4.3: Maintenance Flow 4.3m3/s(135.60MCM), Mp1.0: Maintenance Flow 1.0m3/s(31.54MCM)

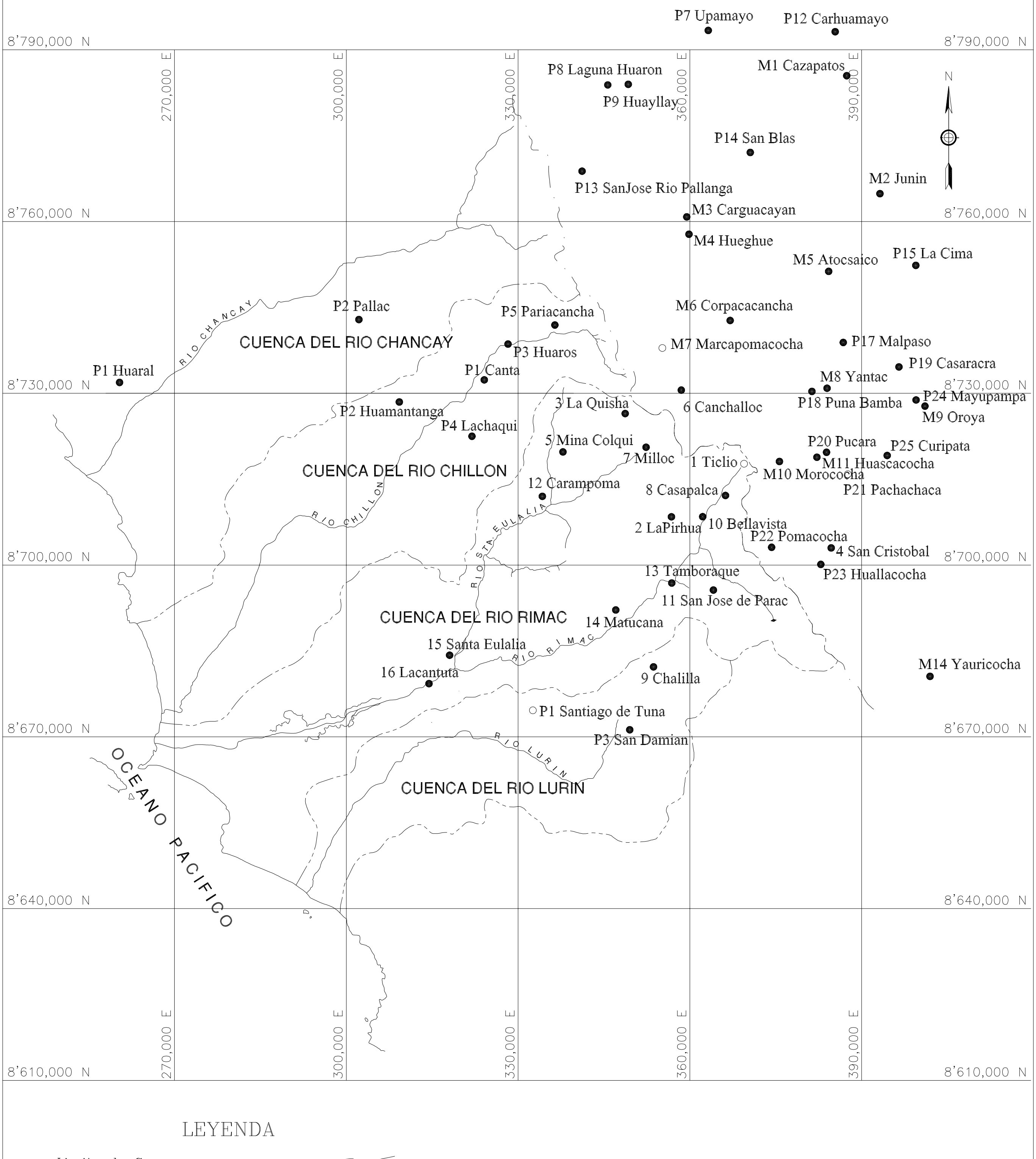
FIGURES



SUPPLEMENTAL INVESTIGATION OF THE STUDY ON INTEGRATED WATER RESOURCES DEVELOPMENT IN THE CAÑETE RIVER BASIN IN THE REPUBLIC OF PERU

THE JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 2.1.1 Lithological Map of Rimac River Basin



LEYENDA

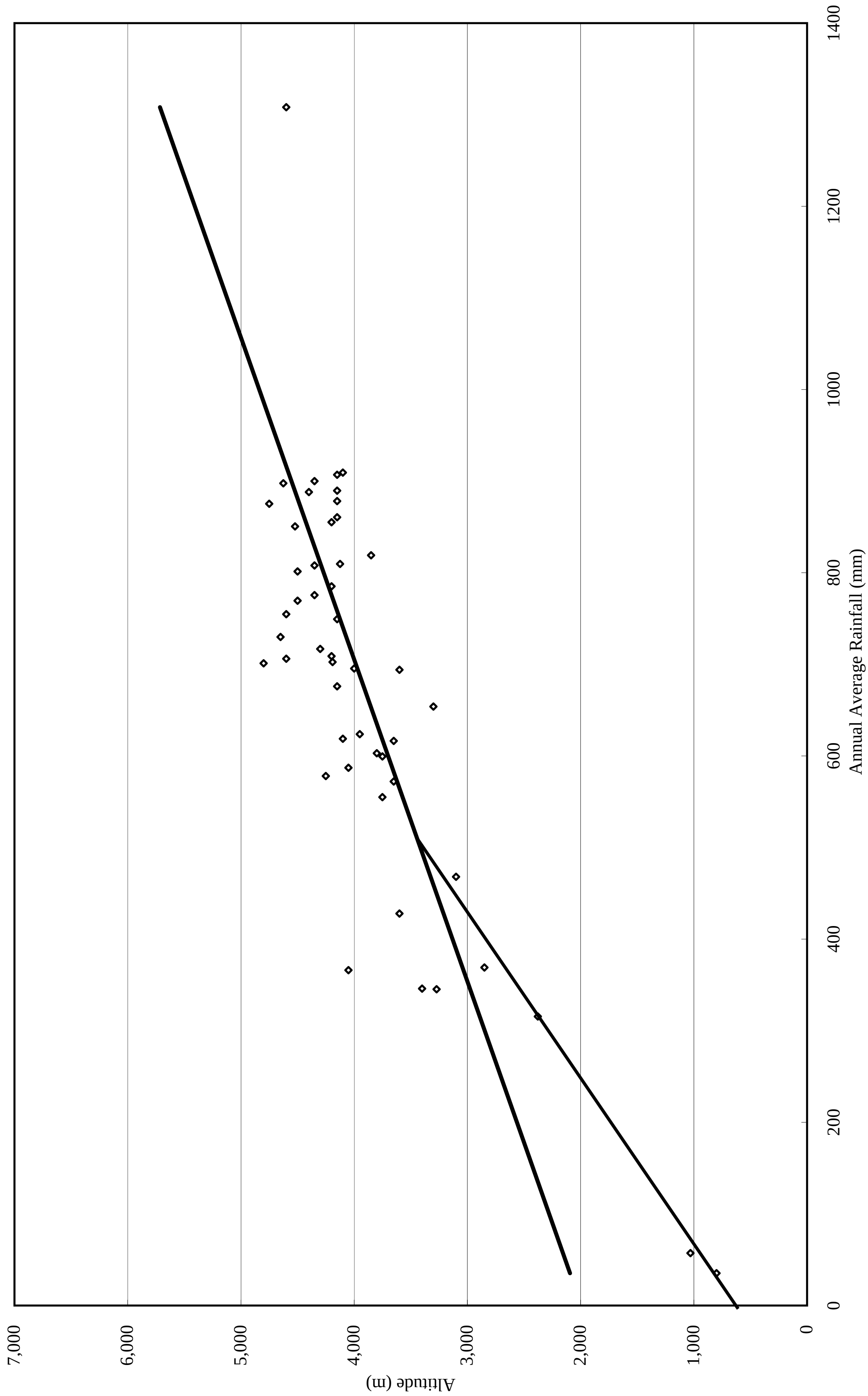
Limite de Cuenca

Divisoria Continental

Estación Climatólogica

15 Santa Eulalia

INVESTIGACION SUPLEMENTARIA DEL ESTUDIO DEL DESARROLLO INTEGRAL DE LOS RECURSOS HIDRICOS EN LA CUENCA DEL RIO CAÑETE EN LA REPUBLICA DEL PERU	Figura 2.2.1 Plano de Ubicación de las Estaciones de Observación Pluviométrica
AGENCIA DE COOPERACION INTERNACIONAL DEL JAPON	



SUPPLEMENTAL INVESTIGATION
OF
THE STUDY ON INTEGRATED WATER RESOURCES DEVELOPMENT
IN THE CAÑETE RIVER BASIN IN THE REPUBLIC OF PERU

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Figure 2.2.2
Distribution of Mean Annual Rainfall in Altitude