JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

EMPRESA NICARAGÜENSE DE ACUEDUCTOS Y ALCANTARILLADOS SANITARIOS (ENACAL)

THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN MANAGUA IN THE REPUBLIC OF NICARAGUA

FINAL REPORT

Supporting Report No.4
Leakage Survey

DECEMBER 2005

NIHON SUIDO CONSULTANTS CO., LTD.
ASIA AIR SURVEY CO., LTD.

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ANNEXES

4.1 OBJECTIVES OF THE LEAKAGE SURVEY

The Leakage Survey in this Study is composed of the following survey components:

1) Continuous 24 Hour Flow and Pressure Measurement in Ten Model Districts (Micro Sectors),
2) Customer Meter Reading for 24 Hour Flow Measurement,
3) Leak Detection in Selected Three Micro Sectors, and
4) Non Revenue Water Survey in the selected Micro Sector among the three.

The objectives of the leakage survey are outlined as follows:

- to measure the magnitude of leakage in ten Model Districts (Micro Sectors),
- to evaluate the effectiveness of micro sectoring, Minimum Night Flow (MNF) measurement, leak detection and repair Work,
- to identify dominating factors of water leakage and Non Revenue Water,
- to provide basic information for improving leakage and wastage reduction,
- to obtain basic information on water consumption, and
- to transfer technical know-how of field leakage survey to ENCAL personnel through OJT.

4.2 SUMMARY OF THE LEAKAGE SURVEY RESULTS

The major output of the Leakage Survey is summarized :

- Continuous 24 hour flow measurement was successful, and the Minimum Night Flow could be practically regarded as the leakage in the measured area.
- The leakage ratio differs area to area ranging from 7% to 46% in the ten micro sectors, and the average leakage ratio was 30%.
- The average leakage ratios in the three zones of different elevations; Zona Baja, Zona Alta, and Zona Alta Superior were 41%, 30% and 17%, respectively. Leakage ratio was highest in Zona Baja.
- The leakage ratio in Asentamiento “Dinamarca” was measured at 40%.
- All the leaks detected in the selected three micro sectors were found out on the service pipes.
- Intensive leak detection using leak detectors and listening bars was very effective to reduce the leakage to a certain satisfactory level.
- The average per capita consumption for all the domestic customers in the entire Managua was estimated at 175 lpcd from the results of 24 hour flow measurement in the micro sectors and Asentamiento.
- At least 16% of the total water meters surveyed were found to be defective in the ten micro sectors.
- Approximately 9% of the total connections in the ten micro sectors were regarded as illegal.

4.3 SELECTION OF MODEL DISTRICTS (MICRO SECTORS) AND METHODOLOGY FOR LEAKAGE SURVEY

4.3.1 Selection of Model Districts (Micro Sectors)

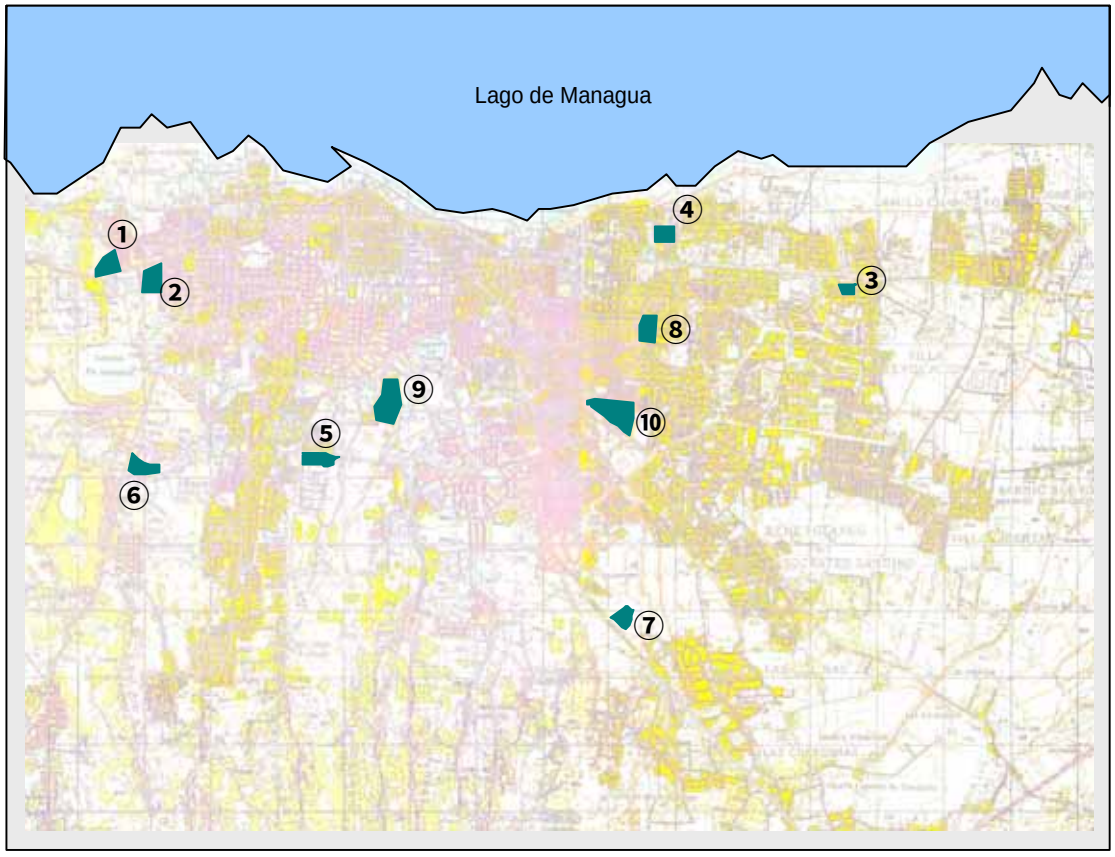
Ten model districts for Leakage Survey were selected consulting with Gerencia Comercial and Gerentia Operaciones of ENACAL. As EANCAL has already defined 265 micro sectors in the past similar NRW survey program carried out during 1990's, 15 micro sectors were selected as candidates of the model districts from the list of the micro sectors. Those candidate model districts were then examined in detail through the field confirmation work for hydraulic isolation from the surrounding area for the MNF measurement.

Locating boundary valves to isolate the model districts was not very easy as the distribution network drawings are not completely updated at the digital drawing section. The isolation of model districts were confirmed by locating all the boundary valves and closing these valves, and then the extent of the area affected by water supply suspension is carefully checked by confirming no flow from customers' faucets in the selected micro sectors through house to house survey.

Finally, 10 model districts, hereinafter referred to as micro sectors, were selected and redefined; four from Low Elevation Zone (Zona Baja), three from Medium Elevation Zone (Zona Alta) and three from High Elevation Zone (Zona Alta Superior). **Table 4.1** shows the list of micro sectors selected, and their locations are shown on **Figure 4.1**.

Table 4.1 Selection of Model Districts (Micro Sectors) for Leakage Survey

MicroSector	Valle Dorado	Los Arcos	Mombacho	Villa P. J. Chamorro	Barrio El Eden	Reparto Tiscapa	El Dorado	Colonia del Periodista	Belmonte	Lomas del Valle
Zone	Low	Low	Low	Low	High	High	High	Super High	Super High	Super High
Location No.	①	②	③	④	⑧	⑨	⑩	⑤	⑥	⑦
No. of Connection	196	253	158	170	382	198	482	234	89	217
Inlet Pipe Material	A.C.	PVC	A.C.	PVC	PVC	PVC	AC	PVC	PVC	PVC
Inlet Pipe Nominal Diameter (mm)	150	150	100	150	150	150	150	150	150	150
Total Length of Pipe Network (km)	1.60	1.48	0.97	1.27	3.0	1.8	4.2	1.76	1.72	3.2
Connections per Pipe Length (No./Km)	123	171	163	134	128	110	115	133	52	68
Area Status *1)	Medium Income Residential Area	Medium Income Residential Area	Medium Income Residential Area	Medium Income Residential Area	Medium Income Residential Area	Medium Income Residential Area	Medium to High Income Residential Area	Medium Income Residential Area	Medium to High Income Residential Area	High Income Residential Area
Existence of Non Domestic Users (Specially large consumers)	non	Government Complex (INIFOM)	non	non	non	non	Restaurants, Schools	rare	rare	Red Cross Offices, Schools, Universities
Use of Domestic Water Tanks	non	non	non	non	non	non	non	rare	rare	40% of costomers
Others										Customers' meters are generally new.



Note: The numbers correspond to the Location Nos. in **Table 4.2**.

Figure 4.1 Locations of Model Districts (Micro Sectors) for Leakage Survey

The drawings of the ten micro sectors with customer registration numbers are compiled in **Annex 4A**.

4.3.2 Methodology of Leakage Survey

The procedure of Leakage Survey is illustrated in the flow chart as shown in **Figure 4.2**. Major activities are described below.

MAP PREPARATION

CAD drawings of the micro sectors with distribution pipelines and registered customers' locations are available. However, interconnected pipelines recently installed are not properly reflected on the drawings and these were to be inspected carefully during the field confirmation work. Through the field inspection the drawing was completely updated prior to the commencement of the leakage survey.

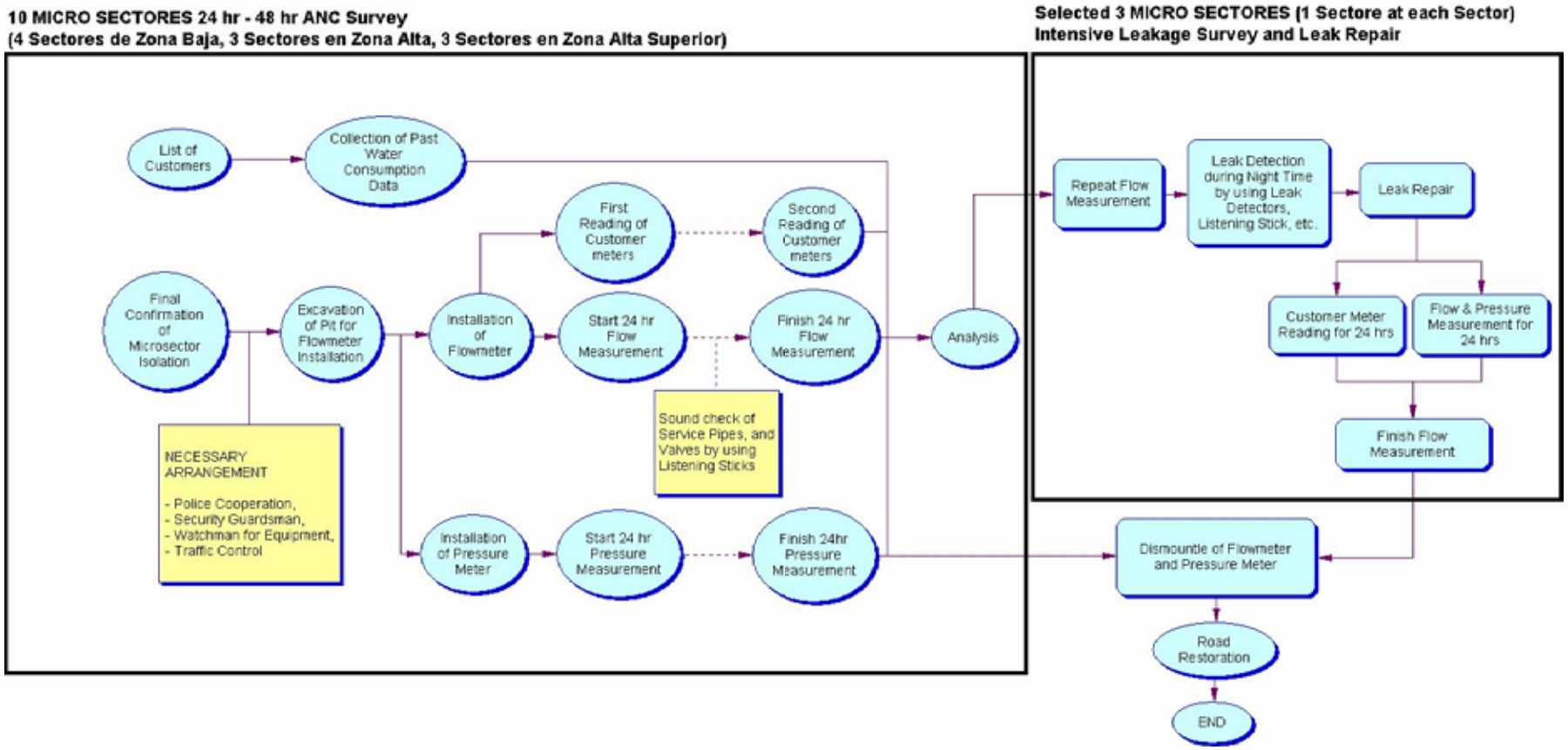


Figure 4.2 Flow Chart of Leakage Survey Procedure

Photo-1 Boundary Valve Check for Isolation

Photo-2 Pipe Length Measurement

CUSTOMER REGISTRATION LIST

The list of the customers with their registration numbers and water meter numbers was prepared for meter reading. The past 6 month average consumptions were also given in the list for the reference.

CONTINUOUS 24 HOUR FLOW MEASUREMENT

Ultrasonic flow meters were installed on the inlet pipes into the micro sectors, so that recorded were instantaneous flow rate to know the Minimum Night Flow (MNF) with the interval of every 1 minute and the total accumulated inflow during the period of 24 hours.

Photo-3 Flow Meter Installation on Inlet Pipe Manhole is available

Photo-4 Flow Meter Installation Arrangement where Inlet Pipe was dug out

WATER PRESSURE MEASUREMENT

Automatic water pressure recorders were installed at the inlet and extremity of the micro sectors to measure the 24 hour water pressure patterns to obtain the average water pressure during 24 hours as well as the water pressure during the minimum night flow.

Photo-5 Pressure Recorder Installation on Pipe

Photo-6 Pressure Recorder at the Extremity Inlet in Supply Area

CUSTOMER METER READING AND INSPECTION WITH LISTENING BARS

Each customer meter was read twice, at the starting and ending of the 24 hour continuous flow measurement to obtain the total water consumption indicated by customer meters. Three meter reading teams started reading simultaneously.

One of the interests of this field survey was to know the conditions of existing water meters and customers' connections. Every customer's connection was examined with the use of listening bars, and the customer meter conditions were also inspected during the meter reading. This house to house survey was very helpful to find defective customer meters, illegal connections, in-house leakage, and wrong customer registration. The surveyors checked the names of customers compared with the customers list obtained from the billing section of the commercial department.

Photo-7 Customer Meter Reading/Recording

Photo-8 Sound Listening Check of Service Line

LEAK DETECTION USING SOUNDING INSTRUMENTS DURING MIDNIGHT

Selecting the worst three micro sectors among ten micro sectors the intensive leak detection during midnight was carried out to locate leaking points. The Team utilized leak detectors and listening bars. The leak detectors were mainly used to pinpoint underground leaks, and listening bars were used to check the flowing sound of each service pipe.

Photo-9 Leak Detection using Leak Detectors

Photo-10 Pinpointing Leaking Point

4.4 CONTINUOUS 24-HOUR MEASUREMENT OF WATER FLOW AND PRESSURE

The continuous 24 hour flow and pressure patters recorded during the survey are compiled in **Annex 4B**. The peak flow tends to appear during the period from 6 am to 10 am, and MNF from 0:00 am to 5 am. These flow patters are very reasonable for those observed in residential areas.

FLOW

Accumulated flow during the period of 24 hours into each micro sector is tabulated in **Table 4.2**. The total inflow into the ten micro sectors was 4,091 m^3/day. The number of connections in these micro sectors is 2,380 connections in total. When the average number of persons per connection is adopted as 5.4 persons the flow per capita per day is calculated to be 318 lpcd. Out of this flow major non-domestic use was deducted, and the inflow into the micro sectors was recalculated to be 307 lpcd as shown in **Table 4.2**.

WATER PRESSURE

Water pressures in the micro sectors surveyed are generally good as shown in **Figure 4.3**. There is a tendency that water pressure during midnight becomes very high.

Table 4.2 Summary of Continuous 24 hour Flow Measurement in 10 Micro Sectors

MicroSector	Unit	Valle Dorado	Los Arcos	Mombacho	Villa P. J. Chamorro	Colonia del Periodista	Belmonte	Lomas del Valle	Barrio El Eden	Reparto Tiscapa	El Dorado	Total or Average
Zone		Low	Low	Low	Low	Super High	Super High	Super High	High	High	High	
No. of Connection	nos.	196	253	158	170	234	89	217	382	198	482	2,379
Total Inflow	m3/d	288	509	155	311	269	330	351	592	336	950	4,091
Inflow Per Capita Per Day incl. Leakage & Non-	lcpd	272	373	182	339	213	687	300	287	314	365	318
Per Capita Consumption excl. Leakage	lcpd	166	202	151	182	170	522	278	220	194	250	
No. of Major Non-Domestic Users (NDU)	nos.	0	3	0	0	0	25	0	0	0	22	
Names & Types of NDUs	-		INIFOM(Government)				Red Cross, French School, Universities,					
Esitimated Water Consumption by NDUs	m3/d	0	24	0	0	0	163.79	0	0	0	42.8	231
Total Inflow after deducting consumption by NDUs	m3/d	176	252	129	167	215.158	87.21	326	454	207	607.2	2,621
No. of connections after deducting NDUs	nos.	196	250	158	170	234	64	217	382	198	460	2,329
Corrected Inflow per Capita per day	lpcd	288	485	155	311	269	166	351	592	336	907	307

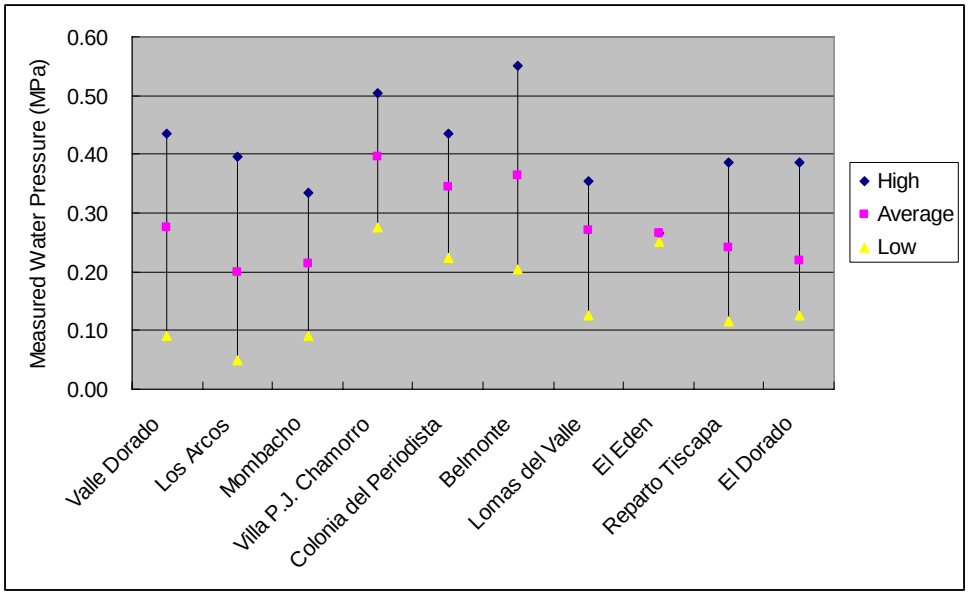


Figure 4.3 Summary of Water Pressure Measurement in 10 Micro Sectors

4.5 MINIMUM NIGHT FLOW REPRESENTING LEAKAGE

The Minimum Night Flow (MNF) is the minimum spontaneous rate of flow passing into an isolated micro sector recorded every one minute by the ultrasonic flow meter. The MNF during the continuous 24 hour flow measurement in each micro sector was regarded as leakage in this Study. One of the example of the night flow rate patterns is shown in **Figure 4.4** for the micro sector, Reparto Tiscapa.

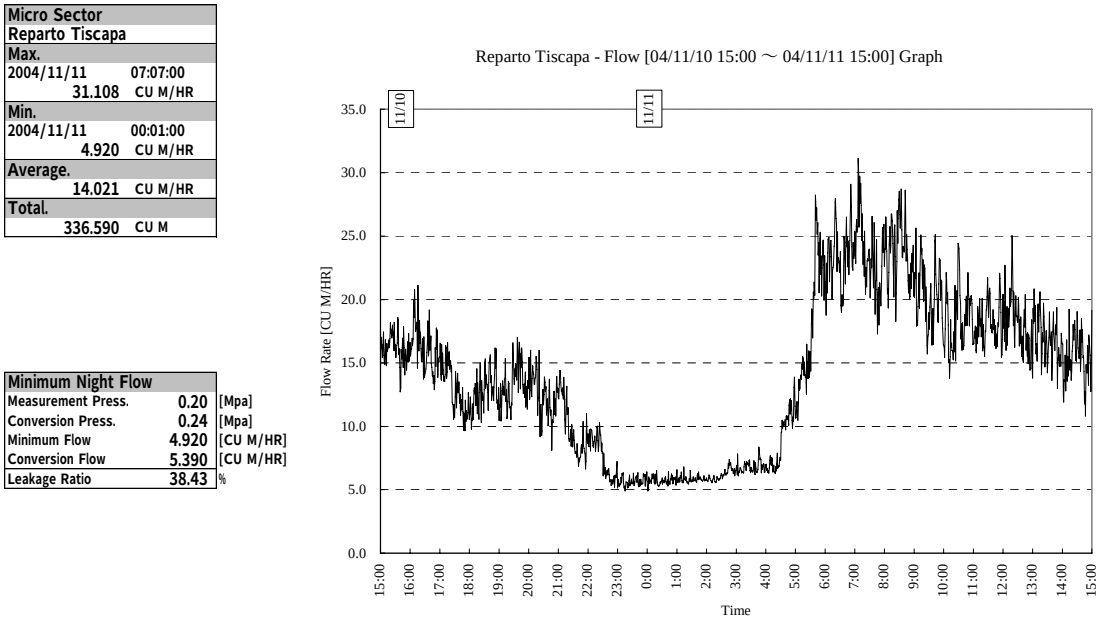


Figure 4.4 Typical 24 Hour Flow Pattern in Micro Sector

The MNF also may contain legitimate water consumption if there exist users that consume water continuously overnight. The micro sectors surveyed are, however, located in residential areas, it was observed that such customers continuously using water throughout the midnight

were rare in number. It is reasonable MNF obtained in this Survey can practically represent leakage. The MNF measured is then converted to be leakage after adjusting the flow rate at the average water pressure in the surveyed area during the measurement period. **Table 4.3** shows the level of leakage thus calculated from MNF in each micro sector together with relevant data on pipes and connections, and also shows several different indicators to express the magnitude of leakage.

LEAKAGE RATIOS EXPRESSED AS THE PERCENTAGES OF QUANTITIES SUPPLIED

The leakage ratio in each micro sector was calculated from the converted MNF, and expressed using percentage of quantities supplied. The leakage ratio differs area to area ranging from 7% to 46% as shown in **Figure 4.5**, and the average ratios in the three zones of different elevations; Zona Baja, Zona Alta, and Zona Alta Superior were 41%, 30% and 17%, respectively as shown in **Figure 4.6**.

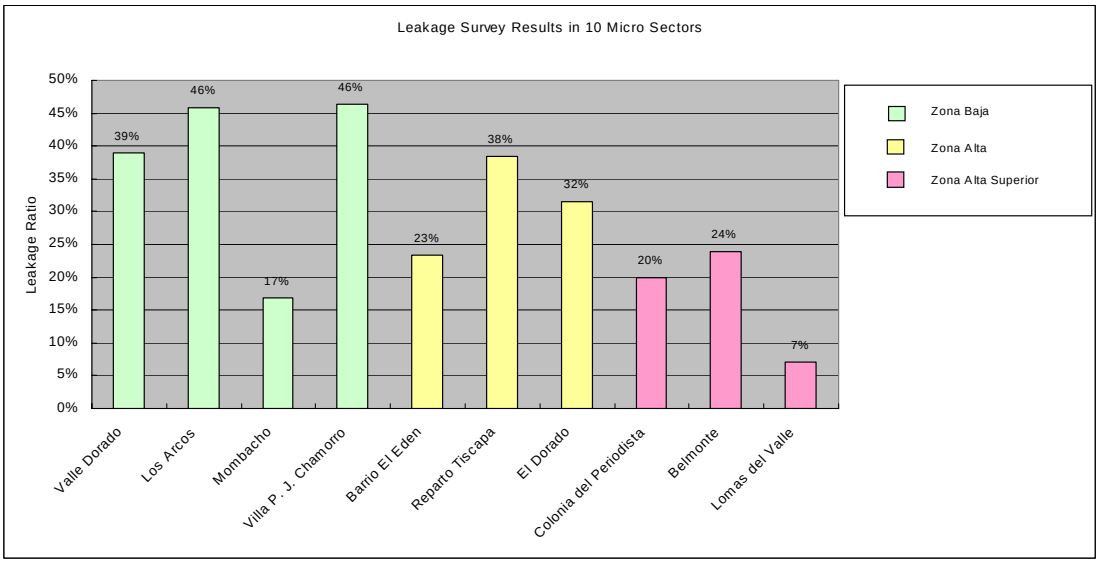


Figure 4.5 Leakage Levels in the Ten Micro Sectors Surveyed

There is a tendency that the lower the zone the higher the average leakage ratio. The overall leakage ratio for the ten micro sectors surveyed was 30% on average.

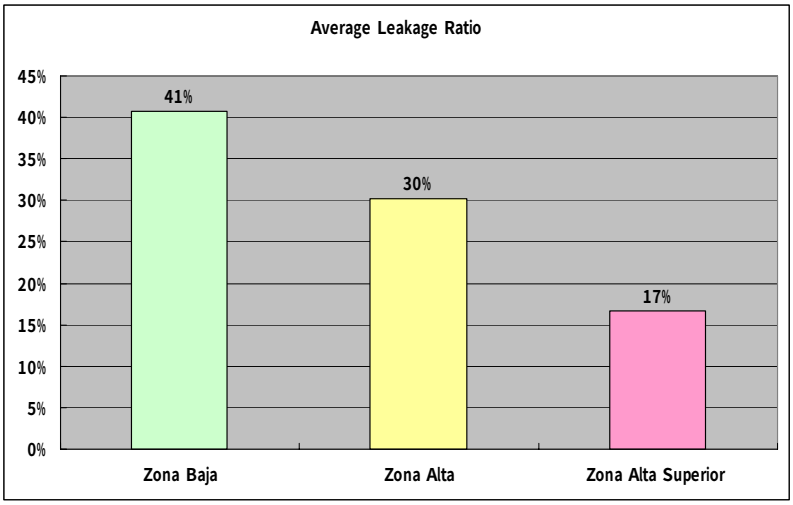


Figure 4.6 Average Leakage Levels in Different Zones in Managua

Table 4.3 Results of Leakage Survey

MicroSector	Unit	Valle Dorado	Los Arcos	Mombacho	Villa P. J. Chamorro	Colonia del Periodista	Belmonte	Lomas del Valle	Barrio El Eden	Reparto Tiscapa	El Dorado	**Total**	**Average**
Zone		Low	Low	Low	Low	Super High	Super High	Super High	High	High	High		
No. of Connection	nos.	196	254	158	170	234	89	217	382	198	482	**2,380**	
Inlet Pipe Material		A.C.	PVC	A.C.	PVC	PVC	PVC	PVC	PVC	PVC	AC		
Inlet Pipe Nominal Diameter	mm	150	150	100	150	150	150	150	150	150	150		
Total Length of Pipe Network	km	1.60	1.48	0.97	1.27	1.76	1.72	3.20	2.98	1.80	4.20	**21**	
Connections per Pipe Length	No./km	123	172	163	134	133	52	68	128	110	115		**113**
Average Water Pressure	Mpa	0.29	0.22	0.204	0.38	0.40	0.37	0.27	0.27	0.24	0.22		**0.29**
Total Inflow	m3/d	288	509	155	311	269	330	351	592	336	950	**4,091**	
MNF(Leakge)	m3/d	112	233	26	144	54	79	25	138	129	300	**1,240**	
Water Consumption	m3/d	176	276	129	167	215	251	326	454	207	650	**2,851**	
Leakage Ratio	%	38.9%	45.8%	16.8%	46.3%	20.0%	23.9%	7.1%	23.3%	38.4%	31.6%		**30%**
Leakage per Unit Length of Pipeline	m3/hr/km	2.9	6.6	1.1	4.7	1.3	1.9	0.3	1.9	3.0	3.0		**2.46**
MNF per Connection	l/hr/connec	24	38	7	35	10	37	5	15	27	26		**21.7**
Sum of Domestic Watermeter Readings	m3/d	168	209	82	101	203	243	237	304	164	633	**2,344**	
Non Revenue Water (Minimum Possible Level)	m3/d	120	300	73	210	66	87	114	288	172	317	**1,747**	
Non Revenue Water Ratio (Minimum Possible Level)	%	42%	59%	47%	68%	25%	26%	32%	49%	51%	33%		**43%**
Average Consumption for Past 6-months Meter Readings	m3/d	217	300	149	163	214	285	195	388	177	606	**2,694**	

MAGNITUDE OF LEAKAGE EXPRESSED IN TERMS OF MINIMUM NIGHT FLOW

Other indicators to express the magnitude of leakage in terms of MNF in "liters per connection per hour" and "cubic meter per kilometer of main per hour" were examined as shown in **Figure 4.7**.

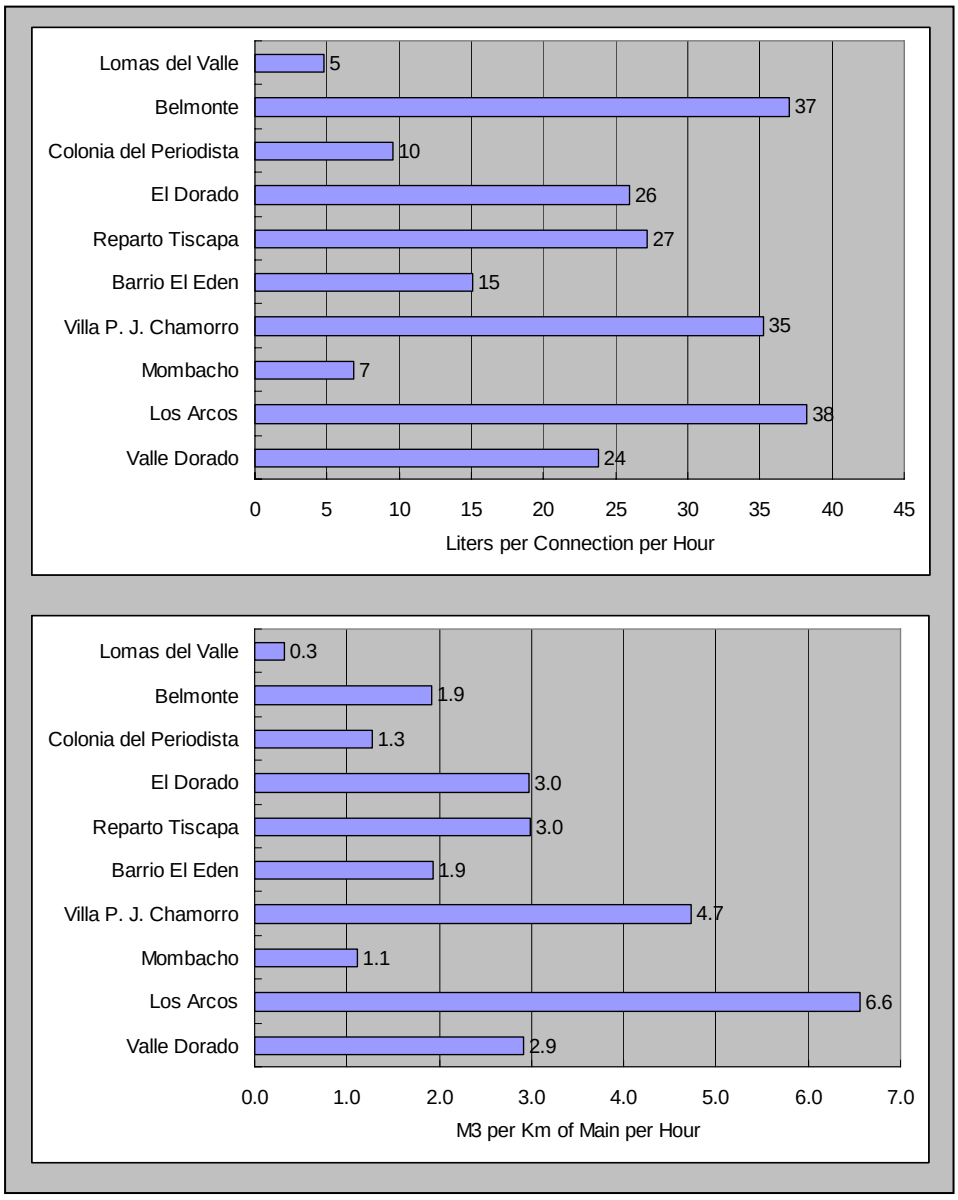


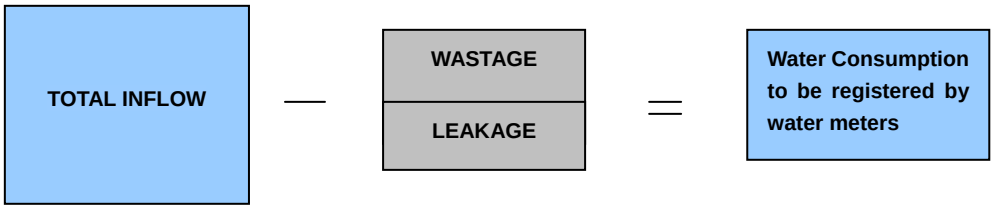
Figure 4.7 Indicators for Magnitude of Leakage Expressed in Terms of MNF

4.6 CUSTOMER METER READING

During the period of the continuous 24 hour flow measurement customers meters were also read to record the consumptions. The conditions of customers' meters are, however, generally poor and accuracy of readings is questioned as there are many old meters without calibration.

The total inflow into the 10 micro sectors was 4,091 m^3/d as previously shown in **Table 4.2**, and

wastage including leakage and "wastage other than leakage" is estimated from the MNF. The balance of these two flows is, accordingly, the sum of water consumptions in the ten micro sectors as shown below.



4,091 M3/D **1,240 M3/D** **2,851 M3/D**

However, the sum of customer meter reading actually registered during the flow measurement in the ten micro sectors was 2,344 m^3/d as shown in **Table 4.3**.

The difference between 2,851m^3/d and 2,344 m^3/d is derived from the fact that 24% of the total connections were not properly metered. This is because 9% of the total connections are of illegal direct connection and the rest of 16% are connections with malfunctioning meters. The conditions of existing connections and water meters are discussed further in **Section 4.8**.

4.7 LEAK DETECTION SURVEY IN SELECTED MICRO SECTORS

Following to the series of the continuous 24 hour flow measurement the Team selected the three micro sectors for further locating actual leaks where the highest leakage ratios were observed in the previous MNF measurement. The Team carried out leak detection using leak detectors and listening bars to pinpoint the leaking points during midnight in collaboration with Commercial Department, Operation Department and Security personnel of ENACAL. The detection work continued approximately 3 to 5 hours depending on the size of the micro sectors.

The selected micro sectors for the leak detection were Los Arcos, Villa P. J. Chamorro and Reparto Tiscapa. The Team requested ENACAL to repair these leaks found out during the leak detection survey so as to evaluate the degree of the leak reduction after the series of activities of this leakage survey.

4.7.1 Results of Leak Detection Using Leak Detectors and Listening Bars

The leaks found out during the survey are summarized in the **Figure 4.8**. All these detected leaks were derived from the service pipes.

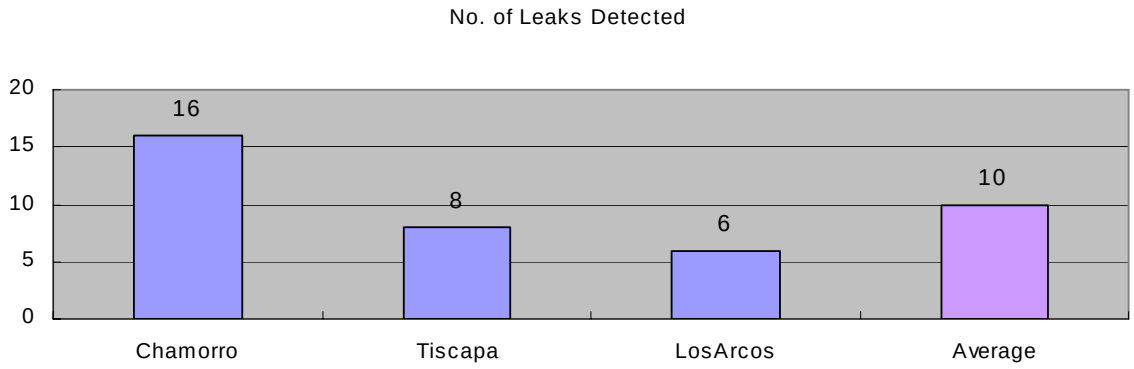


Figure 4.8 Leaks Detected in the Selected Three Micro Sectors

LEAKS DETECTED PER UNIT PIPE LENGTH

Leaks detected in the three micro sectors were expressed in the number of leaks detected per unit pipe length as shown in **Figure. 4.9**.

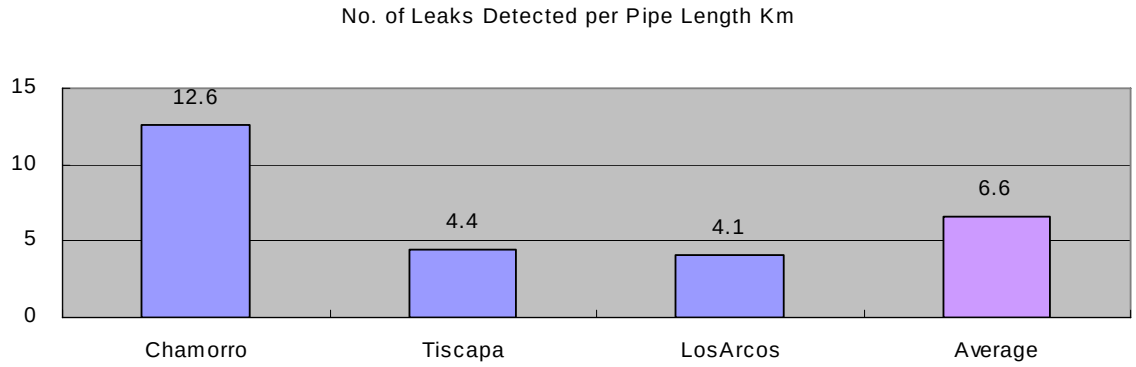


Figure 4.9 Leaks Detected per Unit Pipe length

The average number of cases detected, expressed as leaks detected per unit pipe length, was 6.6 per km. If this rate is simply applied to the total pipe length of 1,328 km within the range of diameter less than 6" in the entire Managua system, there would exist approximately 8,800 leaks.

LEAKS DETECTED PER 100 CONNECTIONS

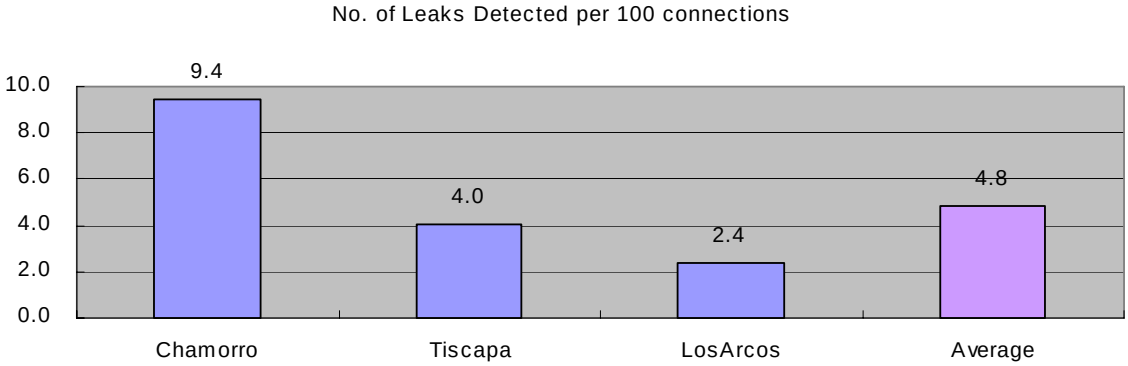


Figure 4.10 Leaks Detected per 100 Connections

The average number of cases detected, expressed as the number of leaks detected per 100 connections, was 4.8. If this rate is simply applied to the total connections of 169,843 in Managua system there would be approximately 8,150 leaks. Whereas, Gerencia Operación of ENCAL reported approximately 24,000 of cases have been repaired in the year 2003. Among which, the leaks from the pipes with the diameter less than 6" amounts to 99.5% of the total cases repaired according to the Departomento de Agua Potable.

The above discussion would indicate that in spite of the present efforts of ENACAL approximately more than 8,000 to 9,000 leaks in number could be detected additionally if leak detection by such a regular sounding is introduced. These leaks are presumed presently left without being attended resulting in making it difficult to decline the leakage level further down below the present level.

LOCATIONS OF LEAKS FOUND OUT

All the leaks detected during the survey were located on service pipelines. This result corresponds to that information obtained from the Departomento de Agua Potable. **Figure 4.11** breaks down the positions of leaks found out on service pipes.

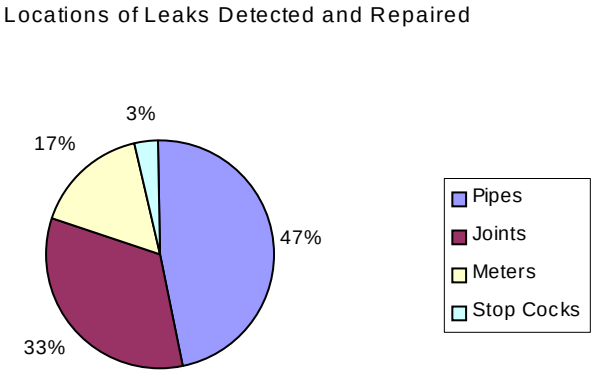
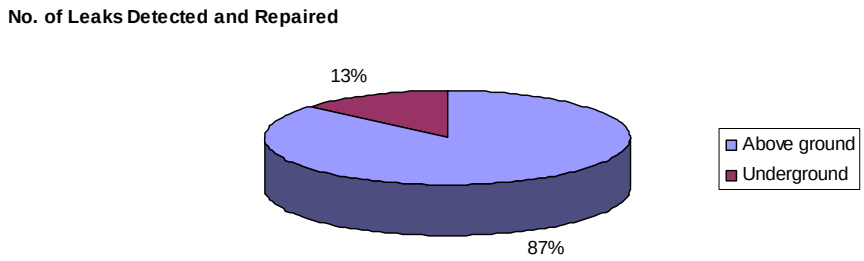
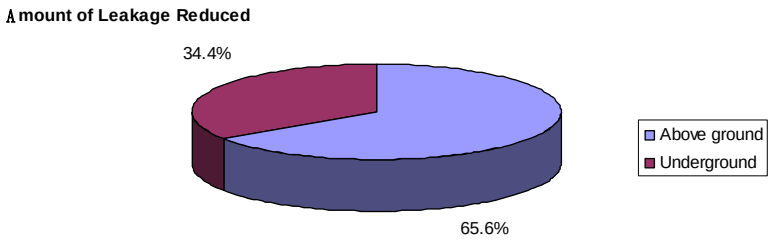


Figure 4.11 Positions of Leaks Found out on the Service Pipes

Although underground leakage contributes 13% in number to the total cases of leaks found out during the survey, it contributes 34% in quantity to the total water loss by all the leaks detected as shown in **Figure 4.12**. It is indicative that many large underground leaks have been left without being detected since ENACAL has not introduced underground leak detection technique using listening devices.



(a) Leaks in number



(b) Leaks in quantity

Figure 4.12 Proportion of Above Ground and Underground Leakages

4.7.2 Effectiveness of Leak Detection and Repair

After the leakage detection in the selected three micro sectors ENACAL repaired all the leaks detected within several days, and then the continuous 24 hour flow measurement was again conducted to evaluate the effectiveness of the leak detection and repair activities.

Table 4.4 compares the various leakage parameters before and after the leak repair. The leakage ratios in the three micro sectors have been improved.

Table 4. 4 Before and After Leak Repair in the Selected Micro Sectors

		Parameters	Unit	Los Arcos	Los Arcos After Leak Repair	Villa P. J. Chamorro	Villa P. J. Chamorro After Leak Repair	Reparto Tiscapa	Reparto Tiscapa After Leak Repair	Average Before Repair	Average After Repair
Zone Characteristic	1	Zone		Low	Low	Low	Low	High	High		
	2	No. of Connection	Nos.	253	253	170	170	198	198		
	3	Inlet Pipe Material		PVC	PVC	PVC	PVC	PVC	PVC		
	4	Inlet Pipe Nominal Diameter	mm	150	150	150	150	150	150		
	5	Total Length of Pipe Network	km	1.48	1.48	1.27	1.27	1.8	1.8		
	6	Connections per Pipe Length	No./km	171	171	134	134	110	110		
	7	Average Water Pressure	Mpa	0.22	0.20	0.38	0.40	0.24	0.24		
Flow Measurement Results	8	Total Inflow	m3/d	509	371	311	250	336	250		
	9	MNF(Leakge) adjusted by Average Water Pressure	m3/d	233	102	144	86	129	50		
	10	Water Consumption incl. Wastage	m3/d	276	269	167	164	207	200		
	11	Leakage Ratio	%	46%	27%	46%	34%	38%	20%	44%	27%
	12	Leakage per Unit Length of Pipeline	m3/hr/km	6.6	2.9	4.7	2.8	3.0	1.2	4.6	2.2
	13	MNF per Connection	l/hr/connec	38	17	35	21	27	11	34	16
	14	Sum of Domestic Watermeter Readings	m3/d	209	230	101	91	164	150		

The average leakage ratio of the worst three micro sectors, 44%, was reduced to 27%. Moreover, if we look at this reduction as a total the average leakage ratio of the 10 micro sectors, 30%, could drop to 25.5%.

Furthermore, in Los Arcos there was found a relatively large leakage in the government premises (INIFOM) but it could not be repaired during the period of the Survey. **Figure 4.13** shows the result of direct measurement of this leakage by continuous 24 hour flow measurement with the installation of an ultrasonic flow meter at the inlet pipe into INIFOM. The night flow pattern after all the offices of INIFOW was closed is very stable showing that the flow represents the leakage. The night flow pattern gradually increasing from around 22:00 to 4:00 corresponds to the increase of water pressure from 0.3 Mpa to 0.4 Mpa during that period. This leakage is estimated to be 45 m^3/d.

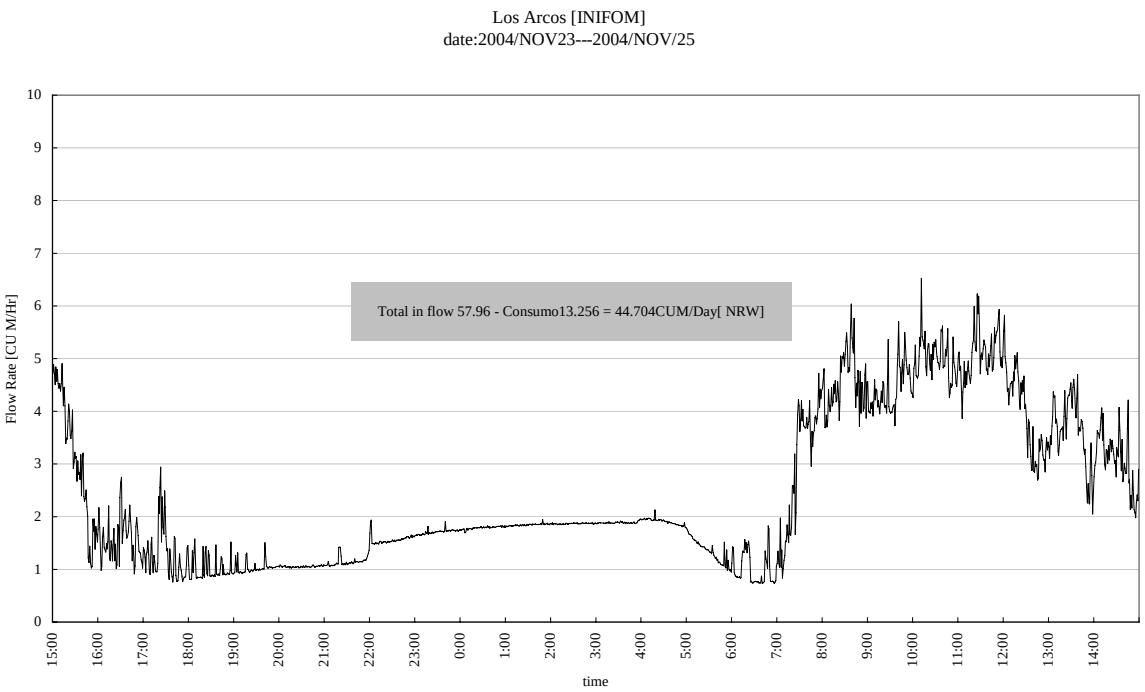


Figure 4.13 Continuous 24 hour Flow Measurement of Inflow into INIFOM

If this leakage is stopped the leakage ratio in Los Arcos could be further reduced to 17%. This reduction contributes to reduce the average leakage ratio in the total 10 micro sectors further down to the level of 24.6%.

It was understood that **intensive leak detection using leak detectors and listening bars was very effective for leakage reduction in Managua**.

4.8 NON REVENUE WATER (NRW) SURVEY

NRW was defined in the Interim Report as shown in **Table 4.5**. It is noted that "billed but not collected consumption" is not included in this definition of NRW as it is considered as a commercial issue and should be handled by improving commercial management.

Table 4.5 Definition of Non-Revenue Water

<table>
<tr><td rowspan="10">System Input Volume</td><td rowspan="3">Authorised Consumption</td><td rowspan="2">Billed Authorised Consumption</td><td>Billed Metered Consumption (including water exported)</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Billed Unmetered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorised Consumption</td><td>Unbilled Metered Consumption</td><td rowspan="8">Non-Revenue Water (NRW)</td></tr>
<tr><td>Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="7">Water Losses</td><td rowspan="2">Apparent Losses</td><td>Unauthorised Consumption</td></tr>
<tr><td>Metering Inaccuracies</td></tr>
<tr><td rowspan="5">Real Losses</td><td>Leakage on Transmission and/or Distribution Mains</td></tr>
<tr><td>Leakage and Overflows at Utility's Storage Tanks</td></tr>
<tr><td>Leakage on Service Connections up to point of Customer metering</td></tr>
</table>

Source: IWA "Best Practice" Water Balance and Terminology

As seen in **Table 4.5** bad conditions of customers meters and unauthorized (illegal) connections would be closely related to the level of NRW. Therefore, the following inspections were also conducted to collect useful information to evaluate the NRW during the Leakage Survey in the ten micro sectors:

- inspection of customers connections, and
- inspection of customer water meters.

Moreover, among the three micro sectors where the leak detection and leak repair work were conducted, one micro sector was selected for further investigation on NRW. This NRW Survey was carried out in **Villas P. J. Chamorro**, where the leakage ratio showed still a higher level among the three after repair of the leaks found out.

4.8.1 Conditions of Customers' Connections and Water Meters

Table 4.6 summaries the conditions of customers' connections and water meters.

Table 4.6 Incidences of Problematic Consumers' Connections in 10 Micro Sectors

MicroSector	Unit	Valle Dorado	Los Arcos	Mombacho	Villa P. J. Chamorro	Barrio El Eden	Reparto Tiscapa	El Dorado	Colonia del Periodista	Belmonte	Lomas del Valle
Zone		Low	Low	Low	Low	High	High	High	Super High	Super High	Super High
No. of Connection		196	254	158	170	382	198	482	234	89	217
Inlet Pipe Material		A.C.	PVC	A.C.	PVC	PVC	PVC	AC	PVC	PVC	PVC
Inlet Pipe Nominal Diameter	mm	150	150	100	150	150	150	150	150	150	150
Total Length of Pipe Network	km	1.60	1.48	0.97	1.27	2.98	1.80	4.20	1.76	1.72	3.20
Connections per Pipe Length	No./km	123	172	163	134	128	110	115	133	52	68
Average Water Pressure	Mpa	0.29	0.22	0.204	0.38	0.27	0.24	0.22	0.40	0.37	0.27
Leakage Ratio	%	39%	46%	17%	46%	23%	38%	32%	20%	24%	7%
Direct Connections without meters or Disconnected (Potential Illegal Users)	nos.	2	12	21	34	65	21	12	11	6	30
Percentage of Direct Connections or Disconnected (Potential Illegal Users)	%	1%	5%	13%	20%	17%	11%	2%	5%	7%	14%
Connections with zero consumption reading or damaged or non readable meters	nos.	34	74	55	42	30	27	35	26	5	18
Percentage of Problematic Meters among Existing Meters	%	18%	31%	40%	31%	9%	15%	7%	12%	6%	10%
Percentage of Problematic Connections	%	18%	34%	48%	45%	25%	24%	10%	16%	12%	22%
Meter Apparently Damaged	nos.	2	2	6	1	7	9	1	4	0	0
Meter No Work (Indicating zero consumption)	nos.	30	65	26	22	15	9	22	19	3	15
Meter buried	nos.	0	5	2	2	1	4	7	0	2	2
Meter Not Located	nos.	0	0	19	15	4	3	2	0	0	0
Meter Not Readable	nos.	2	2	2	2	3	2	3	3	0	1
Meter Removed	nos.	0	4	7	1	52	2	3	0	3	2
Meter Removed but Illegaly Connected	nos.	0	8	14	33	13	19	9	11	3	28
Total of Problematic Meters	nos.	34	86	76	76	95	48	47	37	11	48

Conditions of Water Meters

- Most of the customer meters are installed outside the customers' properties, and properly cased in the meter boxes. The customer meters are located at the side walks in ordinal residential areas and the access to meters seem rather easier. The situations of the installations show, however, in some micro sectors that there are many meter boxes without covers, and many meters could not be located.
- Significant number of water meters indicated zero consumption during the survey even though water is actually consumed and their monthly consumptions are registered in ENACAL billing cycle. It is indicative that such connections have malfunctioning water meters or by-pass connections, many customers are eventually billed by the estimates without actual meter reading. At least approximately 16% of the total water meters surveyed are defective. Percentage of problematic connection in each micro sector is shown in **Figure 4.14**.
- Various water meters of different manufacturers are being used, and most of them are of metric unit but gallon unit meters are also used.

- Many meters seem to be left without reading for a long period of time. There are many water meters not functioning and some are covered with soil or submerged in water with offensive dirt. Such situation is likely to discourage meter readers to make appropriate reading.

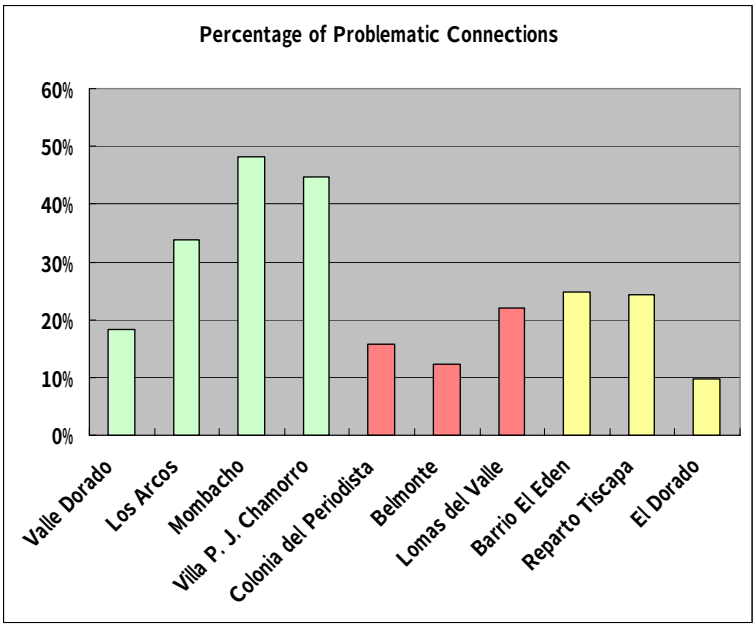


Figure 4.14 Percentage of Problematic Connections in Each Micro Sector

Conditions of Direct Connections or Illegal Connections

The direct connections are significant in number in several micro sectors as shown previously in **Table 4.6**, and the volume of water consumption through such connections is likely to be also considerable. As actual water flows were often observed in such houses during mid-night time indicating that lots of water is considered being wasted probably from abused taps for no useful use. Approximately 9% of the total connections in the ten micro sectors are regarded as illegal direct connections.

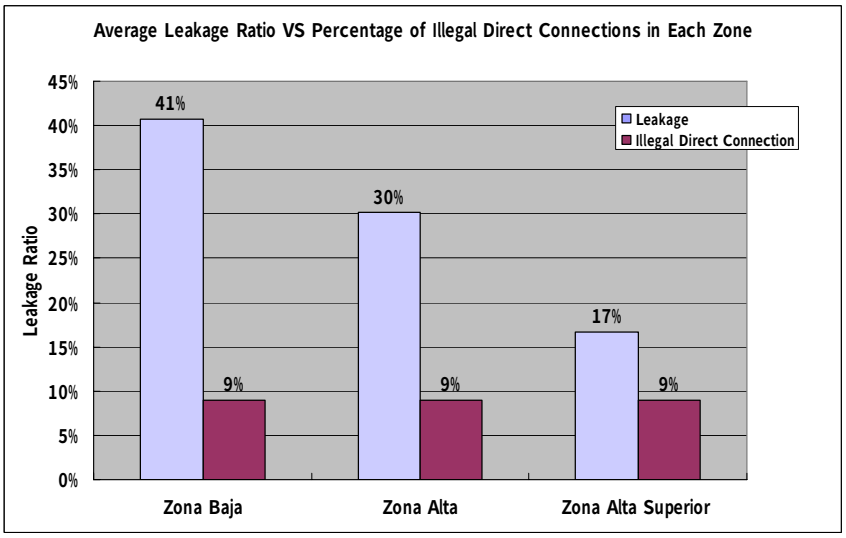


Figure 4.15 Incidences of Illegal Connections Compared with the Average Leakage Ratios in Different Elevation Zones

There are several types of illegal connections as considered below:

(1) Water meters are removed but directly connected,.
(2) Water meters are removed but connected with hoses specially during the night, and
(3) Water meters and pipes can not be located but water is supplied probably from the neighbors or through by-pass pipes laid by illegal users.

Photo 11 Direct Illegal Connection

Photo 12 Direct Illegal Connection with hoses

4.8.2 Results of NRW Survey in Villa P.J. Chamorro

In Villa P. J. Chamorro, one of the worst three micro sectors that showed high levels of MNF, NRW Survey was conducted in collaboration with ANC Comercial of ENACAL. Improvement works on service connections such as meter replacement/installation and disconnection of illegal connections were conducted intensively. Succeeding to these works 24 hour flow measurement was carried out to assess the effectiveness of these works. Major components of the works carried out in this survey are listed as follows:

- ✧ 1 new customer meter was installed.
- ✧ 18 customer meters were replaced.
- ✧ 21 illegal connections were disconnected.

As seen in **Figure 4.16** MNF decreased after these works were carried out. Of the illegal connections, however, although twenty one (21) illegal connections were disconnected according to the ENACAL's procedure, 16 users recommitted the same within one or two days. In spite of this the MNF could be further reduced. It is presumed that ENACAL's activities on accusing illegal users by cutting such connections might demonstrate users to be aware of careful water use.

<u>Customer Meter Reading</u>

After 18 customer meters were replaced and one (1) new meter was installed these meters were measured to check one-day consumption. The total actual consumption measured by these meters was 16.20 m^3/day or 0.85 m^3/connection/day. Furthermore the meters were again read after 12 days, and the total consumption was 246.3 m^3/12days or 1.08 m^3/connection/day.

Before this replacement work ENACAL has billed these customers by the estimation based on their average consumption for the previous 6 months. The total water volume billed to these 19 users in the previous months was 498 m^3/month or 16.6 m^3/d as shown in **Table 4.7**. In contrast,

the actually registered meter readings was 616 m^3/month. The total amount actually billed is lower than the total actual consumption by approximately 20%, and some individual estimated consumptions are quite different from the actual consumption ranging from 33% to 229%.

Due to the existence of many defective meters billing by estimated volume is adopted very commonly, and ENACAL easily adopts the estimated amount for their billing. It is also true that meter readers often register the consumptions without reading meters. Customers' complaints of their bills are in most cases derived from such unreliable billing based on the estimates done by ENACAL. Those complaining tend to refuse settling their bills and their arrears eventually accumulate very large. ENACAL, then, enforces disconnecting the services against such customers. But they reconnect the connections by themselves and they are categorized into illegal users. It is important to chop this vicious circle between bad billing and illegal users by introducing very intensive improvement work.

Table 4.7 Comparison of ENACAL's Estimated Bills and Actual Consumptions

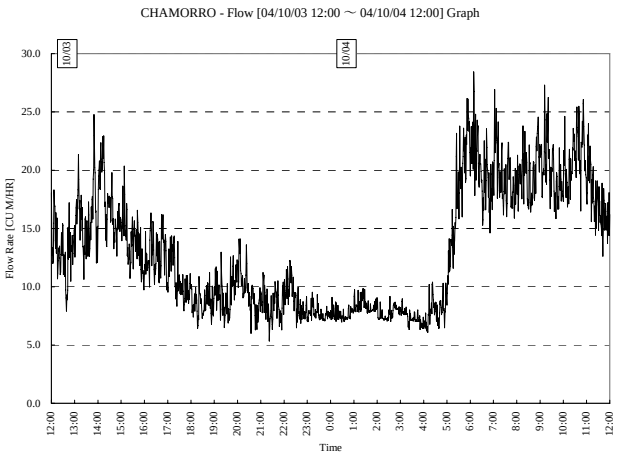
Customers	Average Consumptions	Billed	First Reading	Second Reading	1 day Consumption (m3)	Third Reading	12 days Consumption (m3)	Average Daily Consumption (m3/d)	Monthly Consumption (m3/month)
OSORIO M/HERIBERTO	46	46.0	2656.00	2657.00	1.00	2676.00	19.00	1.67	50.00
SALAZAR DUARTE/MARGARITA	16.1	9.0	28.00	28.70	0.70	36.90	8.20	0.74	22.25
ROSTRAN OROZCO JANETH	20.5	20.6	10.00	10.50	0.50	13.60	3.10	0.30	9.00
OVIEDO DIAZ/FELIPA LAURA	26.2	23.0	27.000	27.40	0.40	35.90	8.50	0.74	22.25
TAPIA C LUIS N	13.8	13.9	43.00	43.60	0.60	59.70	16.10	1.39	41.75
PINEDA/ROSA EMILIA	31.4	39.3	42.00	42.90	0.90	55.00	12.10	1.08	32.50
URBINA S JOSE A	27	13.3	31.00	32.30	1.30	43.40	11.10	1.03	31.00
HUETE M/CARLOS	23.6	31.0	18.00	19.10	1.10	24.60	5.50	0.55	16.50
SUAREZ CH MARIA	21.3	21.7	52.00	53.00	1.00	70.70	17.70	1.56	46.75
GRETA PAIZ MALESPIN	19.9	19.7	31.00	32.10	1.10	43.30	11.20	1.03	30.75
SALINA ESTEBAN/	25.7	25.7	2512.00	2513.00	1.00	2519.00	6.00	0.58	17.50
MARTINEZ R WILFREDO	19.8	19.8	1182.00	1182.00	0.00	1190.00	8.00	0.67	20.00
BLANDON G CRISANTO	33.4	35.2	1454.00	1454.7	0.70	1472.70	18.00	1.56	46.75
GUTIERREZ C ANTONIA	47.6	46.4	4686.00	4687.00	1.00	4697.00	10.00	0.92	27.50
FLORES V ESMERALDA	31.4	31.1	2960.00	2961.20	1.20	2973.20	12.00	1.10	33.00
VILCHEZ R URANIA	28.8	28.8	1682.000	1683.1	1.10	1697.00	13.90	1.25	37.50
MOODYZ V MARIA DEL	46.7	46.8	805.00	806	1.00	836.00	30.00	2.58	77.50
VALLE V NOEL	18	18.0	5996.00	5996.20	0.20	6002.20	6.00	0.52	15.50
BARBERENA C ALFREDO	19	19.0	38.00	39.40	1.40	53.10	13.70	1.26	37.75
Total	516.2	508.30			16.20		230.10	1.08	615.75

Meter Reading was done on 13,14 and 25, January 2005.

Original Condition

Micro Sector	
CHAMORRO	
Max.	
2004/10/04	06:09:00
28.435	CU M/HR
Min.(Night)	
2004/10/03	22:43:00
6.872	CU M/HR
Average.	
12.960	CU M/HR
Total.	
311.430	CU M

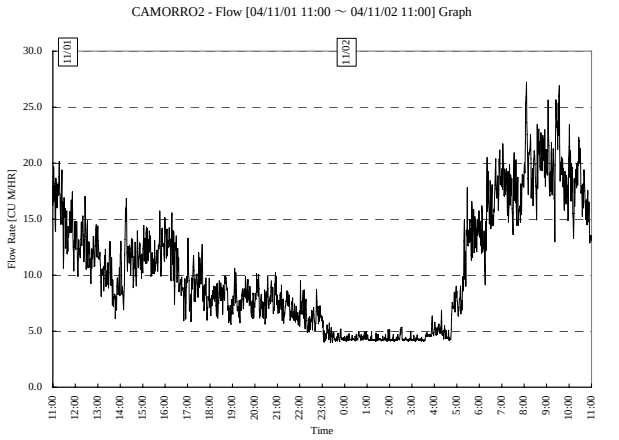
Minimum Night Flow		
Measurement Press.	0.50	[Mpa]
Conversion Press.	0.38	[Mpa]
Minimum Flow	6.872	[CU M/HR]
Conversion Flow	5.991	[CU M/HR]
Leakage Ratio	46.17	%



After leak repair

Micro Sector	
CHAMORRO2	
Max.	
2004/11/02	08:06:00
27.239	CU M/HR
Min.	
2004/11/01	23:22:00
3.983	CU M/HR
Average.	
10.379	CU M/HR
Total.	
249.003	CU M

Minimum Night Flow		
Measurement Press.	0.50	[Mpa]
Conversion Press.	0.40	[Mpa]
Minimum Flow	3.983	[CU M/HR]
Conversion Flow	3.563	[CU M/HR]
Leakage Ratio	34.34	%



After NRW survey

Data No.	
CHAMORRO 3	
Max.	
2005/01/10	11:03:00
24.74	CU M/HR
Min.	
2005/01/10	01:29:00
2.519	CU M/HR
Average.	
9.96	CU M/HR
Total.	
239.00	CU M

Minimum Night Flow		
Measurement Press.	0.45	[Mpa]
Conversion Press.	0.30	[Mpa]
Minimum Flow	2.519	[CU M/HR]
Conversion Flow	2.057	[CU M/HR]
Leakage Ratio	20.65	%

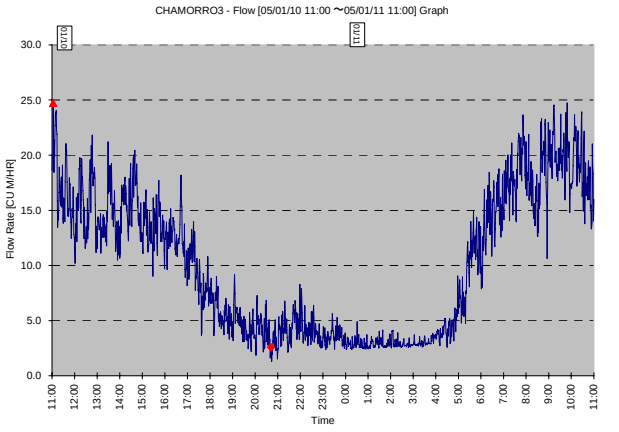


Figure 4.16 MNF Reductions in the Series of Leakage/NRW Survey in Villa P. J. Chamorro

4.9 FLOW MEASUREMENT IN ASENTAMIENTOS

Measuring and recording of the range of rates of flow passing into an asentamiento for 24 hours were carried out to assess the range of water consumed or wasted in the Asentamiento, where the users have no water meters. One of the Asentamientos, Dinamarca, which has 376 connections, was selected for the 24 hour flow measurement. **Figure 4.17** shows the 24 hour flow patters.

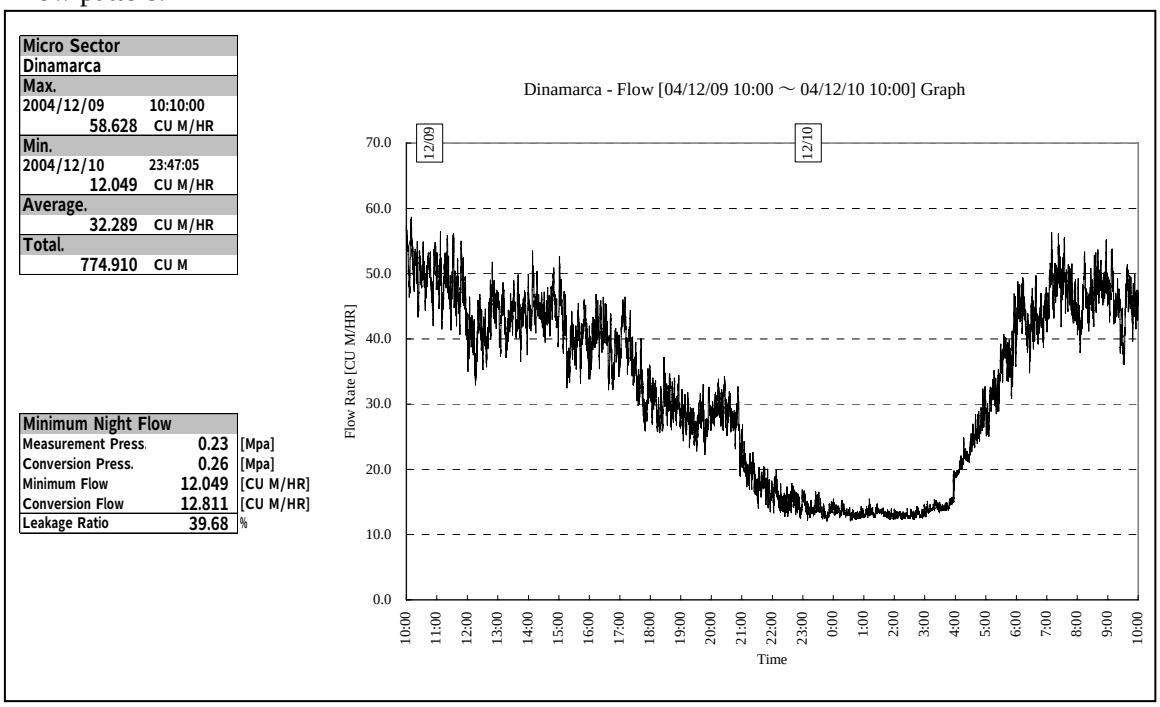


Figure 4.17 Continuous 24 Hour Flow Pattern in Dinamarca

The total inflow into the area was 775 m^3/d, which indicates that 382 lpcd or 62 m^3/connection/month of water is consumed effectively or ineffectively in this area. It is very high compared with residential areas other than Asentamientos, and indicative that considerable amount of water is wasted without useful purpose. Moreover, there are several previous analyses on Asentamiento consumption carried out by ENACAL, and similar results have been obtained from the past flow measurements using macro meters carried out by ENACAL. Macro meters for Asentamientos had been installed starting from the end of 1990's, and their monthly readings were recorded. **Table 4.8** shows the flow measured during the year 2000 in several Asentamientos, where the macro meters were in good condition. The average flow into these Asentamientos, when converted to per capita or per connection water consumption, is calculated to be 359 lpcd or 58 m^3/connection/month, respectively.

Table 4.8 Macro Meter Measurement Records in some Asentamientos in 2000

Nº	ASENTAMIENTOS	POPULATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
1	ARNOLDO ALEMAN	1,890	31,200	38,859	32,925	42,281	35,085	32,000	35,697	34,513	31,553	7,972	20,402	29,405	30,991
2	NACIONES UNIDAS	1,650	2,936	3,256	3,935	4,013	12,009	11,971	12,000	12,103	12,003	10,736	10,431	10,301	8,808
3	31 DE DICIEMBRE	1,400	33,000	25,702	26,722	37,381	29,850	25,049	24,996	20,375	18,977	15,128	15,128	20,354	24,389
4	VILLA DEMOCRACIA	1,200	3,832	5,396	5,844	6,522	4,032	5,045	4,890	4,347	5,217	2,744	4,522	3,779	4,681
5	A. CESAR SANDINO	300	1,749	1,950	2,359	2,809	2,455	2,205	2,231	2,091	2,207	2,192	2,433	2,255	2,245
6	MIRNA UGARTE	1,250	13,734	10,082	13,724	18,338	16,807	12,570	9,940	9,663	13,296	5,905	9,854	8,330	11,854
7	HEROES Y M. SN. JUDA	631	-	3,860	9,069	10,937	11,313	8,815	10,214	4,947	8,554	6,107	6,806	6,745	7,281
												PER CAPITA CONSUMPTION			359

Source: ENACAL

Table 4.9 also shows the ENACAL estimates on water flows into various Asentamientos based on the past macro meter readings. Although 56 macro meters were installed most of them have

been abandoned now with lack of proper maintenance, and the program was finally cancelled in the mid of the year 2003. **Table 4.9** summarizes the past measurement recorded by ENACAL and gives similar idea that the flow equivalent to 360 lpcd or 58 m^3/connection/month was obtained on average for the listed 41 Asentamientos in Managua. In conclusion, considerable amount of water flows into the areas of some Asentamientos as a whole although there are some Asentamientos where water supply conditions are very poor. It was assumed that the flow equivalent to the volume expressed in 360 lpcd is presently allowed into Asentamientos on average.

Table 4.9 Asentamiento Water Consumption Measured by Macro Meters

ASENTAMIENTO WATER CONSUMPTION MEASURED BY MACRO METERS

SEPTIEMBRE 2003

N°	ZONE	Rout	Name of Asentamiento	DIST	Billing Information			Actual Consumption
					No. of Connections	Consumption M³/Month	Fact. C$	M³/Month
1	1	123	Anexo La Primavera	VI	794	20,679.30	43,844.88	9,937.18
2	1	134	Vallarta	VI	81	1,982.20	4,462.99	7,543.55
3	1	107-108	Julio Buitrago	II	407	10,329.40	33,772.41	42,913.99
4	2	120-131	Jorge Dimitrov	IV	1,408	37,176.90	88,397.26	219,184.38
5	2	132-135,137,(6) 132	Carlos Marx	VI	616	16,329.70	27,208.04	6,191.95
6	3	101	Nora Astorga	III	235	6,139.90	13,939.48	4,588.17
7	3	127	Daniel Chavarría	II	92	2,373.00	4,987.85	9,036.12
8	3	164	Juan E. Menocal	II	150	3,897.00	8,265.86	3,919.14
9	3	106,160	La Esperanza	III	635	16,523.50	34,897.08	5,800.21
10	3	109,114	Dinamarca	II	376	2,990.00	6,272.10	24,402.20
11	3	119,181	Marvin Marín	III	75	1,950.00	4,090.50	6,934.89
12	3	131,150	Héroes y Mártires de San Judas	III	281	6,656.00	13,962.24	1,251.29
13	3	120-122,161	Jonathan Gonzalez	III	817	21,836.60	71,120.04	26,060.30
14	3	123-126,135-137	Hialeah	III	1,767	45,940.50	95,705.59	34,348.04
15	3	145-148	Tierra Prometida	III	820	21,328.70	44,954.67	30,449.71
16	4	140	Mirna Ugarte	III	288	7,614.00	18,742.22	3,575.00
17	4	149	Colonia del MINSA	III	80	2,080.00	4,363.20	2,768.78
18	5	154	Unión Soviética	IV	301	8,063.30	28,026.13	50,329.53
19	6	142	Milagros de Dios	VI	190	4,940.00	15,564.00	6,759.54
20	6	163	Anexo J. De Veracruz	V	139	3,600.50	8,623.93	850.64
21	6	189	Pedro Arauz Palaios	VI	165	4,290.00	9,157.32	5,406.14
22	6	192	28 de Mayo	V	153	3,978.00	8,506.80	6,236.70
23	6	194	11 de Mayo	V	171	4,480.00	9,941.96	1,869.61
24	6	199	Villa Canadá	VI	158	4,108.00	8,784.80	8,570.70
25	6	167,171	Enrique Smith	V	351	9,116.60	26,787.61	229,036.21
26	6	215,216	Laureles Norte	VI	428	11,094	24,286.87	45,865.89
27	6	161,184,186,188,190	Georgino Andrade	VI	1,079	28,422.00	67,565.89	54,637.09
28	6	108-114,116-127	Arnoldo Alemán	VI	292	7,586.00	16,508.36	56,039.25
29	6	207-208	Anexo 1° de Mayo	VI	367	9,538.00	20,676.86	746.75
30	7	172	22 de Enero	V	278	7,215.00	15,640.38	8,222.84
31	7	189	Cruz del Paraiso	V	111	2,886.00	6,202.04	103.61
32	7	195	Pantanal	V	152	3,952.00	8,451.20	9,456.16
33	7	171,176,188	Pablo ubeda	V	476	12,376.00	31,478.43	20,334.36
34	7	194,196-197	Augusto C. Sandino	V	402	10,452.00	22,372.54	2,692.00
35	7	208-212	Naciones Unidas	V	631	16,406.00	35,083.60	3,388.76
36	7	220-221	30 de Mayo	V	435	11,310.00	24,186.00	11,981.94
37	9	115	B-15	VI	539	14,014.00	41,799.82	4,416.00
38	9	130	Anexo Waspan Norte	VI	279	7,254.00	16,038.85	18,995.73
39	9	100-110,235-237,240-242	Villa Reconciliación	VI	1,286	34,049.30	82,900.53	14,621.21
40	9	118-120	Waspan Norte	VI	541	14,066.00	30,205.49	64,509.09
41	9	133-135	Villa Israel	VI	426	11,076.00	23,685.60	11,582.69
			TOTAL		**18,272**	**470,099**	**1,101,461**	**1,075,557**
					Consumption per Connection		M³/Month	2.0
					Consumption per Capita		lpcd	363

Source: DEPARTAMENTO ANC COMERCIAL

4.10 EVALUATION OF THE SURVEY RESULTS AND IDENTIFICATION OF PROBLEMS

LEAKAGE LEVEL IN ENTIRE MANAGUA

In ordinal residential and commercial areas in Managua the leakage ratio was estimated at 30% based on the results of the MNF obtained from the continuous 24 hour flow measurement in the ten micro sectors. In Asentamientos, where no customer water meters are installed, the leakage ratio was estimated at 40% based on the MNF measurement carried out in Dinamarca. **The leakage ratio in the entire Managua system is then estimated at 35%** based on the proportion of connections in Asentamientos and the areas other than Asentamientos. The leakage levels of the ten micro sectors were further evaluated by the use of different indicators. These indicators are very important to set the strategic targets in leakage reduction.

Cubic meter per kilometer of mains per hour

The magnitude of leakage in the ten micro sectors was evaluated using this indicator with comparison of the criteria used in Tokyo Metropolitan Waterworks whose target leakage ratio is far less than 10%. It is evaluated as shown in **Table 4.10** that except two micro sectors, Mombacho and Lomas del Valle, the other sectors are all in need to conduct leak detection using sounding devices during midnight.

Table 4.10 Criteria for Leakage Control in terms of MNF m3/km/hr

MNF	Criteria	Recommended Actions
< 1.2CUM/HR/km	A	No action is requiured but immediate repair should be done in case leaks are reported
1.2CUM/HR/km - 3.6CUM/HR/km	B	Leak detection by sounding during midnight and immediate repair of leaks should be done.
> 3.6CUM/HR/km	C	More intensive leak detection during midnight and repir of leaks should be carried out. Replacement of pipeline where leakas are frequently observed.

Micro Sector	MNF	Evaluation
Valle Dorado	2.9	B
Los Arcos	6.6	C
Mombacho	1.1	A
Chamorro	4.7	C
Periodista	1.3	B
Belmonte	1.9	B
Lomas Del Valle	0.3	A
El Eden	1.9	B
Tiscapa	3.0	B
El Dorado	3.0	B

Liters per connection per hour

Another indicator shown in **Table 4.11** is recommended by Water Authorities Association in UK, and it is considered that this indicator fits to the urban water supply.

Table 4.11 Levels of Leakage in Large Urban Areas (Water authorities Association, UK)

Leakage control method	Areas where leakage is typically		
	Low (litter/connection/hr)	Medium (litter/connection/hr)	High (litter/connection/hr)
Passive leakage control	15	18	25
Regular sounding	8	10	14
District metering	6.5	8	11
Waste metering	5	6	8
Combined district and waste metering	5	6	8

When compared with these levels where only passive leakage control is presently conducted as shown in the **Table 4.11**, the leakage in the ten micro sectors are evaluated as shown in **Table 4.12**.

Table 4.12 Evaluation of Leakage Levels in 10 Micro Sectors

Micro Sector	MNF	Evaluation
Valle Dorado	24.0	Medium
Los Arcos	38.0	High
Mombacho	7.0	Low
Chamorro	35.0	High
Periodista	10.0	Low
Belmonte	37.0	High
Lomas Del Valle	5.0	Low
El Eden	15.0	Low
Tiscapa	27.0	High
El Dorado	26.0	High

EVALUATION OF THE EFFECTIVENESS OF LEAK DETECTION AND REPAIR WORK

The Team carried out leak detection surveys during the midnights using leak detectors and listening bars in the most aggravated three areas among the 10 micro sectors. As a result the average leakage ratio of 44% for the three micro sectors was reduced to 27%. **Figure 4.18** illustrates the reduction of leakage ratios in the three micro sectors after these works.

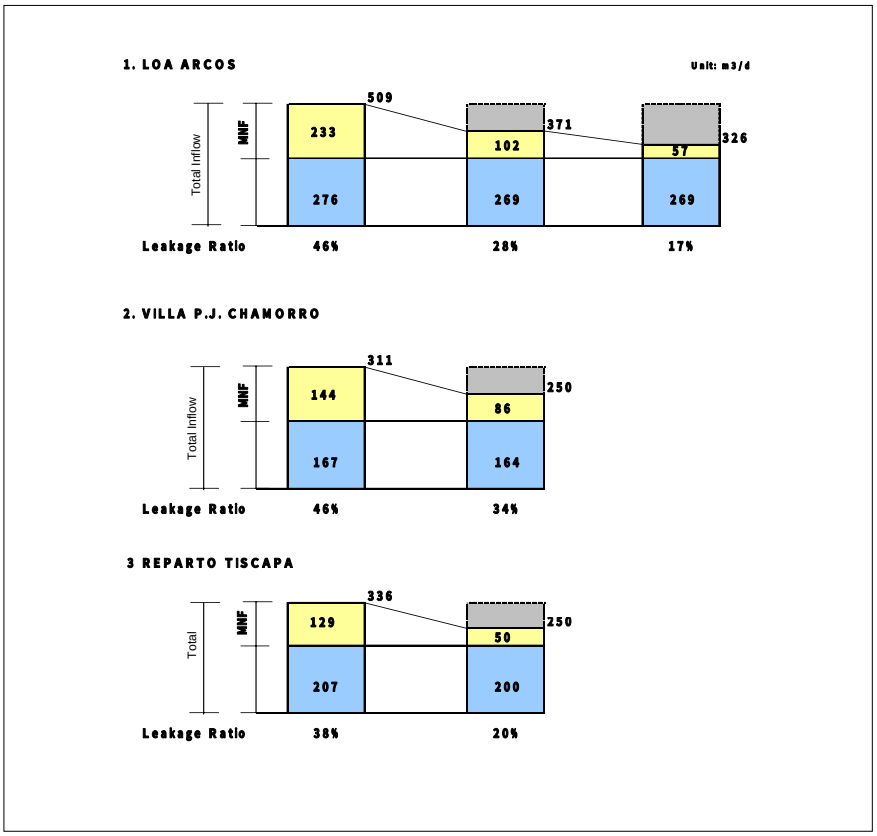


Figure 4.18 Effectiveness of Leak Detection and Repair Work in the Selected 3 Micro Sectors

Moreover, in one of the three micro sectors, Los Arcos, there was significant leakage found out in the government premises but the leaks could not be repaired during the survey. If this leakage was stopped the leakage level in Los Arcos could be reduced to 17%, and the overall average leakage ratio in the ten micro sectors could drop to 23% on average.

WASTAGE AND LEAKAGE

Wastage is defined that water, having been obtained from a source and put into a water supply and distribution system and consumers' installations, leaks or is allowed to escape or is taken therefrom for no useful purpose. Leakage is a part of the wastage as defined above. Leakage is expressed as the quantities calculated based on MNF as previously explained. Although MNF may contain a certain amount of legitimate water use where consumers who use water continuously overnight exist and wastage due to consumers' misuse of water installations during midnight **the MNF is regarded as leakage in this Study.** This is because the MNF is practically the best way to know the level of leakage quantitatively in different micro sectors.

Figure 4.19 illustrates the estimated proportions of effective water use, leakage and wastage other than leakage in ordinal residential areas and Asentamientos in Managua.

Wastage other than leakage is considerable in some areas such as Asentamientos. Comparison of the 24 hour flow measurement and MNF analysis revealed that significant amount of water is wasted both in ordinal residential areas and Asentamientos.

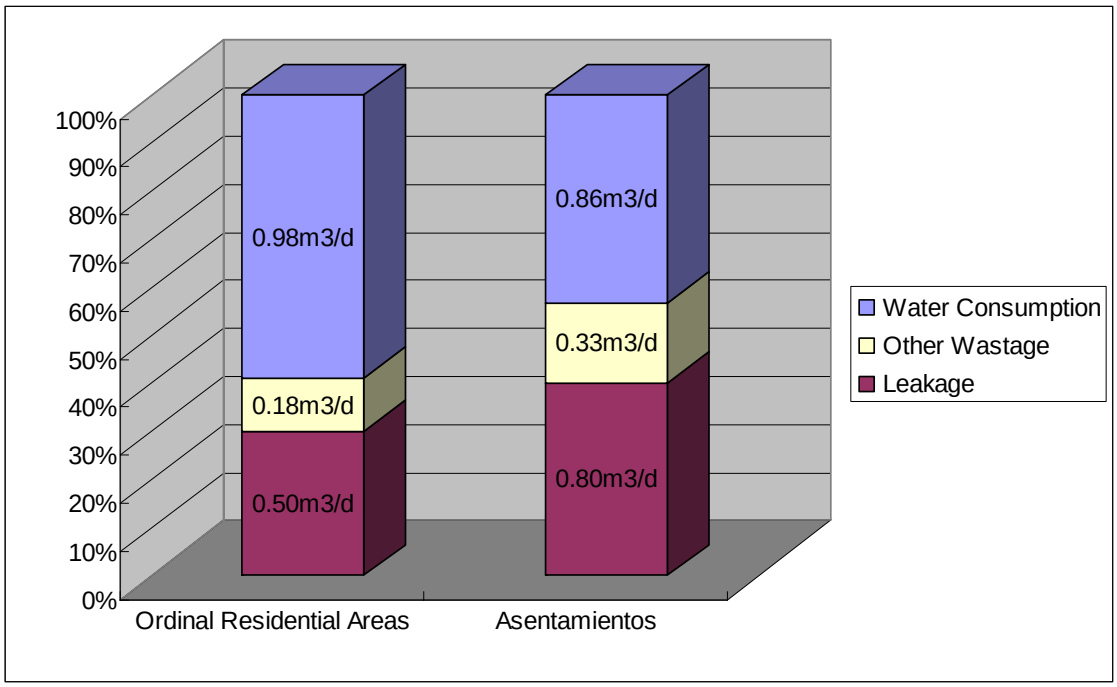


Figure 4.19 Water Consumption and Wastage per Connection in Ordinal Residential Areas and Asentamientos

The cases in Asentamientos are worse in terms of both leakage and wastage as shown **in Figure 4.19**.

Since the origin of these losses of water are different, different approaches should be adopted for control of leakage and "wastage other than leakage".

Leakage can be reduced to a certain degree by enhancing technical approach such as the combination of conventional leakage control procedures widely known as regular sounding and waste metering (micro sectoring).

In contrast, it is necessary to adopt an integrated strategy to reduce the "wastage other than leakage". This is because such wastage is a water loss not originated from technical problems but requires the control at the demand side. Such loss is derived from the consumers' intentional or unintentional misuse of water, poor awareness of water conservation, no incentive for saving water under the fixed flat water charge, social and political circumstance to allow illegal water use.

ESTIMATED PER CAPITA CONSUMPTIONS

The results of continuous 24 hour flow measurement survey also provided the useful information on the present water consumption**. Figure 4.20** summaries the water consumptions in each micro sector obtained from the analysis of the 24 hour flow and MNF. For this analysis all the consumption of major non-domestic customers are deducted from the flow data to obtain the domestic customers' consumptions more accurately.

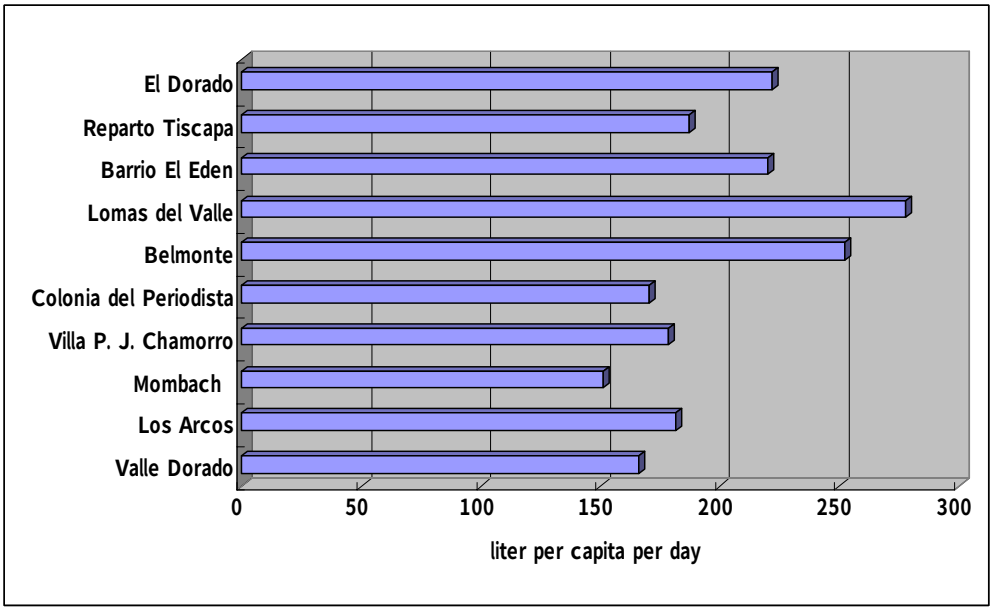


Figure 4.20 Per Capita Consumption in 10 Micro Sectors

Per capita consumptions vary within the range of 151 to 278 lpcd depending on the customers' life styles probably related to their income levels in the different micro sectors surveyed.

Categorizing the micro sectors into "High Income" and "Medium Income" brackets the following per capita consumptions were set forth at the different income levels:

High Income Customers:	260 lpcd
Medium Income Customers:	175 lpcd

Of the customers in Asentamientos where those are categorized into "Low Income" bracket, if 160 lpcd, which is the figure adopted by ENCAL to bill to the customers in Asentamiento**, the average per capita consumption for all the domestic customers in the entire Managua is estimated at 175 lpcd** as shown in **Table 4.13**.

Table 4.13 Results of Per Capita Consumption Analysis in Different Income Levels

High Income User:	Lomas del Valle & Belmonte & El Dorado		
	No. of Connex.	nos.	741
	Water Consumption	m3/d	1020.41
	Per Capita Per Day	lpcd	255

	No. of Connex.	Average lpcd
High income	11515	175
Middle income	96158	
Low income	55934	
Total	163607	

Middle Income User:	V. Dorado, Los Arcos, Mombacho, Chamoro, Periodista, El Eden, Tiscapa		
	No. of Connex.	nos.	1206
	Water Consumption	m3/d	1,137
	Per Capita Per Day	lpcd	175

Asentamient User:	Estimated		
	No. of Connex.	nos.	
	Water Consumption	m3/d	
	Per Capita Per Day	lpcd	160

PRESENT WATER USE ESTEMATED IN ENTIRE MANAGUA

Present water use in the entire Managua system was estimated based on the information obtained by this Leakage Survey, production records and customer information.

As it was presumed 100% of the population in Managua are presently dependent on the ENACAL's water supply system, water produced from water sources is assumed to be demarcated as shown in **Figure 4.21**. Water users in Managua can be categorized into the four types, ordinal domestic users who are mainly categorized in medium or high income bracket in the water tariff structure, Asentamiento users, non-domestic users and other users not registered or suspended users.

Figure 4.21 illustrates how the water produced is presently demarcated to these different types of users on the basis of annual production of the year 2003. From the analysis shown in this Figure the following key indicators are suggested:

- **Wastage Level including leakage and wastage derived from consumers' misuse and excessive use is estimated at 45% in the entire system of Managua.**
- **Leakage Level in the entire system of Managua is estimated at 35%.**

PRIORITY ZONE FOR LEAKAGE ABATEMENT

There is a tendency that leakage level is the highest in Zona Baja. The first priority should be placed on this zone for leakage abatement.

EFFECTIVENESS OF PROACTIVE LEAKAGE CONTROL

Establishing micro sectors and carrying out MNF measurement are effective measures to select the priority areas to be targeted for leakage reduction. Moreover, the results of the Leakage Survey proved that leak detection by using leak detectors succeeded by immediate repair of leaks found out is very effective to reduce the leakage to a satisfactory level.

NEED OF DIFFERENT APPROACHES FOR ASENTAMIENTOS ON WASTAGE REDUCTION

More than 30% of Managua population are living in so-called "Asentamientos", where ENACAL has applied different billing policy to collect water charges from those who are living in Asentamientos.

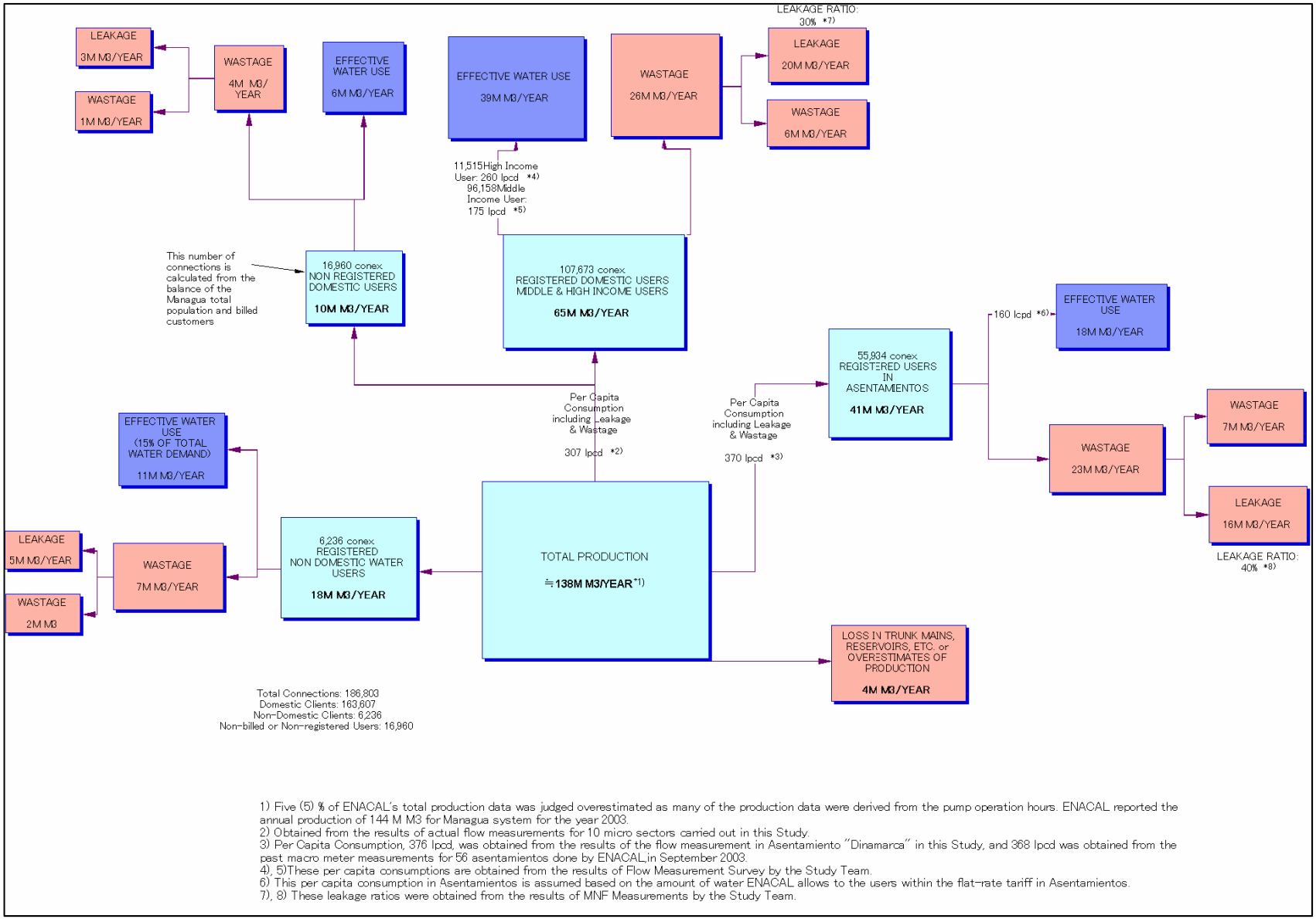


Figure 4.21 Present Water Use in Managua

Separate approaches should be applied for the Asentamientos and the area other than Asentamientos since the present situation in Asentamientos are quite different from those out of Asentamientos as shown in **Table 4.14**.

Table 4.14 Major Water Related Situations in and out of Asentamientos

Items	Asentamientos	Out of Asentamientos
No. of Connections	Approx. 56,000	Approx. 130,000
Income Level	Majority belongs to low income bracket.	Majority belongs to medium and high income brackets.
Water Meters	Without meters	With meters
Water Tariff	Flat-rate	Metered rate
Estimated Wastage	17%	11%
Estimated Leakage	40%	30%
Water Supply	Water supply conditions vary area to area. Asentamientos can be categorized into three types: Type A: Good Supply Type B: Fair Supply Type C: Poor or No Supply	Water supply conditions are fairly good with sufficient water pressure except the areas as identified in the **Supporting Report No. 5**.
Sanitation	No sewer system in some Asentamientos	Sewer system is provided in most areas
Land Ownership	Some are informal or under process of legalization.	formal
Per Capita consumption* calculated from MNF (lpcd)	230	151 – 222

Note: * Calculated as (Total Inflow – MNF)/Population

It is indicative that from the comparison of per capita consumptions between customers in medium income bracket and customers in Asentamientos. As seen in **Table 4.14** per capita consumptions in micro sectors categorized in medium income bracket ranges from 151 lpcd to 222 lpcd. Whereas, the per capita consumption in one of the Asentamientos, Dinamarca, showed high per capita consumption of 230 lpcd. Even though there are many Asentamientos with poor or no water supply there are huge consumption in some Asentamientos where water supply conditions are fair or good.

Water supply to Asentamientos is, thus, a very big issue from both view points of wastage control and water supply and sanitation improvement for the urban poor in Managua. ENACAL is, however, presently in lack of information on the actual situation of Asentamientos to formulate strategic improvement plans. Further discussion is made in **Section 4.12**.

4.11 DISCUSSION ON WASTAGE REDUCTION IN ORDINARY RESIDENTIAL AND COMERCIAL AREAS

4.11.1 Reduction of Leakage by Proactive Leakage Control

The results of the Leakage Survey suggested that the present reactive leakage control can not reduce the leakage level further down below the present level, and ENACAL should shift to conduct the proactive leakage control by introducing the use of leak detection technique with listening devices in conjunction with MNF measurements.

In order to materialize this plan of the proactive leakage control the following works are recommended:

1) Definition of Micro Sectors

The existing micro sector drawings and relevant information are outdated. Micro sectors should be redefined by conducting field confirmation works for isolation of micro sectors. Locating boundary valves and citing pits or chambers for installation of flow meters are very important. Each micro sector may contain 500 – 1, 000 connections sometimes up to 3,000 connections depending on the site conditions.

2) Minimum Night Flow Measurement

As proven in the Leakage Survey results measuring the MNF is very important to set the priorities among the micro sectors for strategic leakage abatement implementation plan. The MNF also provide the information on effectiveness of the work to be input into the micro sectors.

It is also necessary to repeat MNF measurement periodically monthly, quarterly, or once or twice in year to confirm that the leakage levels in the sectors.

3) Identification of Priority Micro Sector

Among the three different elevation zones the Zona Baja showed the highest average leakage ratio. It is recommended to tackle first those micro sectors in the Zona Baja that have higher leakage ratios obtained from the analysis of the MNF measurements.

4) Leak Detection with listening instruments during Midnight

The experiences in the selected three micro sectors in the Leakage Survey showed leak detection during midnight was effective to locate underground leaks. By picking up the sound on each consumers' connections it is also possible to identify the leakage occurring after the meters in the customers' houses or premises. Such suspected customer's side leakage can be confirmed by visiting these customers next day.

5) Immediate Repair of Leaks and Appraisal of Leakage Levels after the Repair

Immediate leak repair should be done after pinpointing the leaking points by the repair team organized separately from the existing leak routine repair teams of the Depto. de Agua Potable although the cooperation between the two is very important.

6) Resources Required for Implementing the Plan

A special unit, that exclusively works for the above works for leakage abatement including MNF measurement, leak detection and leak repair should be organized. The Team would propose to set up **Leakage Abatement Unit (LAU)** which works specifically for the following tasks:

Micro Sectoring, MNF, Leak Detection and Evaluation: 4 workers
Leak Repair: 4 workers

From the experience of the Field Leakage Survey time required for the series of micro sectoring, MNF measurement, leak detection and the evaluation is approximately one month for one micro sector as indicated in **Figure 4.22**.

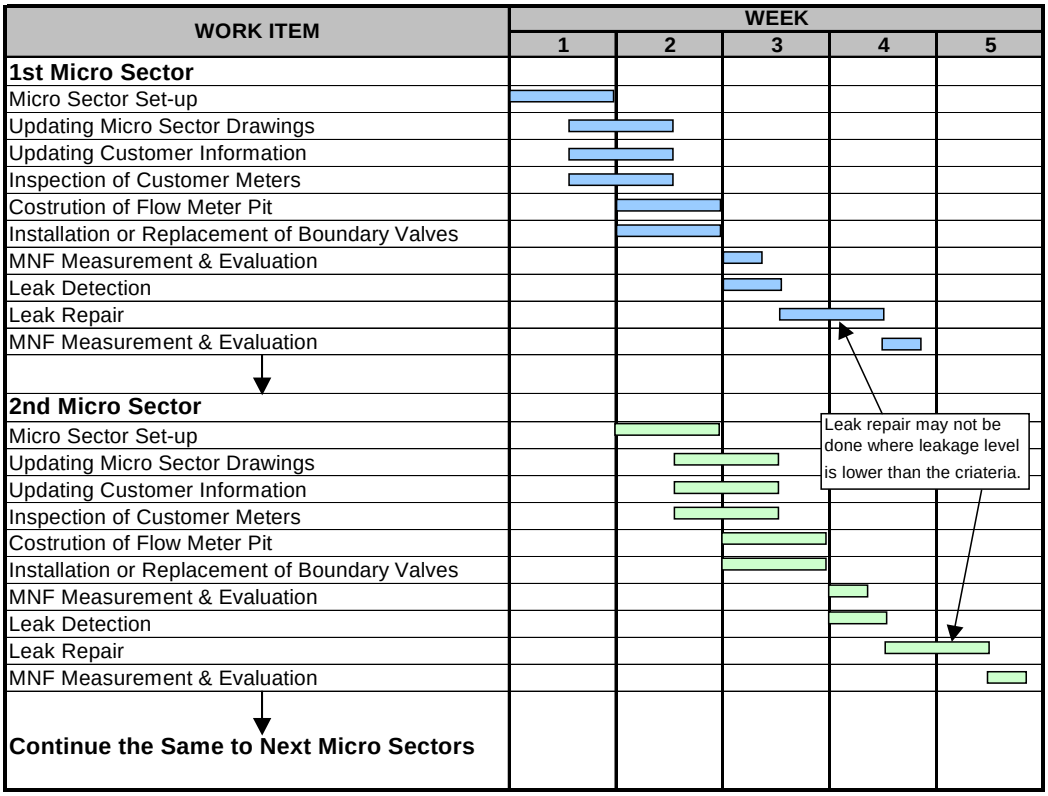


Figure 4.22 Typical Work Schedule of Leakage Survey

4.11.2 Reduction of Wastage Other Than Leakage

Large part of wastage other than leakage is derived from uncontrolled water use thorough normal outlets of users who are illegally connected or customers adopted with flat-rate water charges due to the various meter problems. Those users are generally careless for wasteful waster use. This is because incentives on water conservation at the demand side do not work against such connections. Accordingly, the possible approach to reduce "wastage other than leakage" is to control these users.

1) Control of Illegal Users

According to the Leakage Survey results approximately 9% of the total connections are illegal.

There are two types of illegal users, namely:

A) The registered customers illegally bypass their water meters or install another pipe directly from mains.
B) Those who were ex-customers of ENACAL but whose arrears accumulated for long time are disconnected by ENCAL as a penalty. But these users connect the disconnected service lines again illegally without settling their bills..

According to the ENACAL's customer definition "suspended customers" are defined to be those who do not settle their bills for a certain period of time, and ENACAL takes the following 3 step measures against such users until they start to pay the bills during 6 months:

1st Step: ENACAL closes the cock valves for supply lines.
2nd Step: ENACAL removes the water meters if the users continue to use water supply

without payment.

3rd Step: ENACAL removes the supply lines if the users made direct connections.

After repeating such measures suspended customers are registered as “Inactive” if they still do not pay or request to terminate the water supply contract with ENACAL.

In most cases there are some conflicts between these users and ENACAL regarding water bills, meter reading, and the level of services. Even though ENACAL disconnects the supply lines as a measure for the penalty against such users and register them as “inactive” customers these users commit again illegal connections very soon. In the NRW survey ENACAL cut the 21 service connections but the results indicated only three users came to ENACAL to arrange their payments. This approach of cutting service lines does not seem very effective. What is worse, the relationship between ENACAL and customers deteriorates and such accidents as violence on ENACAL staff by users sometimes happen.

The Team would propose to take the following steps against illegal users:

- House to house survey during regular sounding in collaboration with Leakage Abatement Unit (LAU)
- Explanation on strict penalties against illegal use to those suspected illegal users
- Declare amnesty period.
- Register the illegal users who declared
- Disconnect the illegal connections
- Impose penalties on continuous illegal users and name/shame such vicious non-declared illegal users
- Facilitate new connections using payment options of new connection charges for the poor users if such poor illegal users exist.

The Team would propose to set up a unit, **Illegal Connection Control Unit (ICCU)**, which specifically works against illegal connection control. It is a prerequisite condition to expedite this work that this ICCU should be vested with strong authorities given in the new water regulations.

2) Replacement and Calibration of Customer Meters

According to the leakage survey results at least 16% of the existing customer meters are defective. Considering that the majority of the existing meters (estimated as 65% of the total) are already of age of more than 10 years. These meters are to be replaced with new meters. The project by Spanish Government **(See Section 2.2 of Main Report**) will includes procurement of 100,000 water meters. These meters are to be utilized effectively to improve the present situation.

Since the good condition of customer meters is the first step to recover customers’ credit on ENACAL’s water bills. During the field survey many customers complain of their bills because they don’t believe the consumption records written on their bills. The reasons are very clear that:

- Customers don’t believe that their meters are correctly read by ENACAL meter readers,
- Meters are malfunctioning and they don’t register consumption correctly, and

In order to improve this situation the following work will be required:

- Calibration check of all the existing customer meters by means of using portable

calibration standard meters at site,

- Replacement of defective meters. This work should be intensively done to demonstrate the changing attitude of ENACAL on billing policy (Internal leakage should be also identified during this work),
- Relocation of existing meters which are installed under the aggravated situation or inaccessible conditions, and
- Introduction of spot billing.

The Team would recommend that the locations of the existing customers should be shifted from the outside to the inside of the customers' premises, provided that the regulatory revision is made to transfer the responsibility from ENACAL to customers to keep customer meters good to read.

The Team would also propose to introduce spot billing. The "spot billing" means that meter readers who read the customer meters issue the bills to the customers immediately at the site. The benefit is that the meter readers can show the amount of consumption to be billed to customers or customers can check their billed consumption immediately, vice versa. It is expected that spot billing creates good opportunities to make dialog between ENACAL staff and the customers, and to foster the customers' reliance on ENACAL.

It is also important to inspect leakage inside customers' premises. Leakage inside customers' premises beyond their water meters is a responsibility of the customers. The customers, however, do not know how to locate leaks and sometimes are not aware of underground leakage for a long time. On the occasion of the meter replacement ENACAL staff should check the internal leakage. This can be done very easily after replacing the water meters, that is, "Close all the taps, and check the new water meter".

4.12 DISCUSSION ON WASTAGE REDUCTION IN ASENTAMIENTOS

There exist different types of Asentamientos in terms of present water supply conditions, that could fall into three types as defined in **Supporting Report No. 10**. People in Type A and Type B Asentamientos are enjoying good or fair water supply, but Type C is suffering from a lack of water supply. In view of wastage control Type A and Type B Asentamientos should be targeted as considerable wastage is suspected in most of these Asentamientos. However, for Type C Asentamientos, the lack of both water supply and sanitation facilities is a crucial problem.

As discussed in **Section 4.10** wastage occurring in Asentamientos is worse than that in other residential areas in quantity. Major reason seems that the water tariff adopted to the users in Asentamientos is flat-rate, and people use water abundantly specially in the Asentamientos located in Zona Baja where water pressure is generally good. Regardless of water consumption people in Asentamientos are simply billed by the fixed tariff such as C$55.6/month for water supply.

Moreover, the following social conditions are making more difficult the solution of wastage control in Asentamientos:

- Majority of users in Asentamientos belongs to low income bracket. There are many vulnerable poor people who cannot afford to pay new connection charges. Eventually, these people commit illegal connections to get daily water.
- There is an social and political atmosphere that water supply is free of charge.
- Water supply and sanitation conditions differ largely among Asentamientos. People in Type C Asentamientos are always complaint of that they have been left behind the

ENACAL's services for a long period of time.

It would be necessary to adopt a comprehensive approach technically and socially acceptable to the communities in each Asentamientos in order to address such issues.

Of the wastage control in Asentamientos, the Team would propose that the key of the approach is to introduce water meter. It is, however, paramount important how to motivate people in Asentamientos to have water meters. Furthermore, different approaches should be considered after evaluating the present water supply conditions in Asentamientos.

Another big issue of water supply in Asentamientos is serous water shortage in Type C Asentamientos. There are many vulnerable water users left behind the water supply schemes. Construction of water supply facilities to provide water to these Asentamientos is the first priority but it is also important to take a necessary measure simultaneously to avoid future wastage as well as illegal connections.

In this context the Team would propose to conduct pilot projects for the following three different types of Asentamientos in order to appraise proposed approaches.

Table 4.15 Types of Asentamientos by Water Supply Conditions

	Type A	Type B	Type C
No. of Asentamientos	82	31	53
Water Supply Condition	good	irregular	Poor or no
Sewer system	Mostly available	Fair or less	non
Water Wastage	Very high	fair	negligible

Note: The above categorization is tentative as presently the information of Asentamientos is scarce.

4.12.1 Needs for Asentamientos Data Base

Before going deeply into each Asentamiento, it is necessary to collect information to categorize the Asentamientos by evaluating existing water supply conditions, available supply sources to each Asentamiento, availability of water mains, availability of sewer system, and other necessary prerequisite conditions to provide water supply from the technical view points.

In addition, information on social aspects including the existence of community organizations, legalization status of the settlement, land ownership, people's needs on water and sanitation, etc. should be collected.

Based on the above information collected categorization of Asentamientos and priorities for improvement should be evaluated in line with the implementation schedule of the entire Managua transmission and distribution system improvement proposed by this Improvement Plan.

4.12.2 Implementation of Pilot Projects

The objectives of the pilot projects are to formulate the optional approach to appraise the following
methodology.

<u>Type A Asentamientos:</u>
These Asentamientos are major targets of wastage reduction. Pilot project will evaluate the following points:

- Introduction of water meters together with special tariff application,

- Effectiveness of wastage reduction by introduction of water meters, and
- Community education and wastage reduction campaign.

Type B Asentamientos:
Pilot project will examine the following points:

- Participatory approach to appraise the needs of community for improvement,
- Introduction of water meters together with special tariff application,
- Effectiveness of wastage reduction by introduction of water meters, and
- Community education and wastage reduction campaign.

Type C Asentmamientos:
These Asentamientos are in lack of water supply facilities.

- Participatory approach to appraise the needs of community for improvement,
- Introduction of water meters together with special tariff application,
- Effectiveness of wastage reduction by introduction of water meters, and
- Community education and wastage reduction campaign.

4.12.3 Asentamientos Improvement Program

Based on the outputs from the pilot projects, different approaches to different types of Asentamientos will be evaluated. Important is that each improvement work to be identified in each Asentamiento should be carefully formulated taking into account the people's needs and consents to the proposed work. In this context the Team would strongly recommend to apply community participatory approaches at the earlier stage of the program involving the community for the planning of the improvement works.

The Team would propose that ENACAL should establish a special unit, Asentamiento Improvement Program Unit (AIPU), that can specifically handle all the issues related to water supply and sanitation system in Asentamientos by modifying and strengthening the capacity of the present department, Mejoras de Barrios. Moreover, each improvement work would be formulated and implemented with the help of NGOs and Consultants for technical and social aspects.

The issues on water supply in Asentamientos are very important from the both view points of water resource conservation for the Managua water supply and alleviation of serious water shortage for the urban poor in Managua. Asentamientos Improvement Program aims to tackle these two important issues.

4.12.4 Organizational Rearrangement in Related Departments

Presently different departments are acting for addressing the problems related to Asentamientos. "ANC Comerciál" and "Mejoras de Barrios" in Comerciál Department are major actors. The Team recommends that a special unit, **Asentamientos Improvement Program Unit (AIPU)** should be established to handle the two different major problems concurrently, poor water supply in some Asentamientos and considerable wastage in other Asentamientos.

The AIPU will work together with communities in Asentamientos as well as facilitators for planning and implementing the programs such as consultants and NGOs. The Team recommend to deploy care takers who will have responsibilities to monitor water use, wastage reduction and tariff collection and educate the people in Asentamientos.

4.13 TARGETS FOR REDUCING LEVEL OF WASTAGE

The Team would recommend to set the target for reducing the present level of wastage, 45%, to the level of 25% by the year 2015. Among 45% of wastage, leakage contributes to 35% and wastage other than leakage contributes to 10%, and these levels would be recommended to reduce to 23% and 2%, respectively.

Benefits accrued from reducing wastage is of significance such as deferment of expenditure on capital works, namely, the development of new water sources. It is critical in Managua to reduce the leakage as the potentiality of further development of groundwater resources available nearby Managua has become very low.

The target level of leakage reduction to 23% is judged practically achievable from the experiences of the Leakage Survey. **Table 4.16** gives the criteria expressed in different indicators, and these two criteria values are within the moderate levels when compared with the values previously shown in **Table 4.10** and **Table 4.11**.

Table 4.16 Indicators of Leakage Levels in Managua and Recommended Provisional Criteria for Managua Water Supply

Indicators	Present Level		Recommended Provisional Criteria
	Other than Asentamientos	Asentamientos	
Liters per connection per hour	22	34	<13
Cubic meter per kilometer of main per hour	2.5	4.6	<1.8

The Team would propose the indicator expressed as “Liters per connection per hour” be employed for the future leakage control as this represents more likely the magnitude of leakage in urban areas such as Managua rather than “liters per kilometer of main per hour” that is usually adopted for rural areas in many cases.

Of the wastage other than leakage it would be theoretically possible to set the target level at 0% if the recommended procedures explained in this Report are completed. However, it would be set to be 2% considering practical allowance.

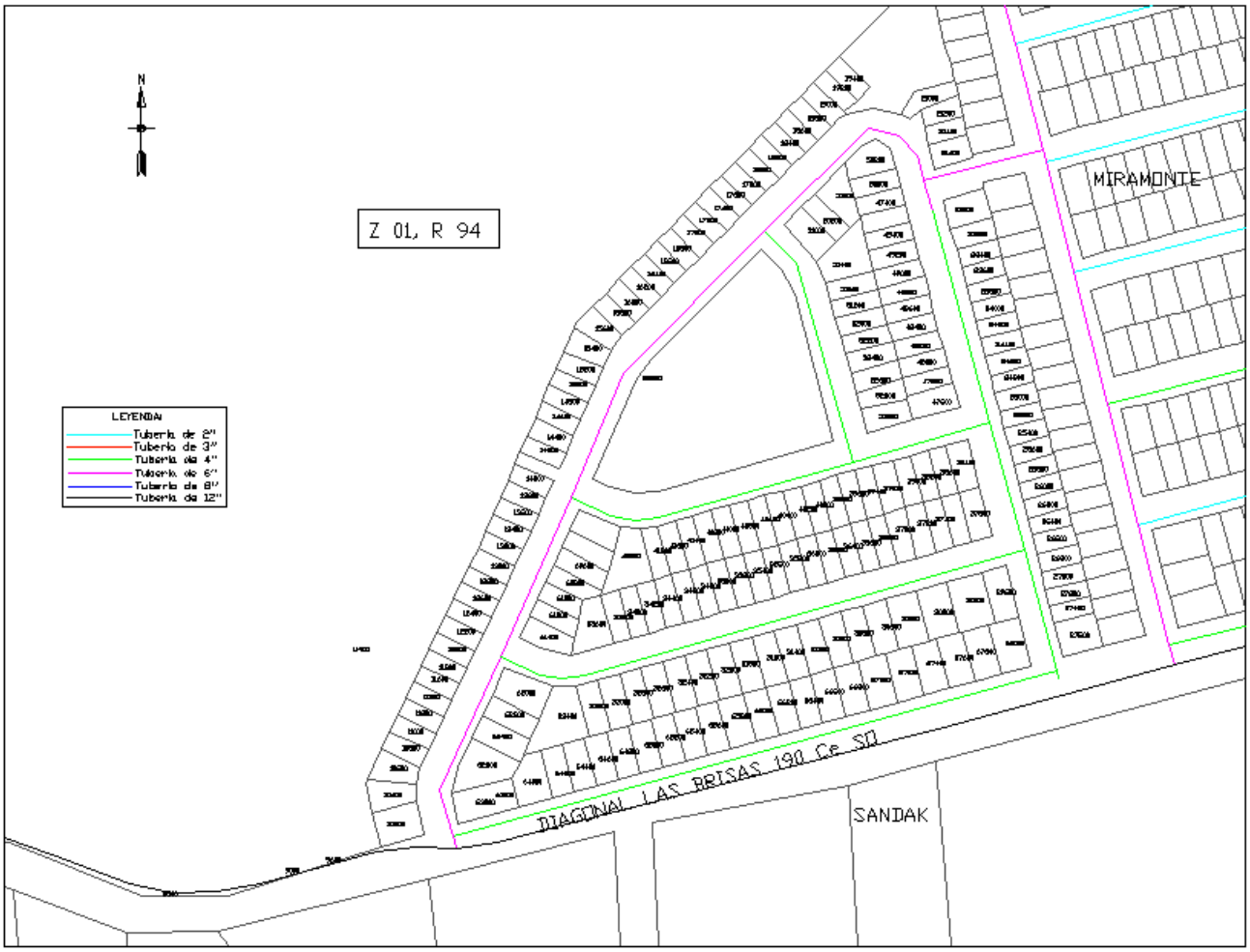
ANNEX 4A

Maps of Ten Micro Sectors Selected for Leakage Survey

ANNEX 4A MAPS OF SELECTED TEN MICRO SECOTRS FOR LEAKAGE SURVEY

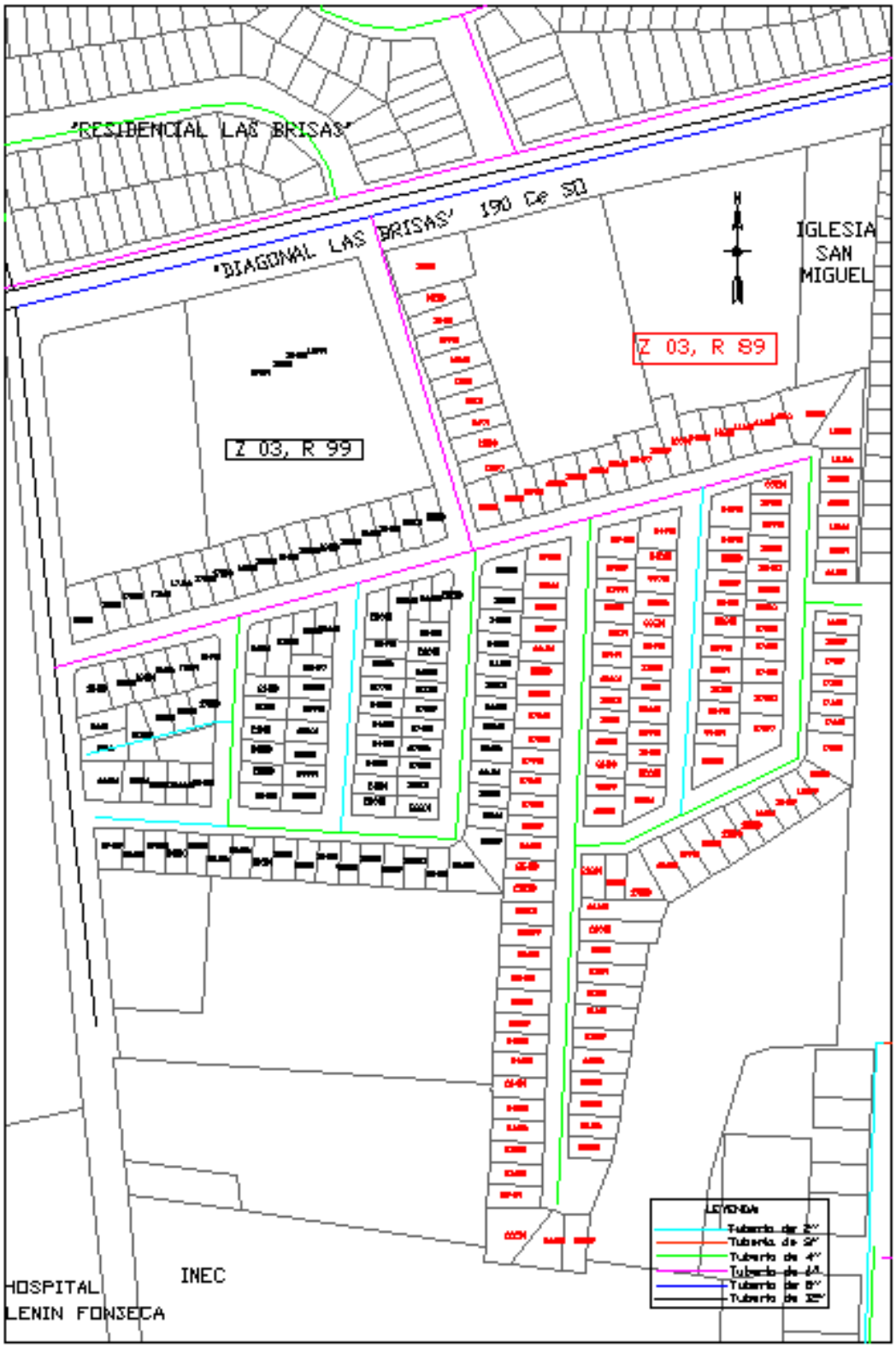
1. Valle Dorado
2. Los Arcos
3. Mombacho
4. Villa P. J. Chamorro
5. Colonia del periodista
6. Belmonte
7. Lomas del Valle
8. Barrio el Eden
9. Reparto Tiscapa
10. El Dorado

1.- Valle Dorado



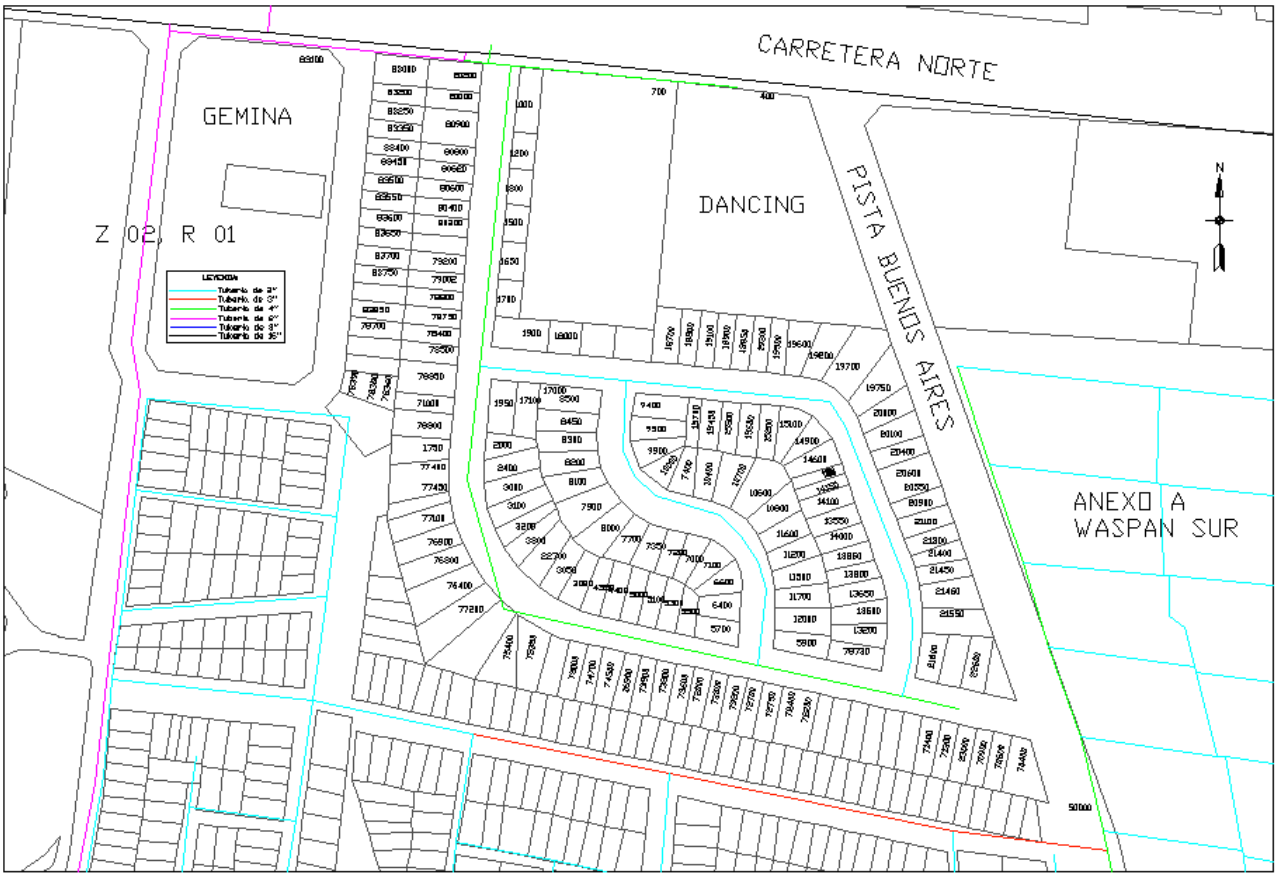
Not to Scale

2.- Los Arcos



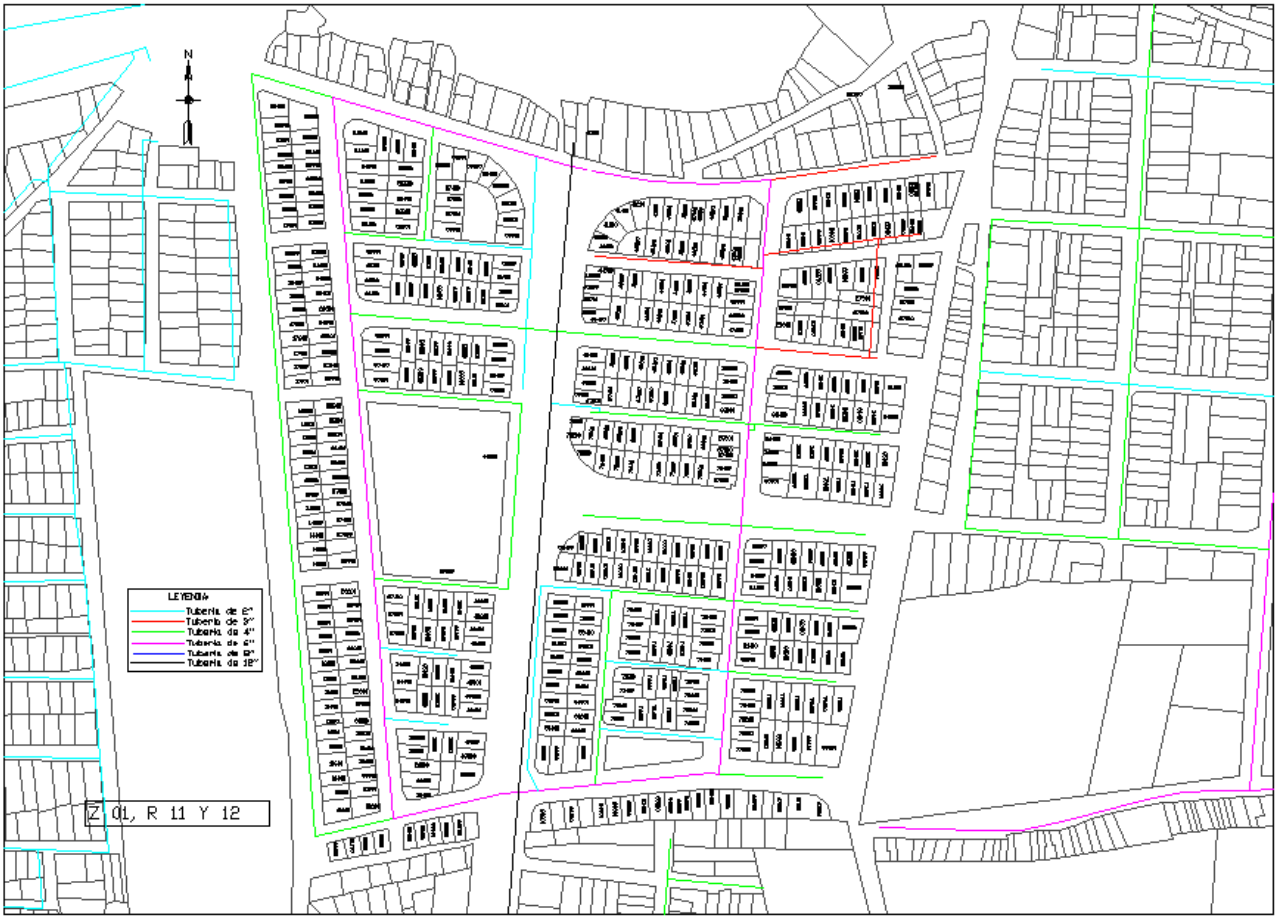
Not to Scale

3.- Reparto Mombacho



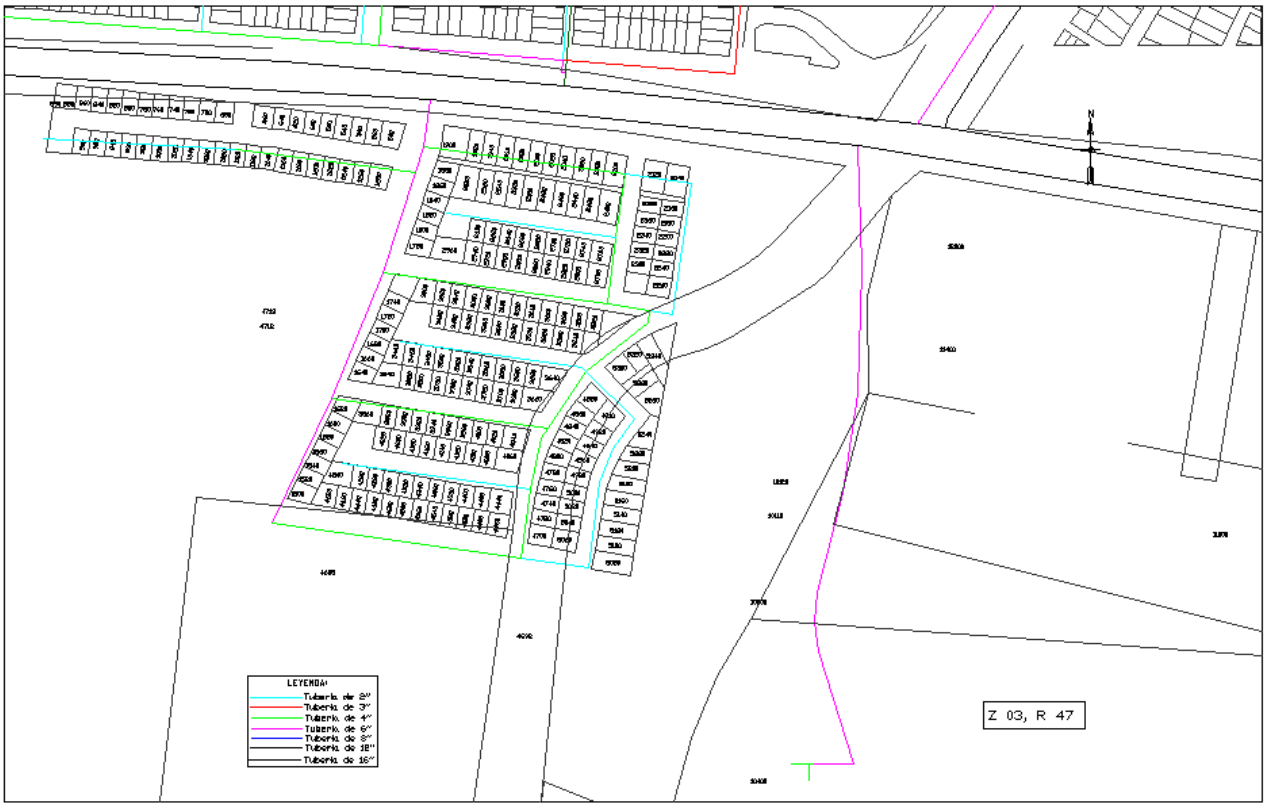
Not to Scale

4.- Villa PJ Chamorro



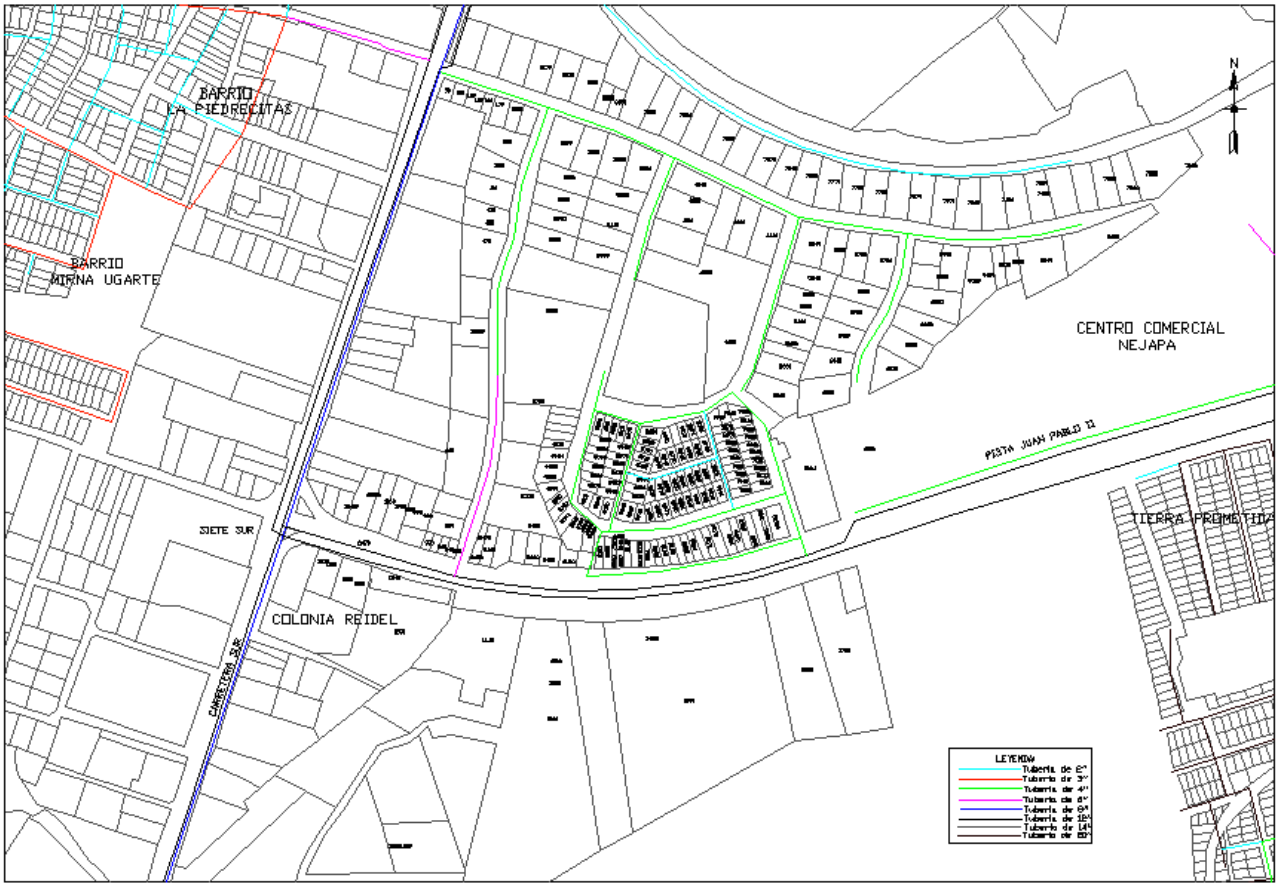
Not to Scale

5.- Colonia El Periodista



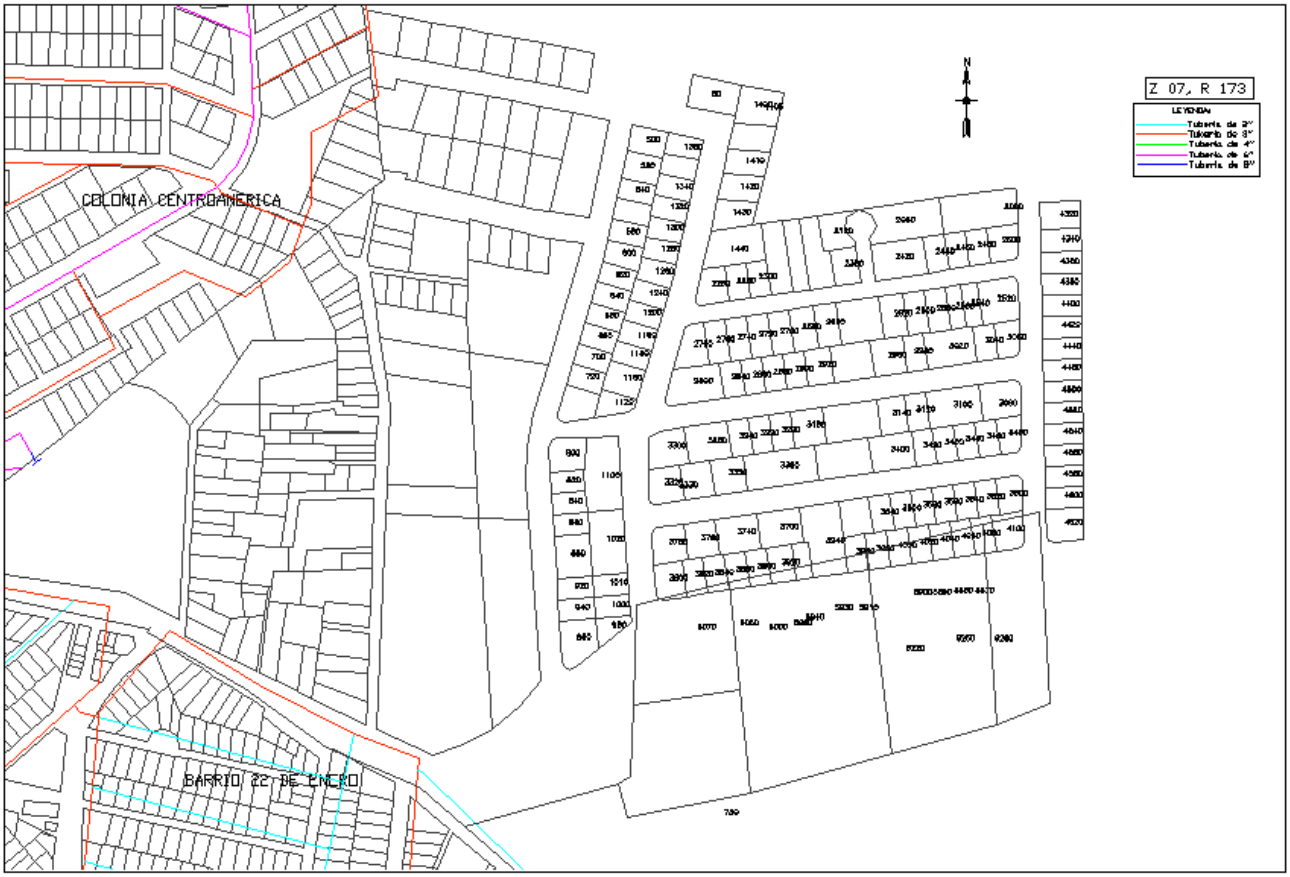
Not to Scale

6.- Reparto Belmonte



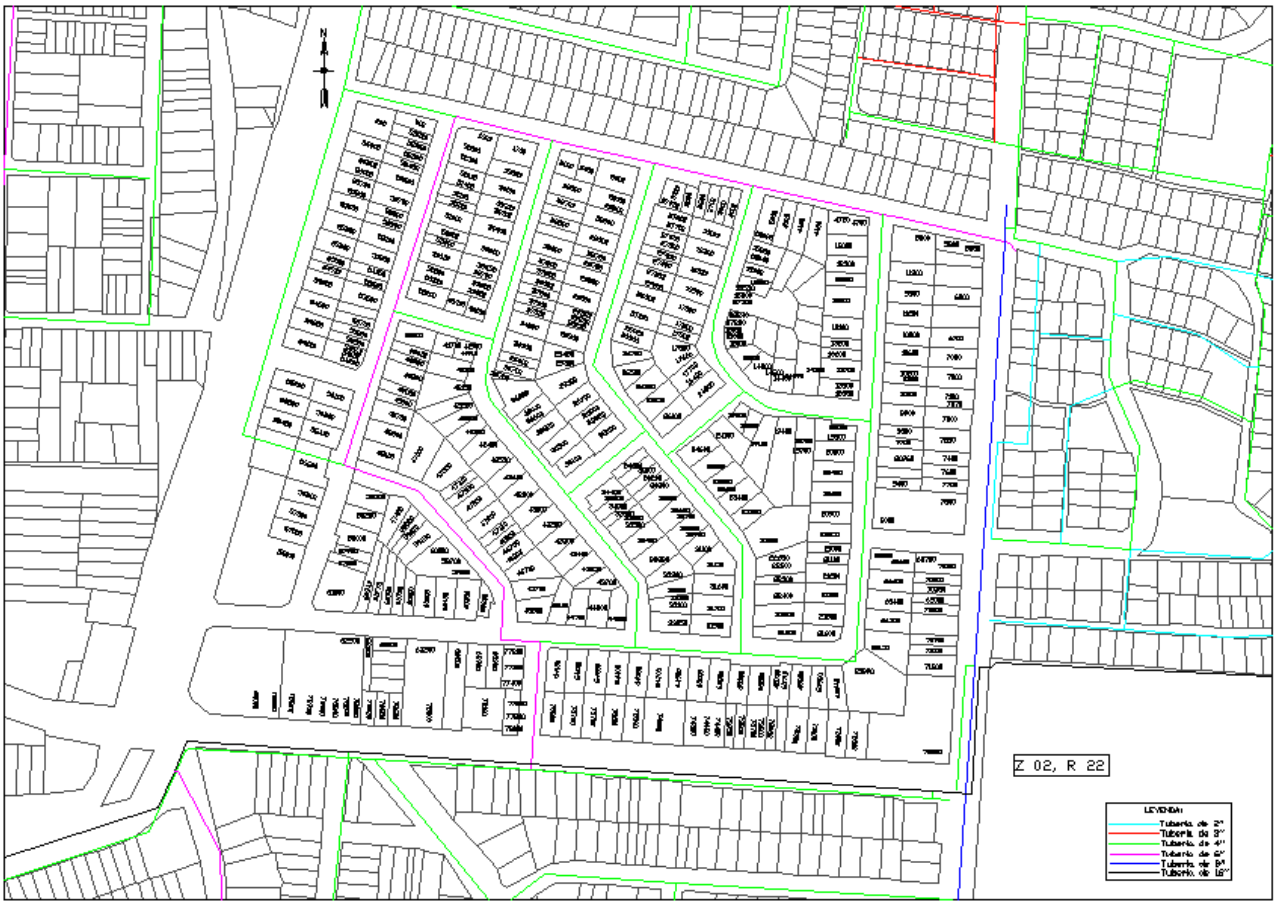
Not to Scale

7.- Reparto Lomas Del Valle



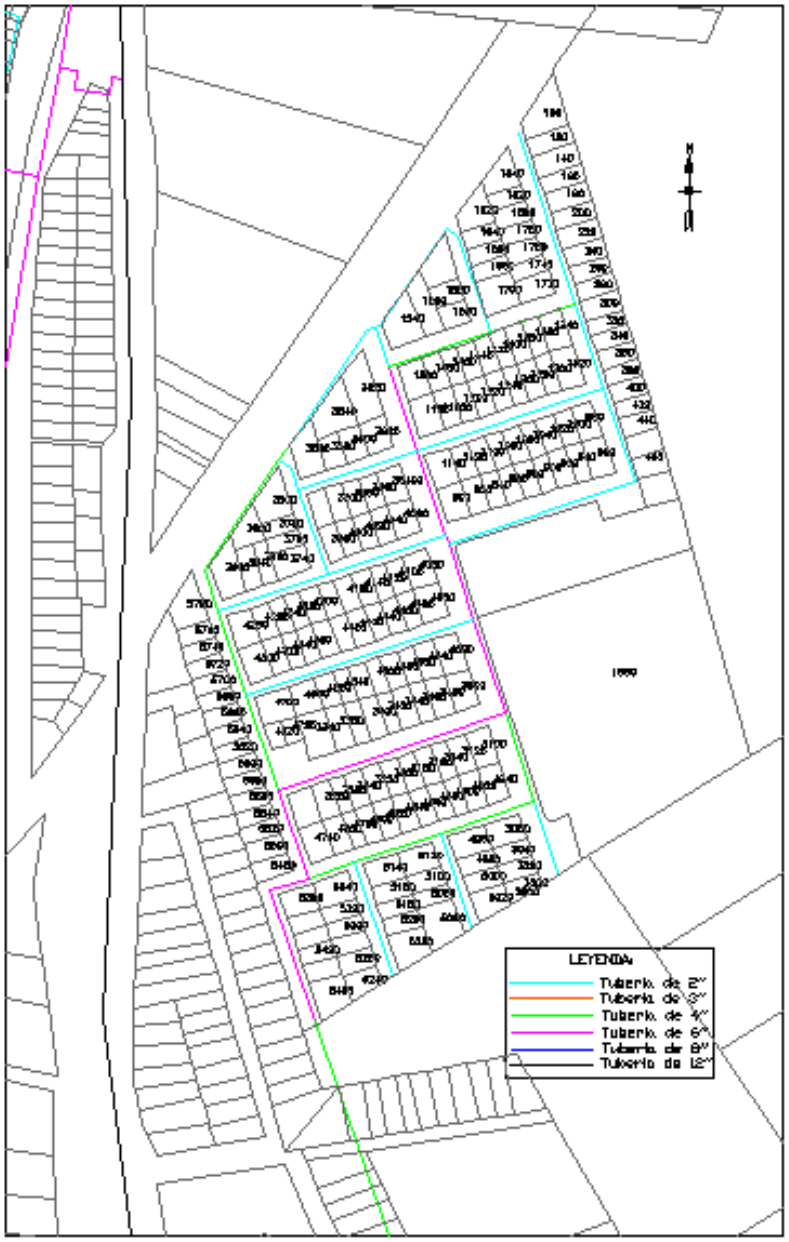
Not to Scale

8.- El Edén



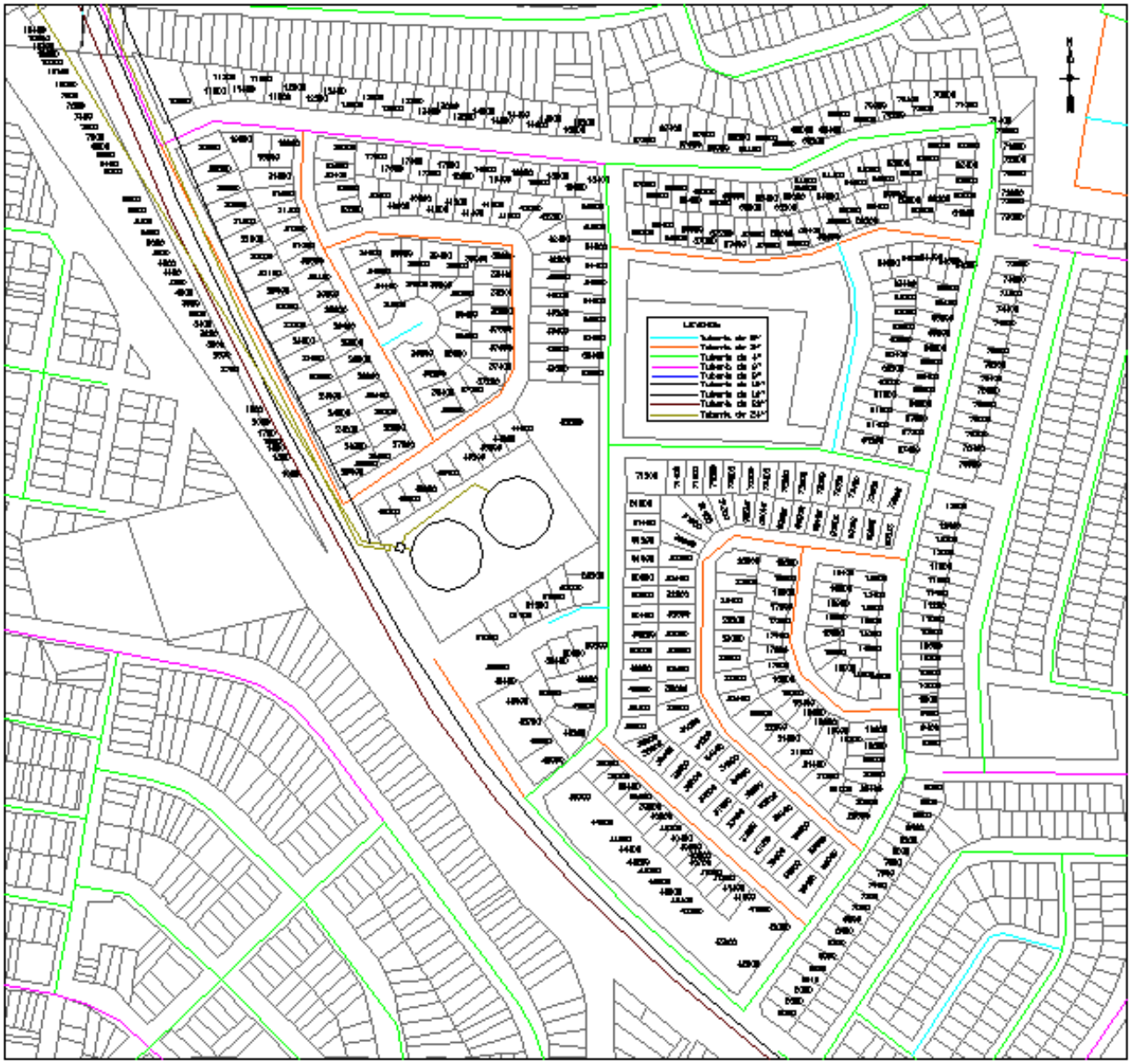
Not to Scale

9.- Villa Tiscapa



Not to Scale

10-. Residencial El Dorado



Not to Scale

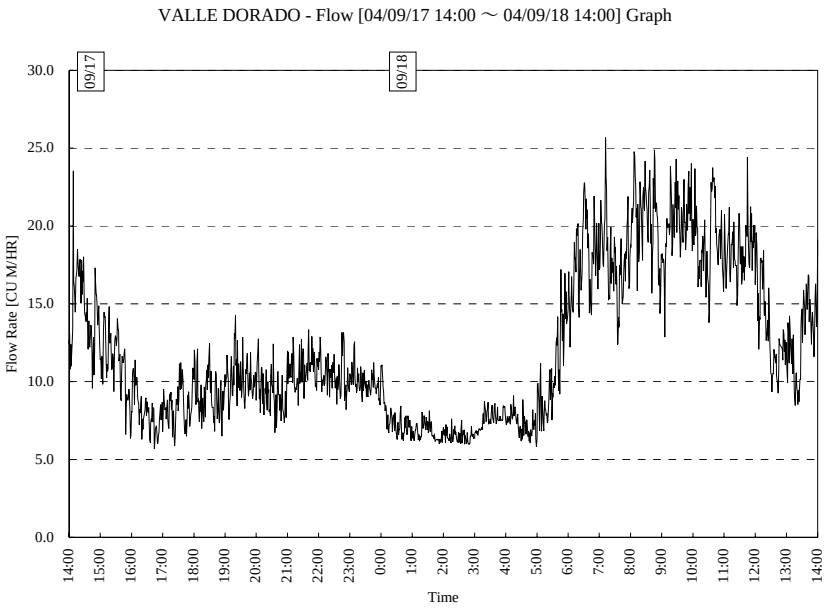
ANNEX 4B

Continuous 24-hour Flow and Pressure Measurements in Micro Sectors

ANNEX 4B CONTINUOUS 24-HOUR FLOW AND PRESSURE MEASUREMENTS IN MICRO SECTORS

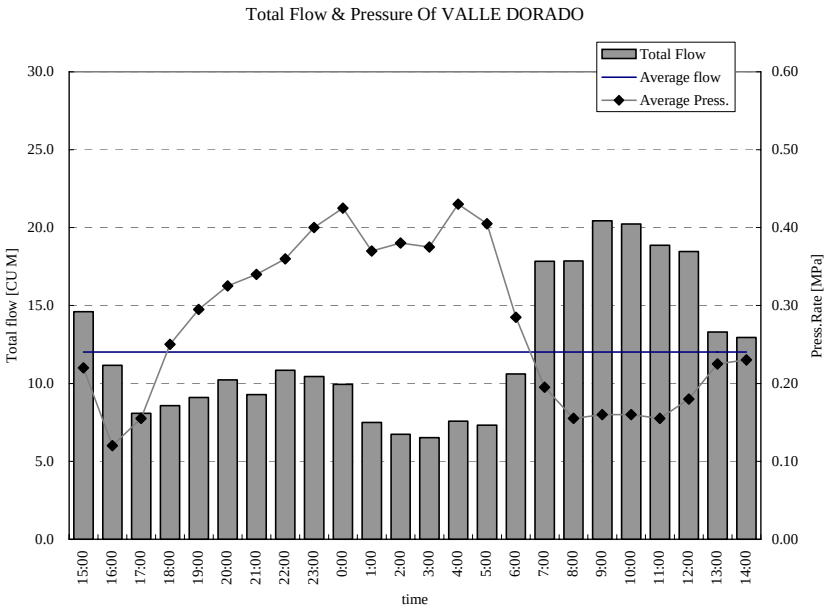
1. Micro Sector - Valle Dorado

Micro Sector		
VALLE DORADO		
Max.		
2004/09/18	07:12:00	
25.686	CU M/HR	
Min.		
2004/09/18	04:59:00	
5.817	CU M/HR	
Average.		
12.014	CU M/HR	
Total.		
288.460	CU M	



Minimum Night Flow		
Measurement Press.	0.42	[Mpa]
Conversion Press.	0.27	[Mpa]
Minimum Flow	5.817	[CU M/HR]
Conversion Flow	4.664	[CU M/HR]
Leakage Ratio	38.80	%

Total Flow Ave.	
12.02	CU M/HR
Total Flow Max.	
20.44	CU M/HR
Max.Flow ratio	
1.70	



Date	Time	Total Flow
2004/9/17	15:00	14.6
2004/9/17	16:00	11.16
2004/9/17	17:00	8.07
2004/9/17	18:00	8.58
2004/9/17	19:00	9.1
2004/9/17	20:00	10.23
2004/9/17	21:00	9.28
2004/9/17	22:00	10.84
2004/9/17	23:00	10.45
2004/9/18	0:00	9.95
2004/9/18	1:00	7.5
2004/9/18	2:00	6.73
2004/9/18	3:00	6.51
2004/9/18	4:00	7.58
2004/9/18	5:00	7.32
2004/9/18	6:00	10.61
2004/9/18	7:00	17.84
2004/9/18	8:00	17.85
2004/9/18	9:00	20.44
2004/9/18	10:00	20.23
2004/9/18	11:00	18.87
2004/9/18	12:00	18.47
2004/9/18	13:00	13.3
2004/9/18	14:00	12.95

Pressure Measurement Data

MICRO SECTOR: VALLE DORADO — Low Elevation Zone

DATE: 2004/SEP/17 --- 2004/SEP/18

LOCATION: A

COORDENADAS: Este 574339 Norte 1343031 Elev. m

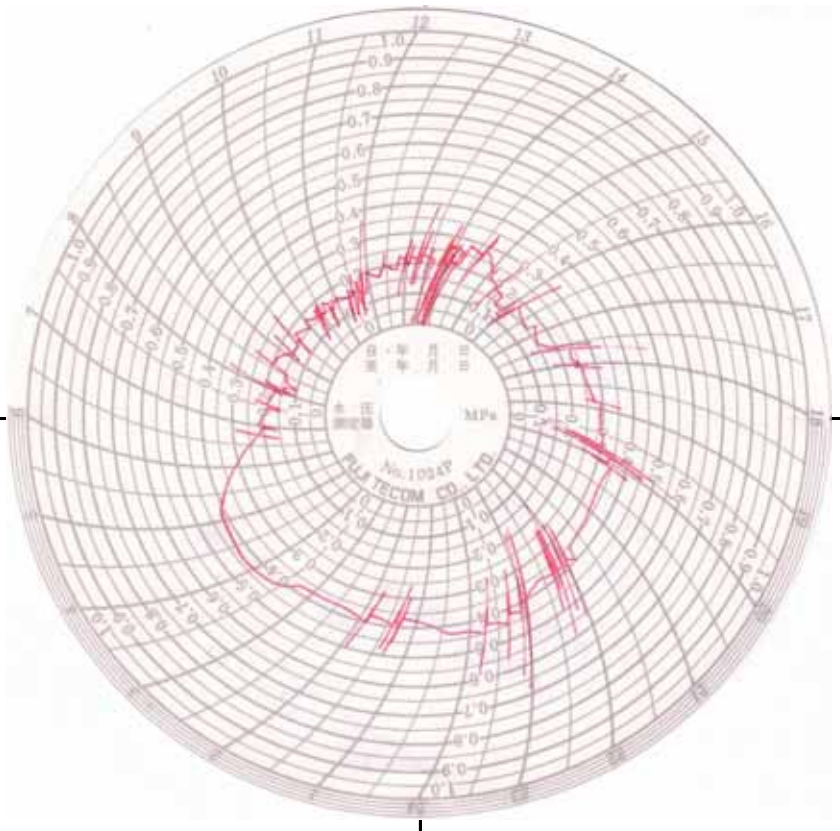
MEASURED VALUE

Pressure	[MPa]	[psi]
High	0.44	63.82
Average*	0.28	40.61
Low	0.10	14.50

* Average of Hourly variation

Hourly variation [MPa]

time	1	2	3	4	5	6	7	8	9	10	11	12
value	0.37	0.39	0.37	0.43	0.41	0.31	0.20	0.15	0.15	0.17	0.16	0.19
time	13	14	15	16	17	18	19	20	21	22	23	24
value	0.21	0.20	0.24	0.12	0.16	0.25	0.29	0.33	0.34	0.37	0.40	0.43



Note:

Pressure Measurement Data

MICRO SECTOR: VALLE DORADO Low Elevation Zone

DATE: 2004/SEP/17 --- 2004/SEP/18

LOCATION: B CASA:E-46

COORDENADAS: Este 574439 Norte 1343055 Elev. m

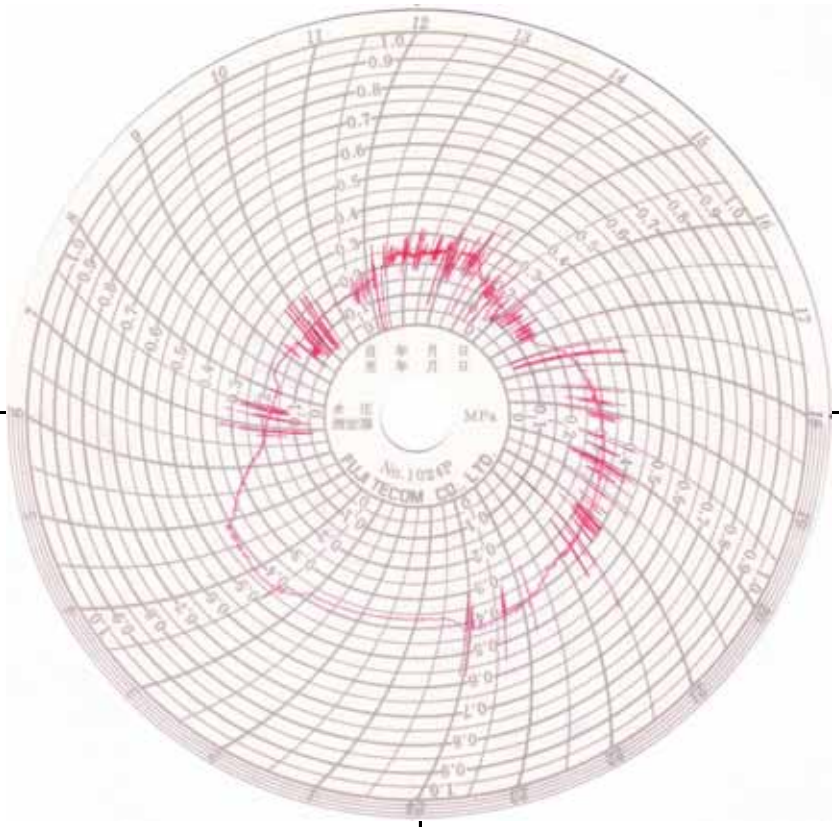
MEASURED VALUE

Pressure	[MPa]	[psi]
High	0.43	62.37
Average*	0.27	39.16
Low	0.08	11.60

* Average of Hourly variation

Hourly variation [MPa]

time	1	2	3	4	5	6	7	8	9	10	11	12
value	0.37	0.37	0.38	0.43	0.40	0.26	0.19	0.16	0.17	0.15	0.15	0.17
time	13	14	15	16	17	18	19	20	21	22	23	24
value	0.24	0.26	0.20	0.12	0.15	0.25	0.30	0.32	0.34	0.35	0.40	0.42



Note:

2. Micro Sector - Los Arcos

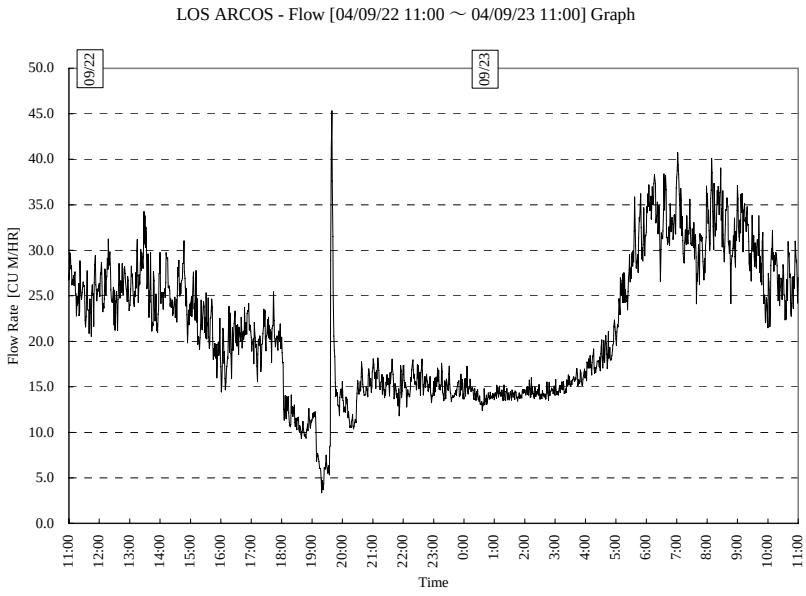
Micro Sector	
LOS ARCOS	
Max.	
2004/9/23	7:02
40.741	CU M/HR
Min.	
2004/9/23	0:36
12.420	CU M/HR
Average.	
21.212	CU M/HR
Total.	
508.985	CU M

Abnormalities [blackout]

Max.	
2004/9/22	19:39
45.318	CU M/HR
Min.	
2004/09/22	19:19
3.356	CU M/HR

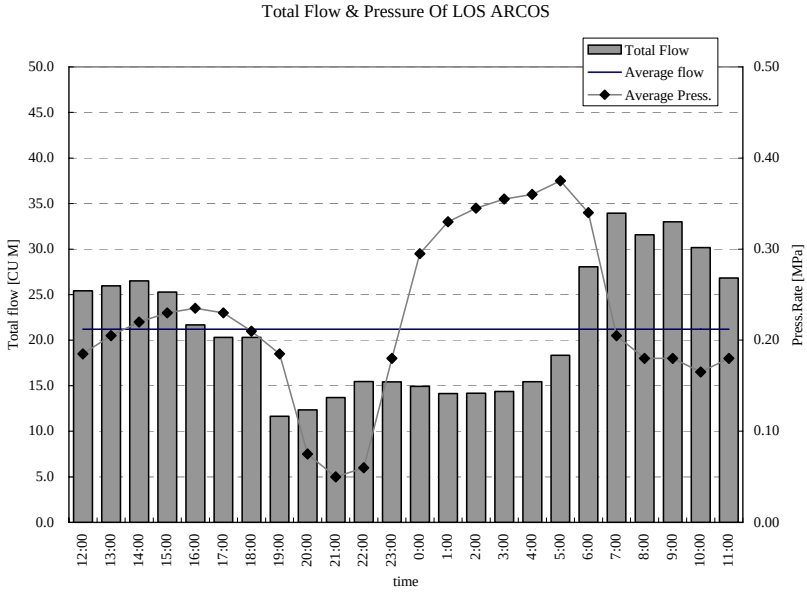
Abnormalities [blackout]		
Measurement Press.	0.03	[Mpa]
Conversion Press.	0.22	[Mpa]
Minimum Flow	3.356	[CU M/HR]
Conversion Flow	9.088	[CU M/HR]

Minimum Night Flow		
Measurement Press.	0.36	[Mpa]
Conversion Press.	0.22	[Mpa]
Minimum Flow	12.42	[CU M/HR]
Conversion Flow	9.709	[CU M/HR]
Leakage Ratio	45.78	%



Total Flow Ave.
21.21 CU M/HR
Total Flow Max.
33.94 CU M/HR
Max.Flow ratio
1.60

Date	Time	Total Flow
2004/9/22	12:00	25.43
2004/9/22	13:00	25.96
2004/9/22	14:00	26.52
2004/9/22	15:00	25.28
2004/9/22	16:00	21.68
2004/9/22	17:00	20.30
2004/9/22	18:00	20.30
2004/9/22	19:00	11.64
2004/9/22	20:00	12.35
2004/9/22	21:00	13.69
2004/9/22	22:00	15.47
2004/9/22	23:00	15.43
2004/9/23	0:00	14.92
2004/9/23	1:00	14.14
2004/9/23	2:00	14.18
2004/9/23	3:00	14.38
2004/9/23	4:00	15.43
2004/9/23	5:00	18.35
2004/9/23	6:00	28.04
2004/9/23	7:00	33.94
2004/9/23	8:00	31.57
2004/9/23	9:00	32.99
2004/9/23	10:00	30.16
2004/9/23	11:00	26.83



Pressure Measurement Data

MICRO SECTOR: LOS ARCOS Low Elevation Zone

DATE: 2004/SEP/22 --- 2004/SEP/23

LOCATION: A Entrada 50metros al este

COORDENADAS: Este 575001 Norte 1343011 Elev. m

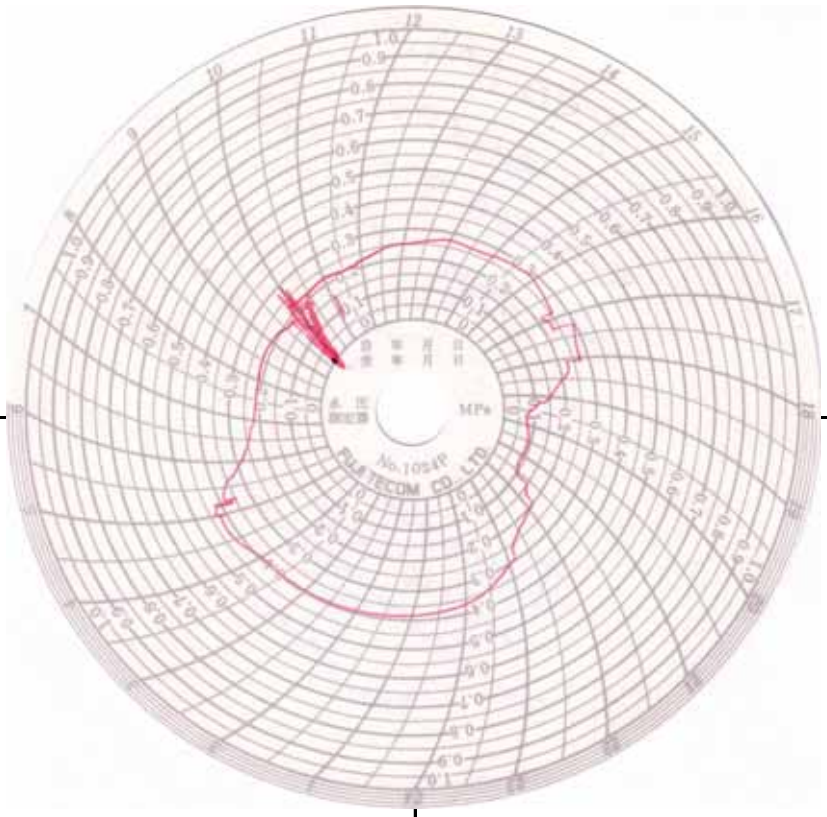
MEASURED VALUE

Pressure	[MPa]	[psi]
High	0.43	62.37
Average*	0.26	37.71
Low	0.08	11.60

* Average of Hourly variation

Hourly variation [MPa]

time	1	2	3	4	5	6	7	8	9	10	11	12
value	0.38	0.39	0.40	0.40	0.43	0.28	0.22	0.21	0.21	0.22	0.22	0.22
time	13	14	15	16	17	18	19	20	21	22	23	24
value	0.25	0.27	0.27	0.28	0.23	0.27	0.15	0.08	0.09	0.20	0.30	0.36



Note: Outage [SEP22 18:00 to 19:40pm]

Pressure Measurement Data

MICRO SECTOR: LOS ARCOS — Low Elevation Zone

DATE: 2004/SEP/22 --- 2004/SEP/23

LOCATION: B Entrada al Hospital Lenin Fonseca 4c Este 2c. Al sur ultima casa

COORDENADAS: Este 575194 Norte 1342774 Elev. m

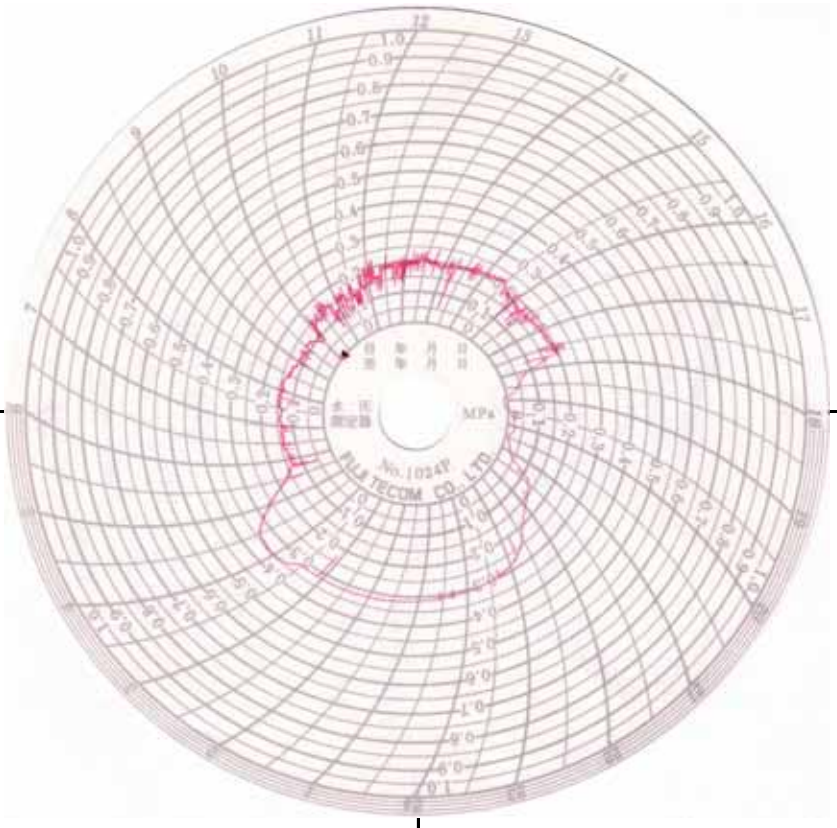
MEASURED VALUE

Pressure	[MPa]	[psi]
High	0.35	50.76
Average*	0.18	26.11
Low	0.00	0.00

* Average of Hourly variation

Hourly variation [MPa]

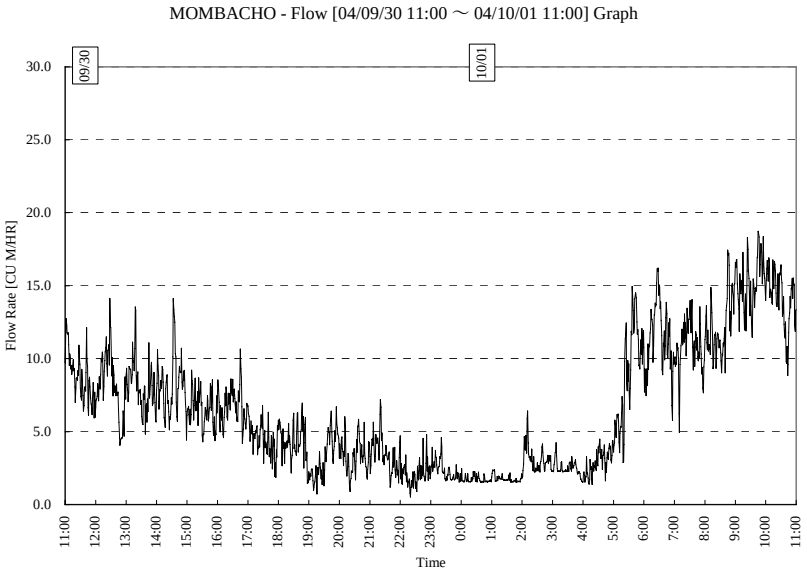
time	1	2	3	4	5	6	7	8	9	10	11	12
value	0.31	0.32	0.32	0.35	0.25	0.13	0.14	0.15	0.12	0.14	0.15	0.19
time	13	14	15	16	17	18	19	20	21	22	23	24
value	0.19	0.19	0.20	0.18	0.19	0.10	0.00	0.02	0.03	0.16	0.29	0.30



Note: Outage [SEP22 18:00 to 19:40pm]

3. Micro Sector – Mombacho

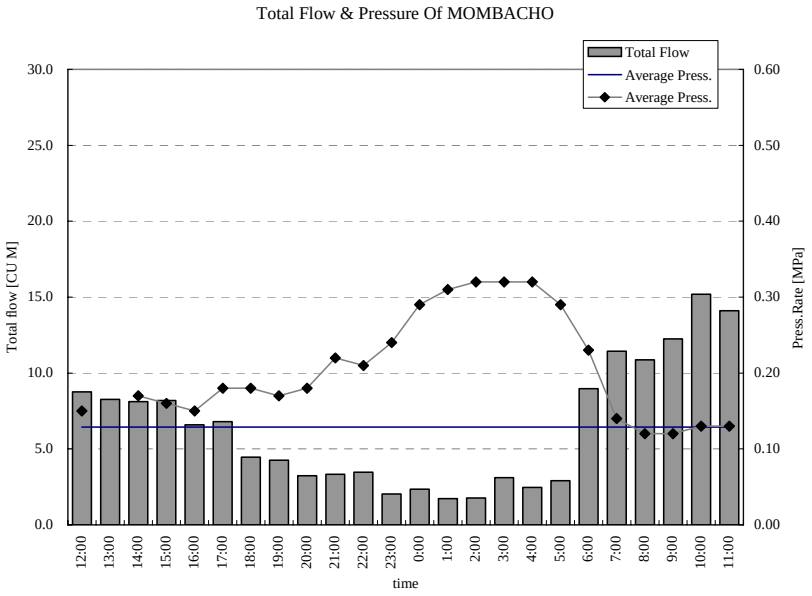
Micro Sector	
MOMBACHO	
Max.	
2004/10/01	09:45:00
18.738	CU M/HR
Min.(Night)	
2004/10/01	04:18:00
1.365	CU M/HR
Average.	
6.447	CU M/HR
Total.	
154.670	CU M



Minimum Night Flow		
Measurement Press.	0.32	[Mpa]
Conversion Press.	0.20	[Mpa]
Minimum Flow	1.365	[CU M/HR]
Conversion Flow	1.090	[CU M/HR]
Leakage Ratio	16.91	%

Total Flow Ave.	
6.44	CU M/HR
Total Flow Max.	
15.19	CU M/HR
Max.Flow ratio	
2.36	

Date	Time	Total Flow
2004/9/30	12:00	8.8
2004/9/30	13:00	8.3
2004/9/30	14:00	8.1
2004/9/30	15:00	8.2
2004/9/30	16:00	6.6
2004/9/30	17:00	6.8
2004/9/30	18:00	4.5
2004/9/30	19:00	4.3
2004/9/30	20:00	3.2
2004/9/30	21:00	3.3
2004/9/30	22:00	3.5
2004/9/30	23:00	2.0
2004/10/1	0:00	2.3
2004/10/1	1:00	1.7
2004/10/1	2:00	1.8
2004/10/1	3:00	3.1
2004/10/1	4:00	2.5
2004/10/1	5:00	2.9
2004/10/1	6:00	9.0
2004/10/1	7:00	11.4
2004/10/1	8:00	10.9
2004/10/1	9:00	12.3
2004/10/1	10:00	15.2
2004/10/1	11:00	14.1



Pressure Measurement Data

MICRO SECTOR: MOMBACHO Low Elevation Zone

DATE: 2004/SEP/29 --- 2004/SEP/30

LOCATION: A CASA;700-2-01-80900

COORDENADAS: Este 585266 Norte 1342952 Elev. m

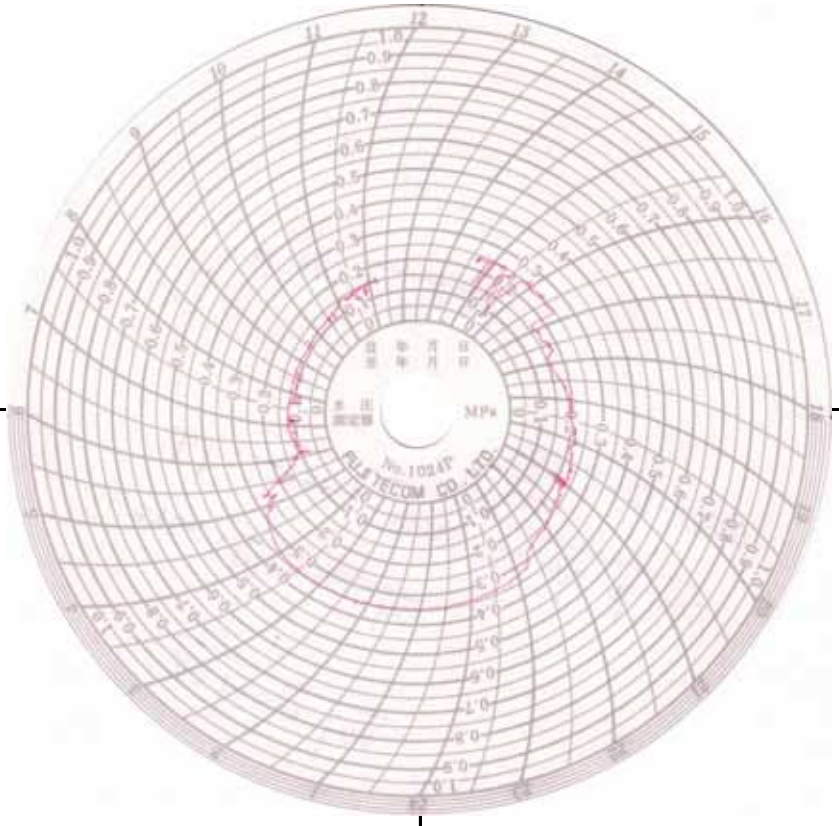
MEASURED VALUE

Pressure	[MPa]	[psi]
High	0.35	50.76
Average*	0.22	31.91
Low	0.08	11.60

* Average of Hourly variation

Hourly variation [MPa]

time	1	2	3	4	5	6	7	8	9	10	11	12
value	0.35	0.35	0.35	0.34	0.26	0.12	0.12	0.12	0.11	0.11	0.14	0.15
time	13	14	15	16	17	18	19	20	21	22	23	24
value			0.25	0.25	0.16	0.15	0.19	0.22	0.23	0.25	0.33	0.35



Note:

Pressure Measurement Data

MICRO SECTOR: MOMBACHO — Low Elevation Zone

DATE: 2004/SEP/30 --- 2004/OCT/01

LOCATION: B Dancinos 2C Sur 1C.abajo

COORDENADAS: Este 585473 Norte 1342721 Elev. m

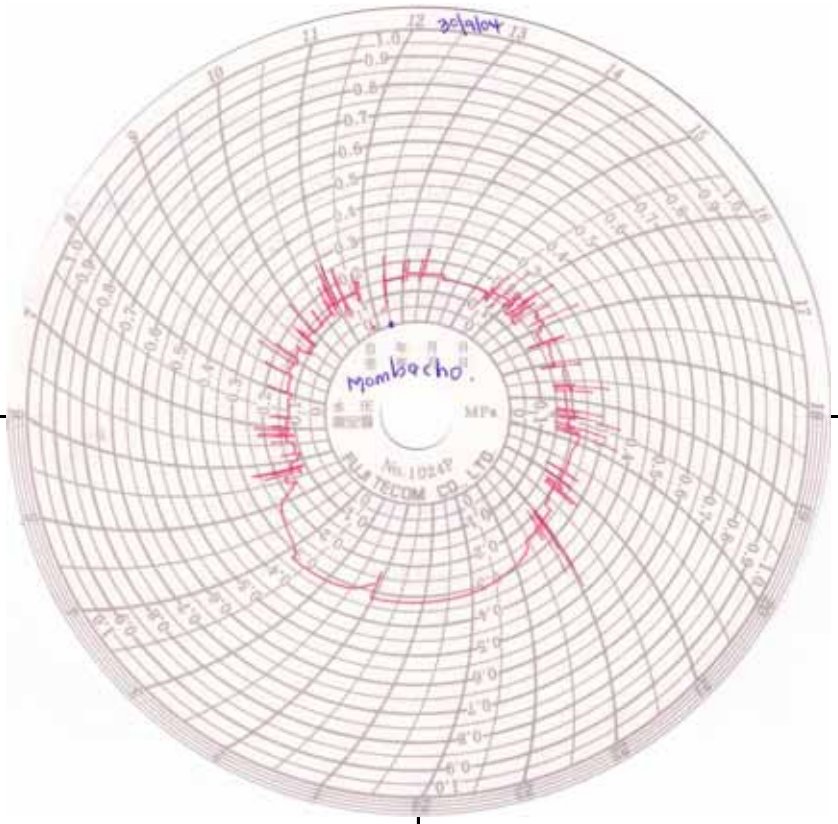
MEASURED VALUE

Pressure	[MPa]	[psi]
High	0.32	46.41
Average*	0.21	30.46
Low	0.10	14.50

* Average of Hourly variation

Hourly variation [MPa]

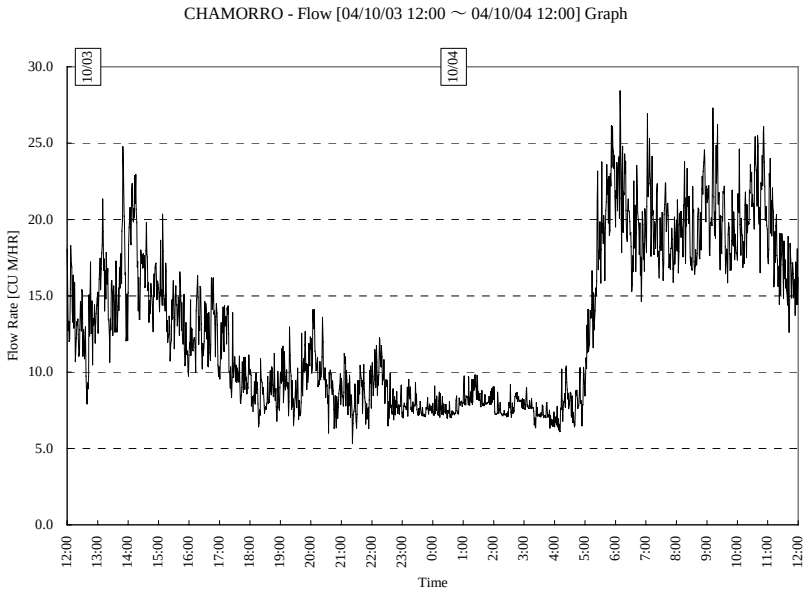
time	1	2	3	4	5	6	7	8	9	10	11	12
value	0.32	0.32	0.32	0.29	0.23	0.14	0.12	0.12	0.13	0.13	0.15	
time	13	14	15	16	17	18	19	20	21	22	23	24
value	0.17	0.16	0.15	0.18	0.18	0.17	0.18	0.22	0.21	0.24	0.29	0.31



Note:

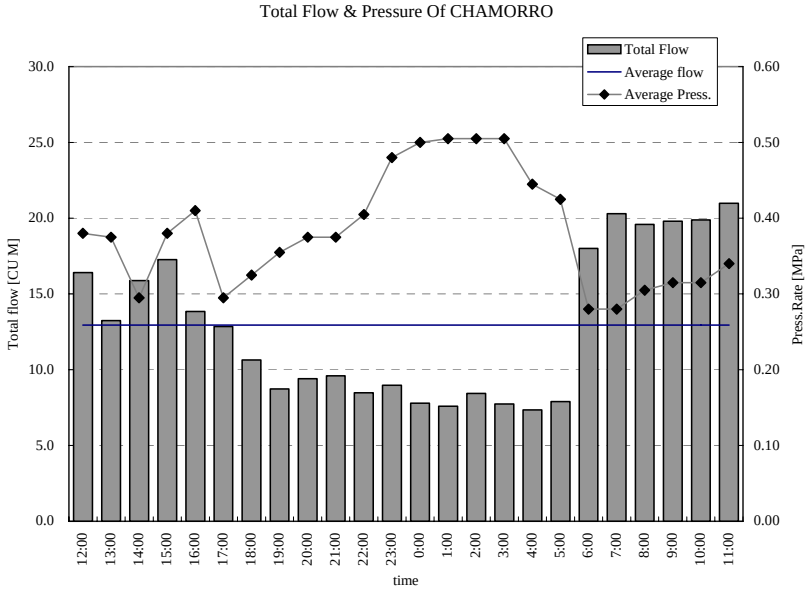
4. Micro Sector – Villa P. J. Chamorro

Micro Sector	
CHAMORRO	
Max.	
2004/10/04	06:09:00
28.435	CU M/HR
Min.(Night)	
2004/10/03	22:43:00
6.872	CU M/HR
Average.	
12.960	CU M/HR
Total.	
311.430	CU M



Minimum Night Flow		
Measurement Press.	0.50	[Mpa]
Conversion Press.	0.38	[Mpa]
Minimum Flow	6.872	[CU M/HR]
Conversion Flow	5.991	[CU M/HR]
Leakage Ratio	46.17	%

Total Flow Ave.
12.95 CU M/HR
Total Flow Max.
20.99 CU M/HR
Max.Flow ratio
1.62



Date	Time	Total Flow
2004/10/3	12:00	16.4
2004/10/3	13:00	13.3
2004/10/3	14:00	15.9
2004/10/3	15:00	17.3
2004/10/3	16:00	13.9
2004/10/3	17:00	12.8
2004/10/3	18:00	10.6
2004/10/3	19:00	8.7
2004/10/3	20:00	9.4
2004/10/3	21:00	9.6
2004/10/3	22:00	8.5
2004/10/3	23:00	9.0
2004/10/4	0:00	7.8
2004/10/4	1:00	7.6
2004/10/4	2:00	8.4
2004/10/4	3:00	7.8
2004/10/4	4:00	7.4
2004/10/4	5:00	7.9
2004/10/4	6:00	18.0
2004/10/4	7:00	20.3
2004/10/4	8:00	19.6
2004/10/4	9:00	19.8
2004/10/4	10:00	19.9
2004/10/4	11:00	21.0

Pressure Measurement Data

MICRO SECTOR: CHAMORRO Low Elevation Zone

DATE: 2004/OCT/04 --- 2004/OCT/05

LOCATION: A ENTRADA 20ms ARRIBA

COORDENADAS: Este 582899 Norte 1343569 Elev. m

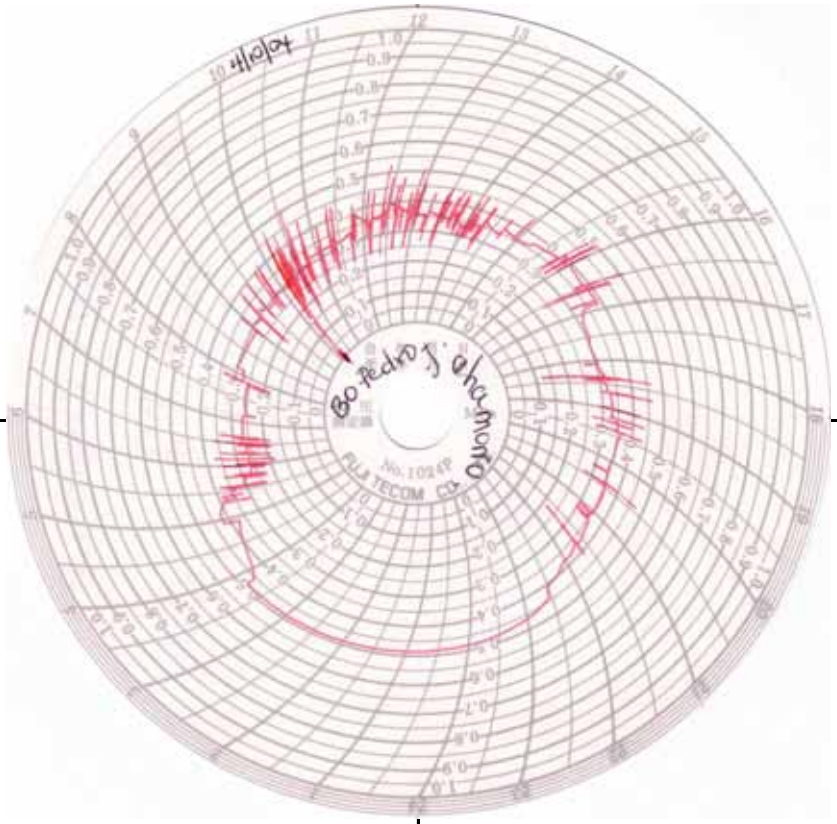
MEASURED VALUE

Pressure	[MPa]	[psi]
High	0.49	71.07
Average*	0.37	53.66
Low	0.19	27.56

* Average of Hourly variation

Hourly variation [MPa]

time	1	2	3	4	5	6	7	8	9	10	11	12
value	0.49	0.49	0.49	0.44	0.42	0.26	0.26	0.27	0.30	0.29	0.32	0.36
time	13	14	15	16	17	18	19	20	21	22	23	24
value	0.35	0.33	0.36	0.39	0.33	0.30	0.33	0.35	0.35	0.38	0.46	0.48



Note:

Pressure Measurement Data

MICRO SECTOR: CHAMORRO Low Elevation Zone

DATE: 2004/OCT/04 --- 2004/OCT/05

LOCATION: B Customer No.37000

COORDENADAS: Este 583020 Norte 1343769 Elev. m

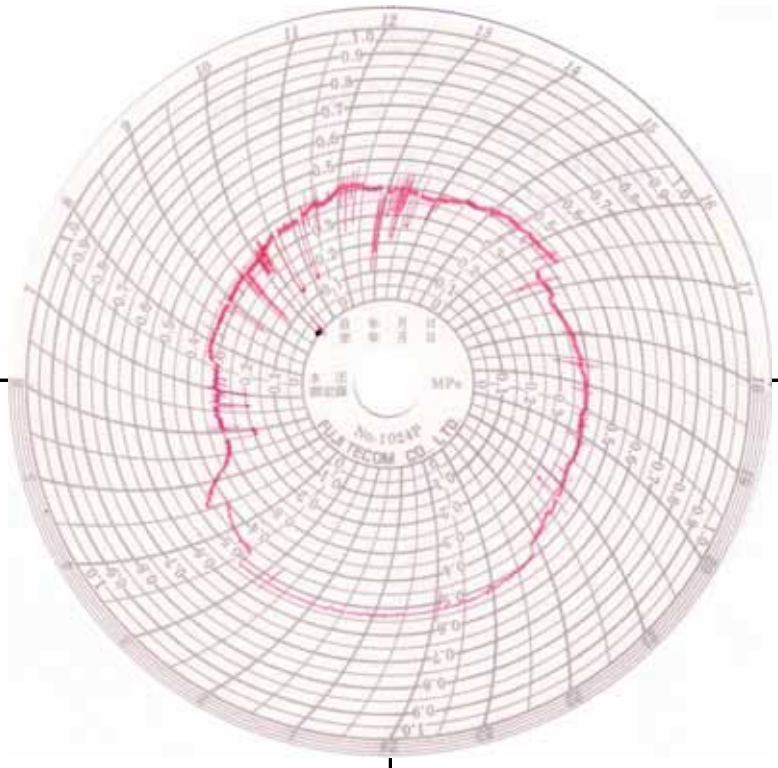
MEASURED VALUE

Pressure	[MPa]	[psi]
High	0.52	75.42
Average*	0.40	58.02
Low	0.15	21.76

* Average of Hourly variation

Hourly variation [MPa]

time	1	2	3	4	5	6	7	8	9	10	11	12
value	0.52	0.52	0.52	0.45	0.43	0.30	0.30	0.34	0.33	0.34	0.36	0.40
time	13	14	15	16	17	18	19	20	21	22	23	24
value	0.40	0.26	0.40	0.43	0.26	0.35	0.38	0.40	0.40	0.43	0.50	0.52

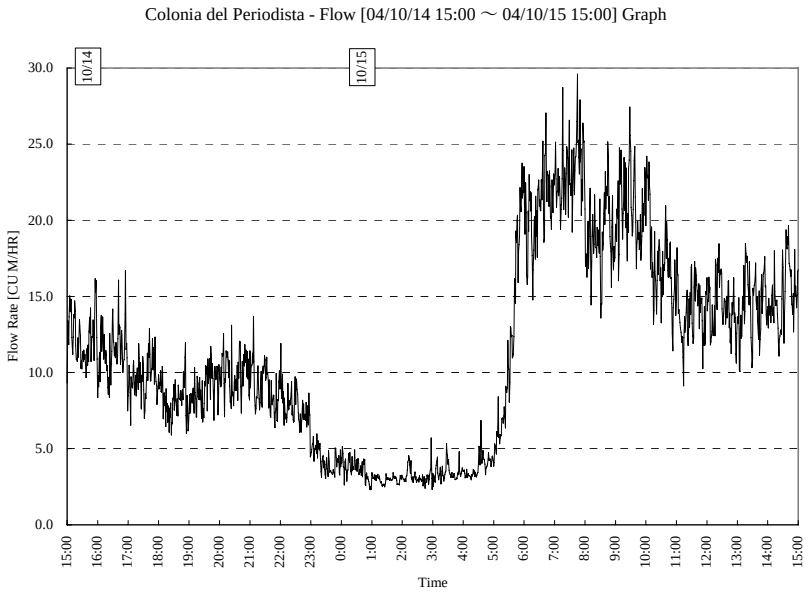


Note:

DATE: 2004/OCT/04 --- 2004/OCT/05

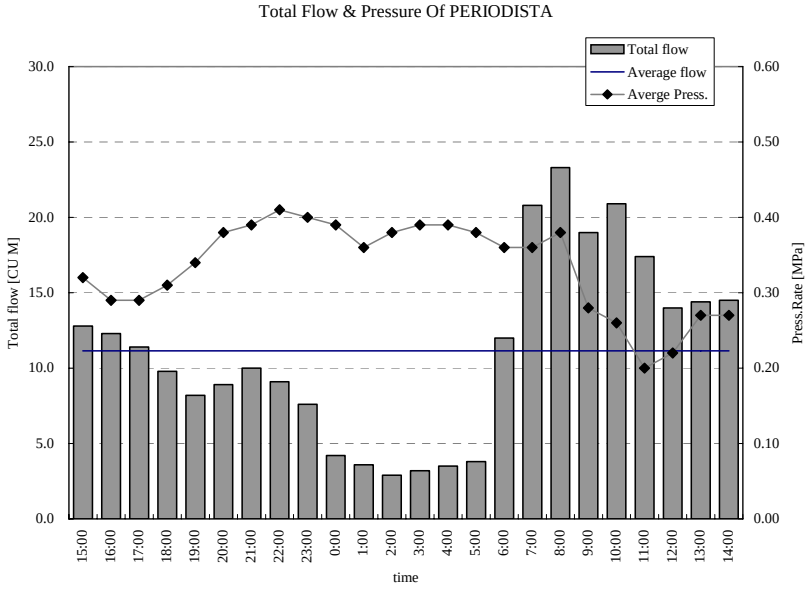
5. Colonia del Periodista

Micro Sector	
Colonia del Periodista	
Maximum flow	
2004/10/15	07:45:00
29.591	CU M/HR
Minimum flow	
2004/10/15	00:58:00
2.298	CU M/HR
Average flow	
11.224	CU M/HR
Total flow	
268.990	CU M



Minimum Night Flow		
Measurement Press.	0.42	[Mpa]
Conversion Press.	0.40	[Mpa]
Minimum Flow	2.298	[CU M/HR]
Conversion Flow	2.243	[CU M/HR]
Leakage Ratio	20.01	%

Total Flow Ave.	
11.2	CU M/HR
Total Flow Max.	
23.3	CU M/HR
Max.Flow ratio	
2.09	



Date	Time	Total flow
2004/10/14	15:00	12.8
2004/10/14	16:00	12.3
2004/10/14	17:00	11.4
2004/10/14	18:00	9.8
2004/10/14	19:00	8.2
2004/10/14	20:00	8.9
2004/10/14	21:00	10
2004/10/14	22:00	9.1
2004/10/14	23:00	7.6
2004/10/15	0:00	4.2
2004/10/15	1:00	3.6
2004/10/15	2:00	2.9
2004/10/15	3:00	3.2
2004/10/15	4:00	3.5
2004/10/15	5:00	3.8
2004/10/15	6:00	12
2004/10/15	7:00	20.8
2004/10/15	8:00	23.3
2004/10/15	9:00	19
2004/10/15	10:00	20.9
2004/10/15	11:00	17.4
2004/10/15	12:00	14
2004/10/15	13:00	14.4
2004/10/15	14:00	14.5

Pressure Measurement Data

MICRO SECTOR: Colonia del Periodista — Super High Elevation Zone

DATE: 2004/OCT/14 --- 2004/OCT/15

LOCATION: A Near the Inlet

COORDENADAS: Este 577678 Norte 1340347 Elev. m

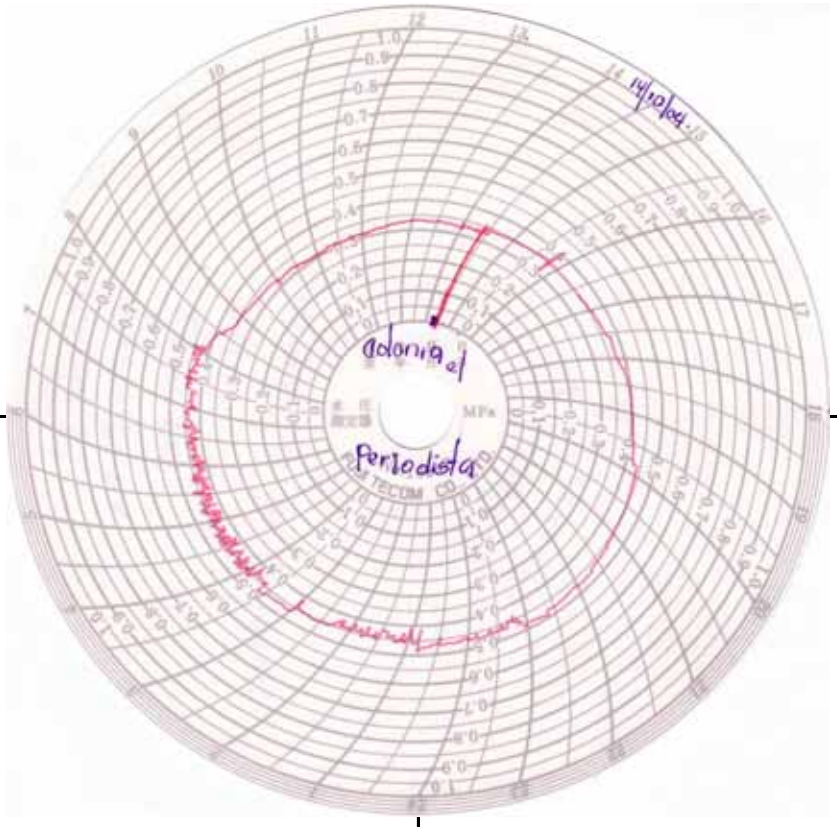
MEASURED VALUE

Pressure	[MPa]	[psi]
High	0.49	71.07
Average*	0.40	58.02
Low	0.30	43.51

* Average of Hourly variation

Hourly variation [MPa]

time	1	2	3	4	5	6	7	8	9	10	11	12
value	0.41	0.44	0.46	0.45	0.44	0.43	0.43	0.45	0.35	0.33	0.30	0.31
time	13	14	15	16	17	18	19	20	21	22	23	24
value	0.34	0.34	0.35	0.35	0.35	0.37	0.40	0.44	0.45	0.47	0.48	0.46



Note:

Pressure Measurement Data

MICRO SECTOR: Colonia del Periodista — Super High Elevation Zone

DATE: 2004/OCT/14 --- 2004/OCT/15

LOCATION: B Casa Cuenta 52200

COORDENADAS: Este 577809 Norte 1340131 Elev. m

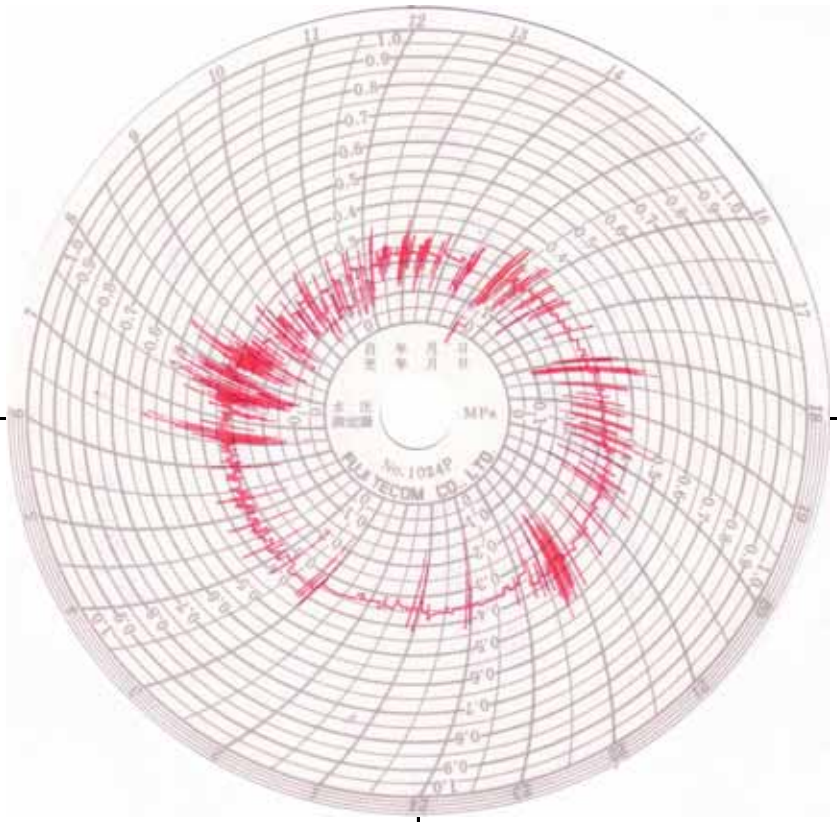
MEASURED VALUE

Pressure	[MPa]	[psi]
High	0.38	55.11
Average*	0.29	42.06
Low	0.15	21.76

* Average of Hourly variation

Hourly variation [MPa]

time	1	2	3	4	5	6	7	8	9	10	11	12
value	0.34	0.34	0.35	0.35	0.34	0.32	0.32	0.33	0.24	0.21	0.12	0.16
time	13	14	15	16	17	18	19	20	21	22	23	24
value	0.22	0.23		0.25	0.25	0.27	0.30	0.34	0.35	0.37	0.35	0.35

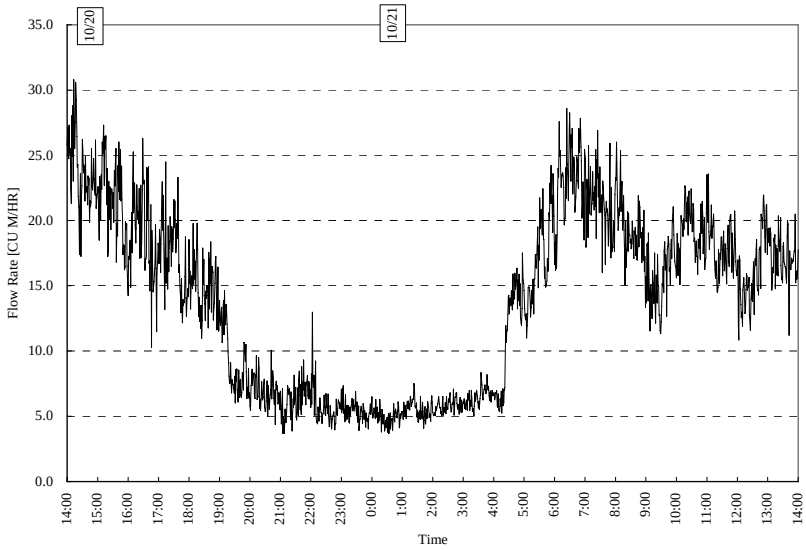


Note:

6. Micro Sector – Belmonte

Micro Sector	
BELMONTE	
Max.	
2004/10/20	14:13:00
30.804	CU M/HR
Min.	
2004/10/21	00:34:00
3.675	CU M/HR
Average.	
13.788	CU M/HR
Total.	
330.560	CU M

BELMONTE - Flow [04/10/20 14:00 ～ 04/10/21 14:00] Graph

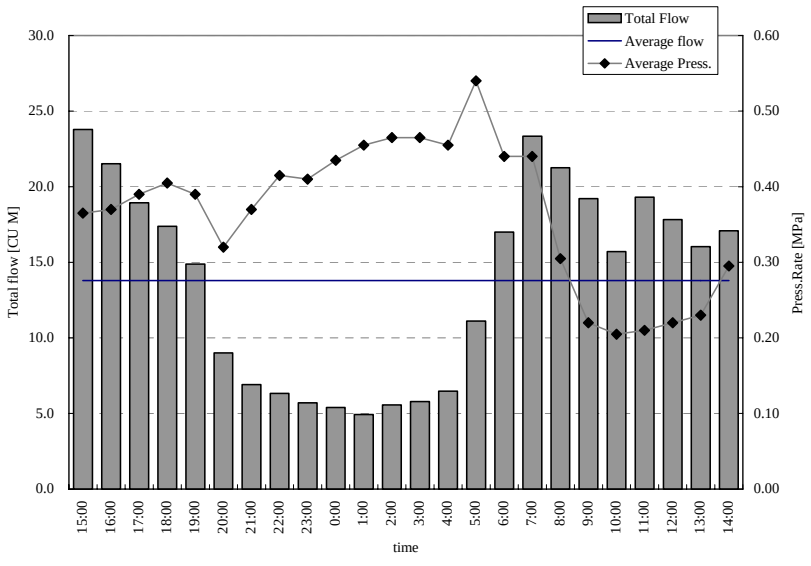


Minimum Night Flow		
Measurement Press.	0.46	[Mpa]
Conversion Press.	0.37	[Mpa]
Minimum Flow	3.675	[CU M/HR]
Conversion Flow	3.296	[CU M/HR]
Leakage Ratio	23.93	%

Total Flow Ave.	
13.77	CU M/HR
Total Flow Max.	
23.79	CU M/HR
Max.Flow ratio	
1.73	

Date	Time	Total Flow
2004/10/20	15:00	23.79
2004/10/20	16:00	21.52
2004/10/20	17:00	18.93
2004/10/20	18:00	17.38
2004/10/20	19:00	14.89
2004/10/20	20:00	9.01
2004/10/20	21:00	6.92
2004/10/20	22:00	6.33
2004/10/20	23:00	5.71
2004/10/21	0:00	5.40
2004/10/21	1:00	4.94
2004/10/21	2:00	5.57
2004/10/21	3:00	5.79
2004/10/21	4:00	6.48
2004/10/21	5:00	11.12
2004/10/21	6:00	17.00
2004/10/21	7:00	23.34
2004/10/21	8:00	21.26
2004/10/21	9:00	19.22
2004/10/21	10:00	15.71
2004/10/21	11:00	19.30
2004/10/21	12:00	17.83
2004/10/21	13:00	16.04
2004/10/21	14:00	17.08

Total Flow & Pressure Of BELMONTE



LOCATION: A Near the Inlet

COORDENADAS: Este 574905 Norte 1340042 Elev. m

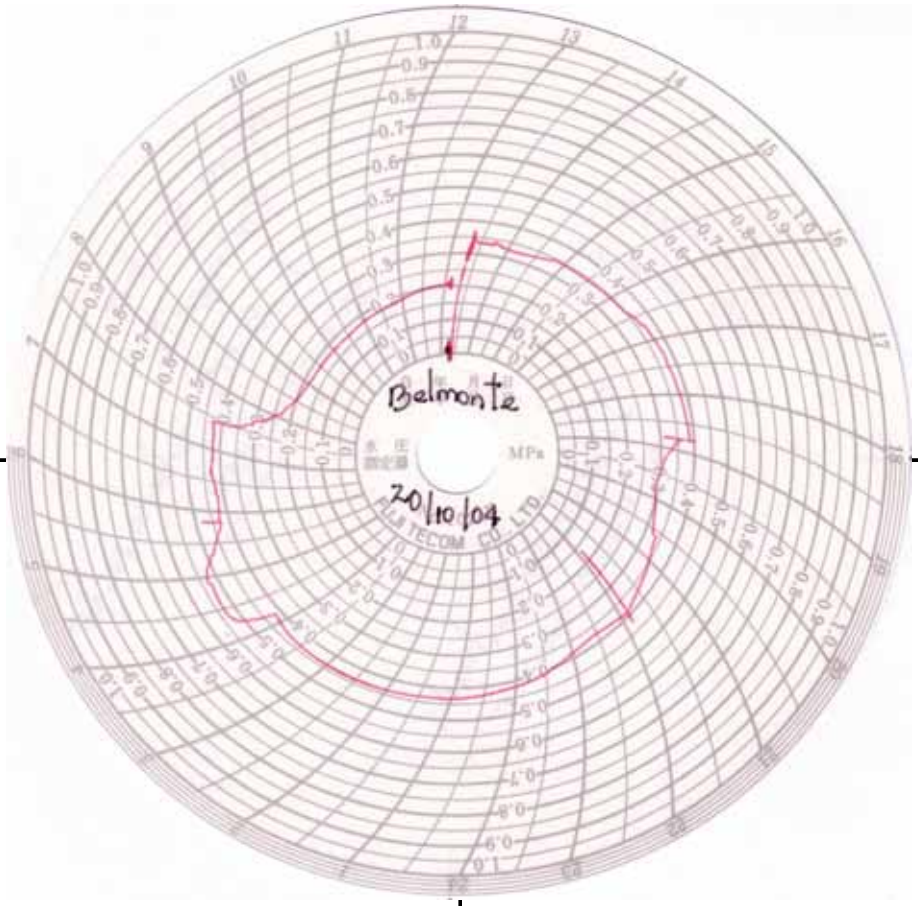
MEASURED VALUE

Pressure	[MPa]	[psi]
High	0.53	76.87
Average*	0.34	49.31
Low	0.17	24.66

* Average of Hourly variation

Hourly variation [MPa]

time	1	2	3	4	5	6	7	8	9	10	11	12
value	0.44	0.44	0.44	0.43	0.52	0.42	0.42	0.25	0.19	0.17	0.18	0.19
time	13	14	15	16	17	18	19	20	21	22	23	24
value	0.20	0.33	0.35	0.35	0.37	0.38	0.34	0.30	0.35	0.39	0.39	0.42



Note:

Pressure Measurement Data

MICRO SECTOR: Belmonte — Super High Elevation Zone

DATE: 2004/OCT/20 --- 2004/OCT/21

LOCATION: B

COORDENADAS: Este 575451 Norte 1340358 Elev. m

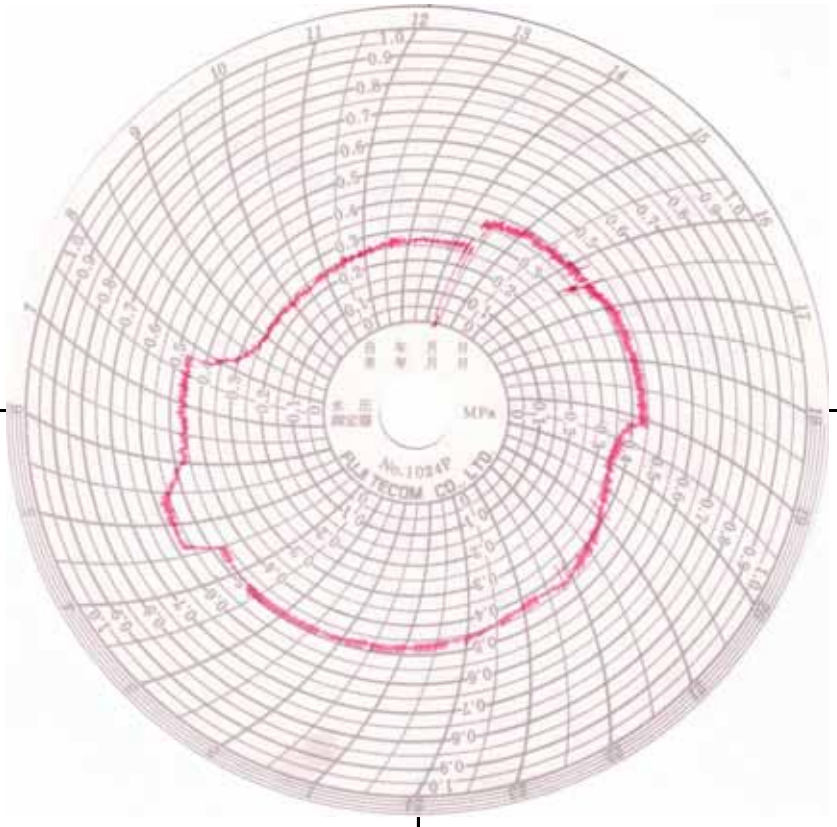
MEASURED VALUE

Pressure	[MPa]	[psi]
High	0.57	82.67
Average*	0.39	56.56
Low	0.24	34.81

* Average of Hourly variation

Hourly variation [MPa]

time	1	2	3	4	5	6	7	8	9	10	11	12
value	0.47	0.49	0.49	0.48	0.56	0.46	0.46	0.36	0.25	0.24	0.24	0.25
time	13	14	15	16	17	18	19	20	21	22	23	24
value	0.26	0.26	0.38	0.39	0.41	0.43	0.44	0.34	0.39	0.44	0.43	0.45

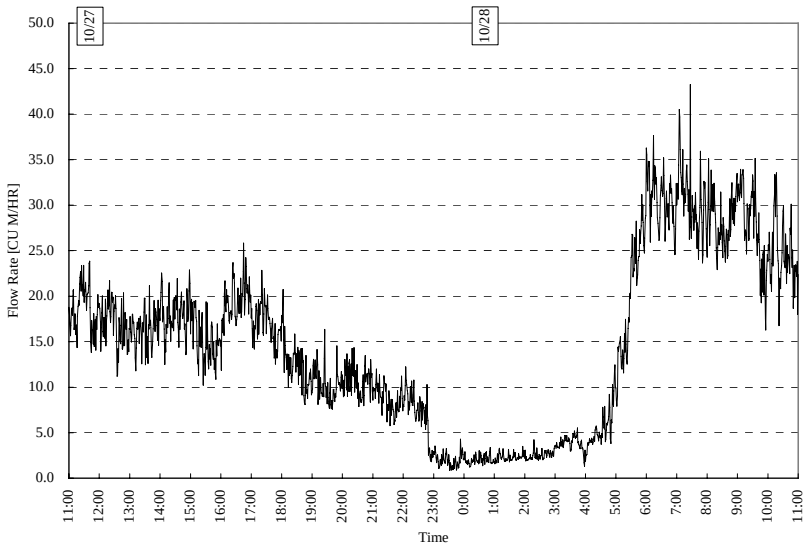


Note:

7. Micro Sector – Lomas del Valle

Micro Sector	
LOMAS DEL VALLE	
Max.	
2004/10/28	07:27:00
43.250	CU M/HR
Min.	
2004/10/27	23:32:00
0.860	CU M/HR
Average.	
14.630	CU M/HR
Total.	
351.160	CU M

LDV - Flow [04/10/27 11:00 ～ 04/10/28 11:00] Graph



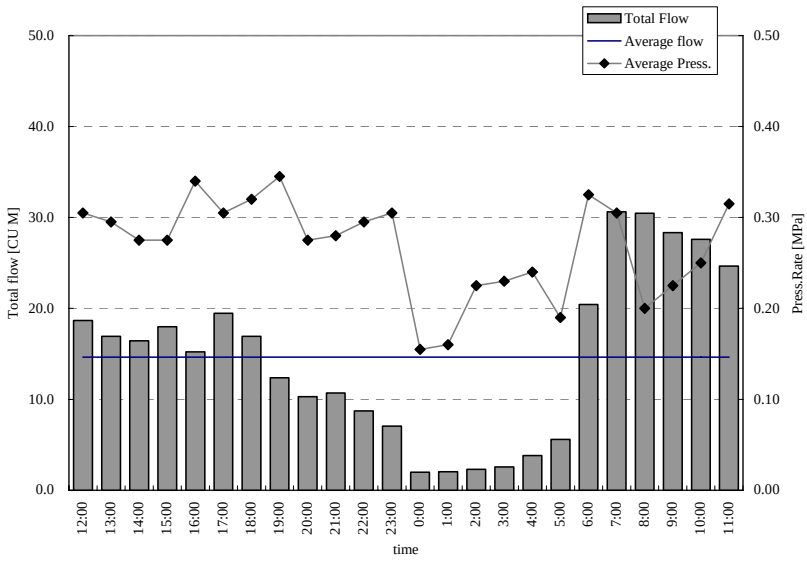
Minimum Night Flow		
Measurement Press.	0.19	[Mpa]
Conversion Press.	0.27	[Mpa]
Minimum Flow	0.860	[CU M/HR]
Conversion Flow	1.039	[CU M/HR]
Leakage Ratio	7.10	%

	Existing meter	Measured value
2004/10/27 10:30	130746.9	0.72
2004/10/28 11:30	131118.9	373.05
Total[CU M]	372.0	372.33

Total Flow Ave.	
14.63	CU M/HR
Total Flow Max.	
30.61	CU M/HR
Max.Flow ratio	
2.09	

Date	Time	Total Flow
2004/10/27	12:00	18.7
2004/10/27	13:00	16.9
2004/10/27	14:00	16.4
2004/10/27	15:00	18.0
2004/10/27	16:00	15.2
2004/10/27	17:00	19.5
2004/10/27	18:00	16.9
2004/10/27	19:00	12.4
2004/10/27	20:00	10.3
2004/10/27	21:00	10.7
2004/10/27	22:00	8.7
2004/10/27	23:00	7.0
2004/10/28	0:00	2.0
2004/10/28	1:00	2.0
2004/10/28	2:00	2.3
2004/10/28	3:00	2.6
2004/10/28	4:00	3.8
2004/10/28	5:00	5.6
2004/10/28	6:00	20.4
2004/10/28	7:00	30.6
2004/10/28	8:00	30.5
2004/10/28	9:00	28.3
2004/10/28	10:00	27.6
2004/10/28	11:00	24.7

Total Flow & Pressure Of Lomas del Valle



Pressure Measurement Data

MICRO SECTOR: Lomas del Valle — Super High Elevation Zone

DATE: 2004/OCT/27 --- 2004/OCT/28

LOCATION: A OFICINA VIVEXSA

COORDENADAS: Este 582063 Norte 1338487 Elev. m

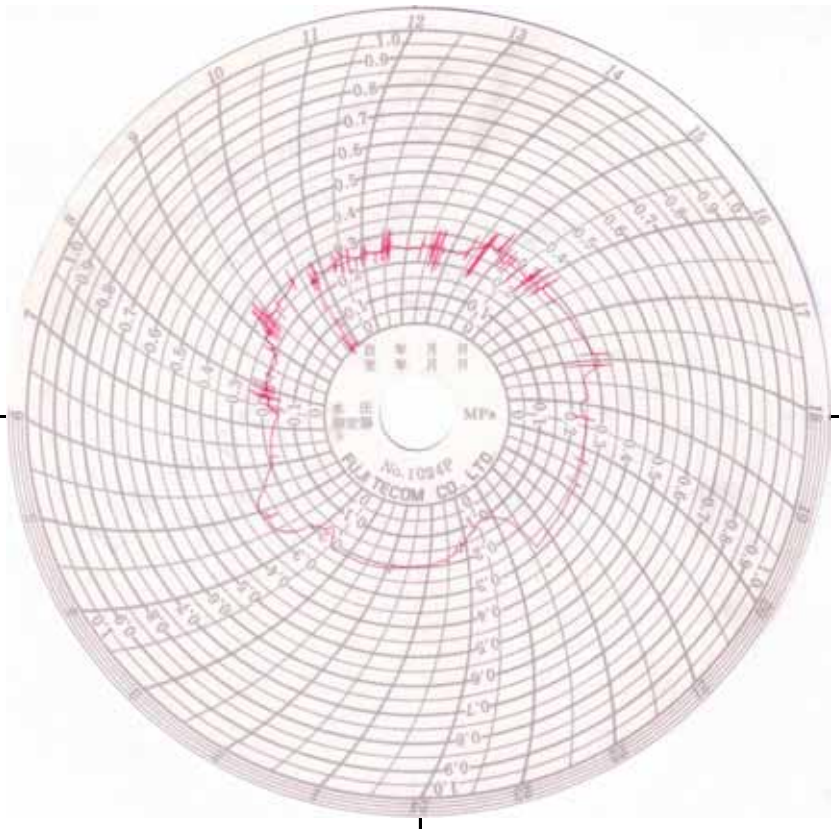
MEASURED VALUE

Pressure	[MPa]	[psi]
High	0.31	44.96
Average*	0.24	34.81
Low	0.10	14.50

* Average of Hourly variation

Hourly variation [MPa]

time	1	2	3	4	5	6	7	8	9	10	11	12
value	0.20	0.20	0.21	0.18	0.30	0.30	0.17	0.20	0.25	0.28	0.25	0.25
time	13	14	15	16	17	18	19	20	21	22	23	24
value	0.25	0.25	0.29	0.27	0.29	0.31	0.24	0.25	0.26	0.27	0.12	0.15



Note:

Pressure Measurement Data

MICRO SECTOR: Lomas del Valle — Super High Elevation Zone

DATE: 2004/OCT/27 --- 2004/OCT/28

LOCATION: B Parte Final

COORDENADAS: Este 582259 Norte 1338728 Elev. m

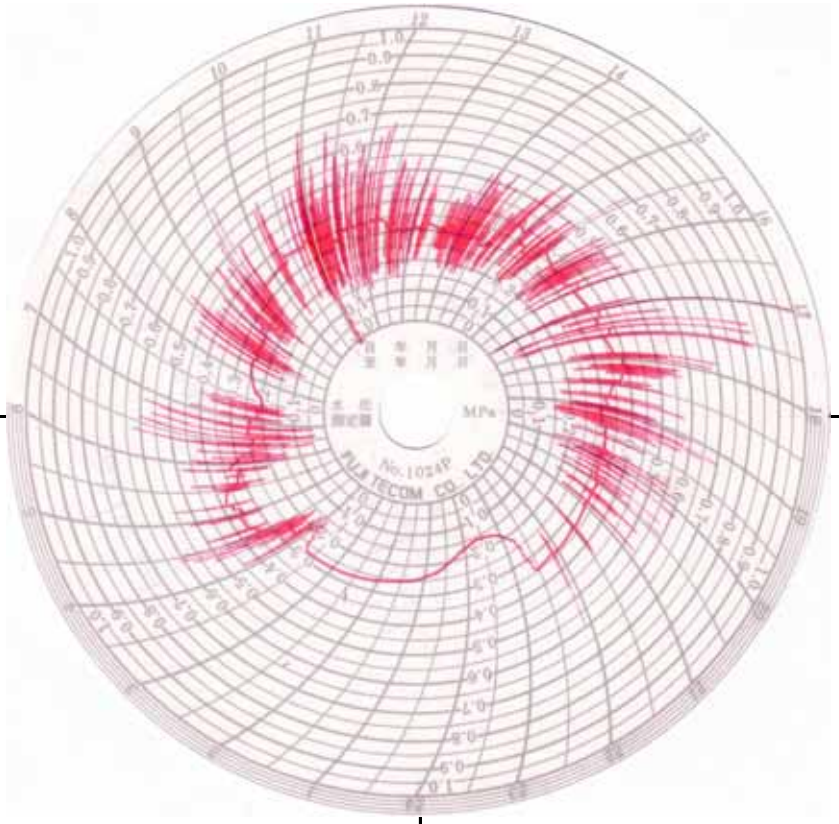
MEASURED VALUE

Pressure	[MPa]	[psi]
High	0.40	58.02
Average*	0.30	43.51
Low	0.15	21.76

* Average of Hourly variation

Hourly variation [MPa]

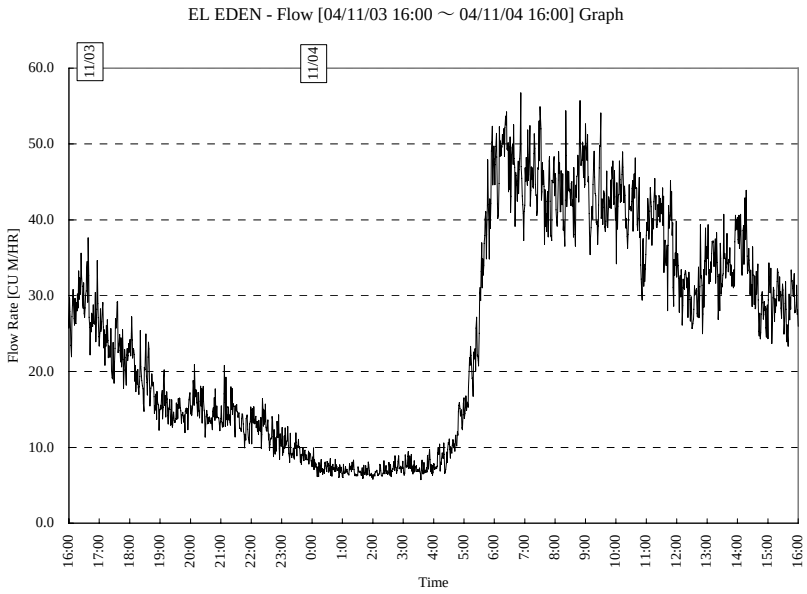
time	1	2	3	4	5	6	7	8	9	10	11	12
value	0.25	0.26	0.27	0.20	0.35	0.31	0.23	0.25	0.25	0.35	0.36	0.34
time	13	14	15	16	17	18	19	20	21	22	23	24
value	0.30	0.30	0.39	0.34	0.35	0.38	0.31	0.31	0.33	0.34	0.19	0.17



Note:

8. Micro Sector – Bario el Eden

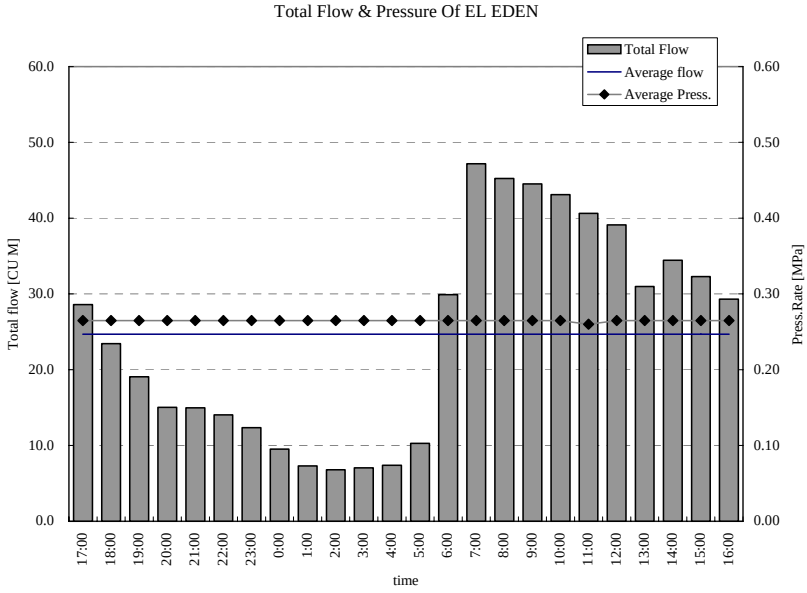
Micro Sector	
EL EDEN	
Max.	
2004/11/04	06:52:00
56.737	CU M/HR
Min.	
2004/11/04	03:35:00
5.741	CU M/HR
Average.	
24.680	CU M/HR
Total.	
592.290	CU M



Minimum Night Flow		
Measurement Press.	0.27	[Mpa]
Conversion Press.	0.27	[Mpa]
Minimum Flow	5.741	[CU M/HR]
Conversion Flow	5.741	[CU M/HR]
Leakage Ratio	23.26	%

Total Flow Ave.
24.69 CU M/HR
Total Flow Max.
47.19 CU M/HR
Max.Flow ratio
1.91

Date	Time	Total Flow
2004/11/3	17:00	28.6
2004/11/3	18:00	23.4
2004/11/3	19:00	19.1
2004/11/3	20:00	15.0
2004/11/3	21:00	15.0
2004/11/3	22:00	14.0
2004/11/3	23:00	12.3
2004/11/4	0:00	9.5
2004/11/4	1:00	7.3
2004/11/4	2:00	6.8
2004/11/4	3:00	7.0
2004/11/4	4:00	7.4
2004/11/4	5:00	10.3
2004/11/4	6:00	29.9
2004/11/4	7:00	47.2
2004/11/4	8:00	45.2
2004/11/4	9:00	44.5
2004/11/4	10:00	43.1
2004/11/4	11:00	40.6
2004/11/4	12:00	39.1
2004/11/4	13:00	31.0
2004/11/4	14:00	34.4
2004/11/4	15:00	32.3
2004/11/4	16:00	29.3



Pressure Measurement Data

MICRO SECTOR: El Eden — High Elevation Zone

DATE: 2004/NOV/03 --- 2004/NOV/04

LOCATION: A Near the Inlet

COORDENADAS: Este 582642 Norte 1342071 Elev. m

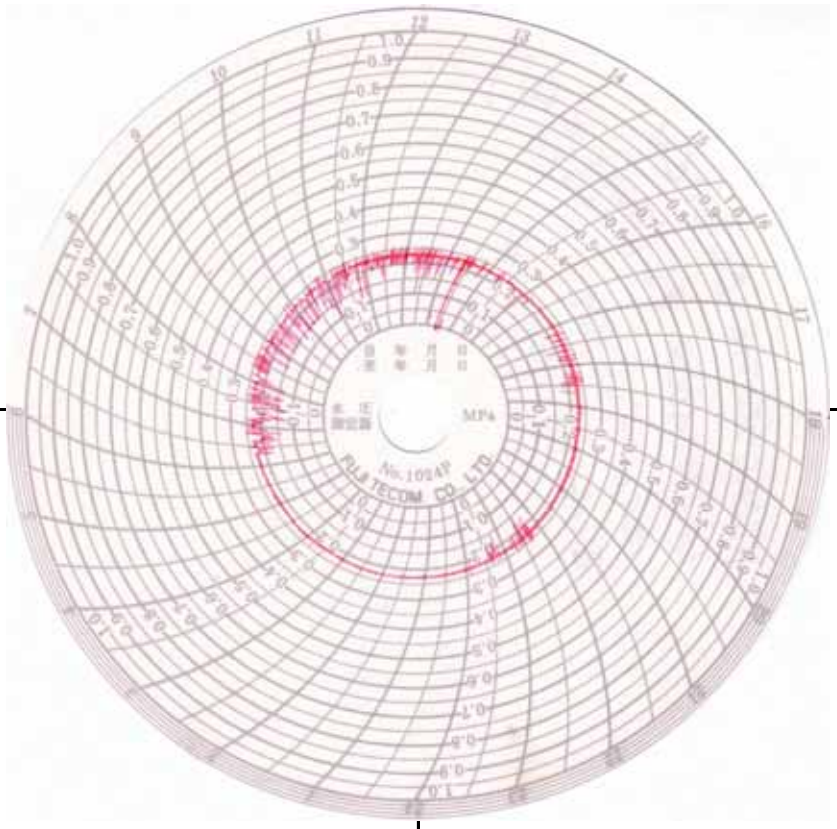
MEASURED VALUE

Pressure	[MPa]	[psi]
High	0.23	33.36
Average*	0.23	33.36
Low	0.20	29.01

* Average of Hourly variation

Hourly variation [MPa]

time	1	2	3	4	5	6	7	8	9	10	11	12
value	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.22	0.23
time	13	14	15	16	17	18	19	20	21	22	23	24
value	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23



Note:

Pressure Measurement Data

MICRO SECTOR: El Eden — High Elevation Zone

DATE: 2004/NOV/03 --- 2004/NOV/04

LOCATION: B Parte Final

COORDENADAS: Este 582864 Norte 1342399 Elev. m

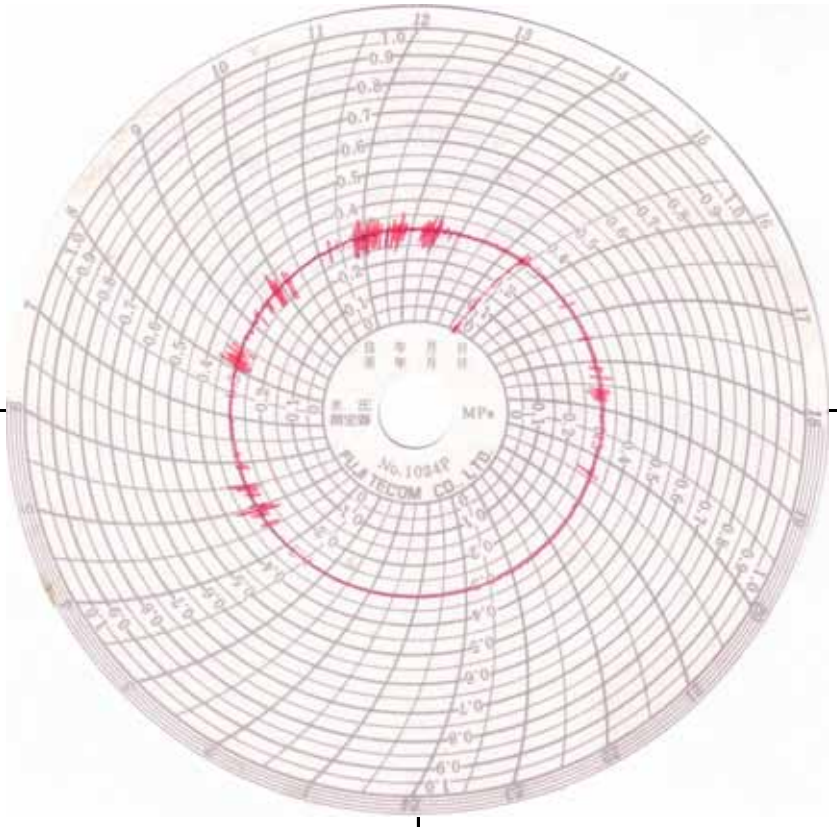
MEASURED VALUE

Pressure	[MPa]	[psi]
High	0.30	43.51
Average*	0.30	43.51
Low	0.30	43.51

* Average of Hourly variation

Hourly variation [MPa]

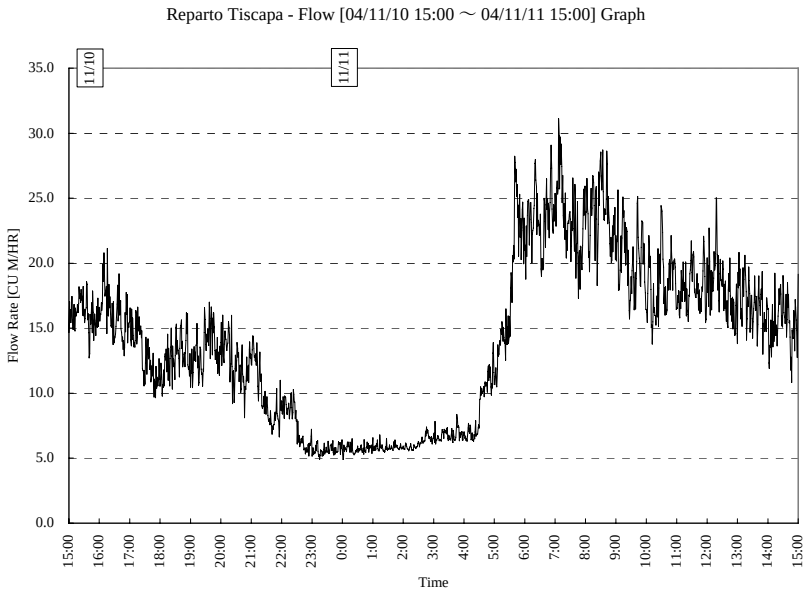
time	1	2	3	4	5	6	7	8	9	10	11	12
value	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
time	13	14	15	16	17	18	19	20	21	22	23	24
value	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30



Note:

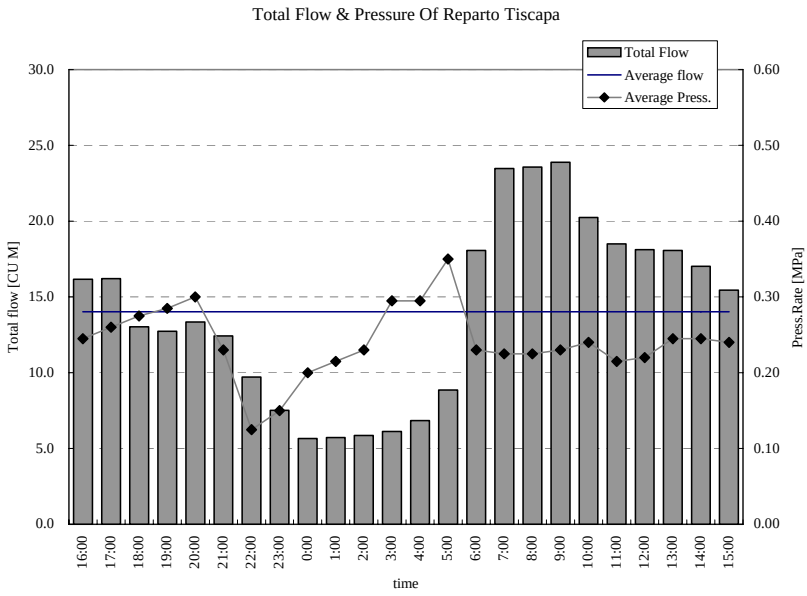
9. Micro Sector – Reparto Tiscapa

Micro Sector	
Reparto Tiscapa	
Max.	
2004/11/11	07:07:00
31.108	CU M/HR
Min.	
2004/11/11	00:01:00
4.920	CU M/HR
Average.	
14.021	CU M/HR
Total.	
336.590	CU M



Minimum Night Flow		
Measurement Press.	0.20	[Mpa]
Conversion Press.	0.24	[Mpa]
Minimum Flow	4.920	[CU M/HR]
Conversion Flow	5.390	[CU M/HR]
Leakage Ratio	38.43	%

Total Flow Ave.	
14.02	CU M/HR
Total Flow Max.	
23.89	CU M/HR
Max.Flow ratio	
1.70	



Date	Time	Total Flow
2004/11/10	16:00	16.2
2004/11/10	17:00	16.2
2004/11/10	18:00	13.0
2004/11/10	19:00	12.7
2004/11/10	20:00	13.4
2004/11/10	21:00	12.4
2004/11/10	22:00	9.7
2004/11/10	23:00	7.5
2004/11/11	0:00	5.7
2004/11/11	1:00	5.7
2004/11/11	2:00	5.9
2004/11/11	3:00	6.1
2004/11/11	4:00	6.8
2004/11/11	5:00	8.9
2004/11/11	6:00	18.1
2004/11/11	7:00	23.5
2004/11/11	8:00	23.6
2004/11/11	9:00	23.9
2004/11/11	10:00	20.2
2004/11/11	11:00	18.5
2004/11/11	12:00	18.1
2004/11/11	13:00	18.1
2004/11/11	14:00	17.0
2004/11/11	15:00	15.5

Pressure Measurement Data

MICRO SECTOR: Reparto Tiscapa — High Elevation Zone

DATE: 2004/NOV/10 --- 2004/NOV/11

LOCATION: A Near the Inlet

COORDENADAS: Este 578973 Norte 1340561 Elev. m

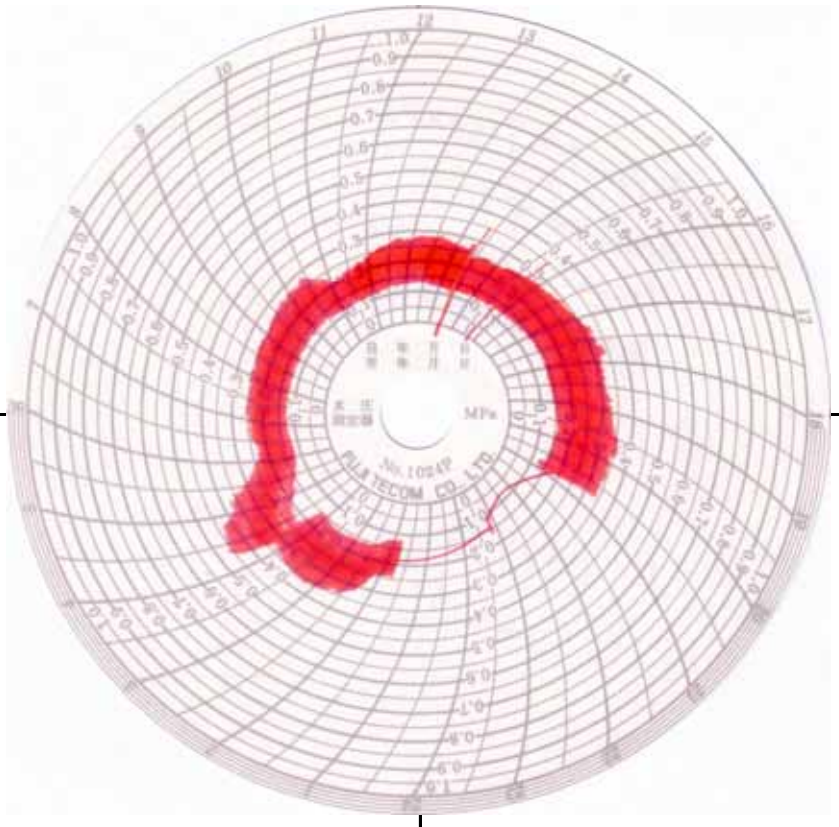
MEASURED VALUE

Pressure	[MPa]	[psi]
High	0.36	52.21
Average*	0.20	29.01
Low	0.08	11.60

* Average of Hourly variation

Hourly variation [MPa]

time	1	2	3	4	5	6	7	8	9	10	11	12
value	0.18	0.20	0.26	0.25	0.30	0.18	0.18	0.18	0.18	0.20	0.17	0.18
time	13	14	15	16	17	18	19	20	21	22	23	24
value	0.21	0.20	0.19	0.21	0.22	0.23	0.25	0.26	0.16	0.09	0.10	0.16



Note:

Pressure Measurement Data

MICRO SECTOR: Reparto Tiscapa — High Elevation Zone

DATE: 2004/NOV/10 --- 2004/NOV/11

LOCATION: B Parte Final

COORDENADAS: Este 579085 Norte 1340920 Elev. m

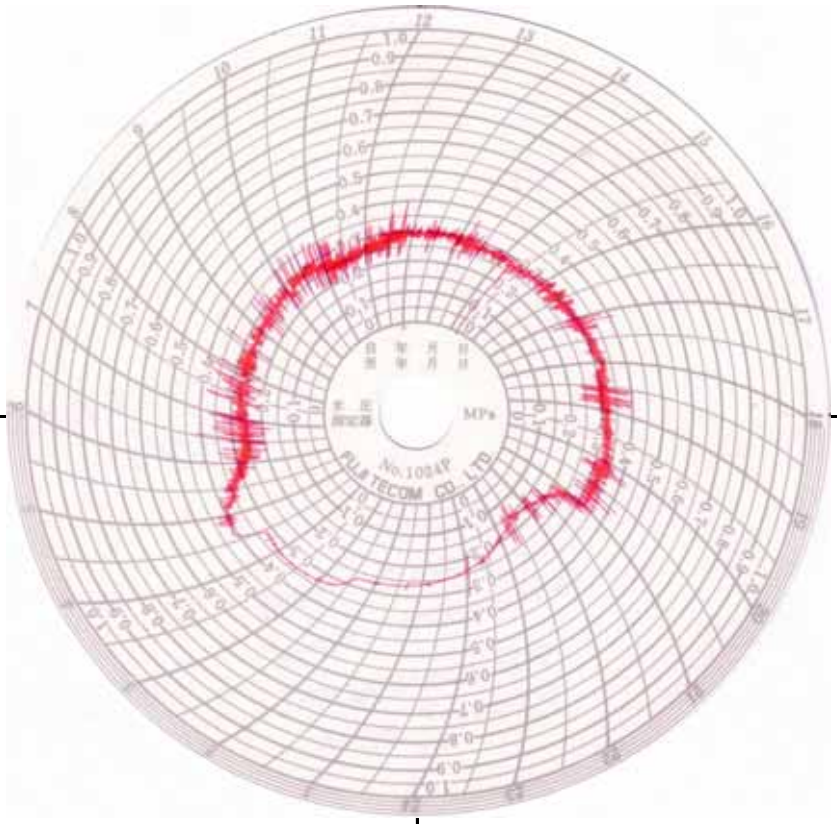
MEASURED VALUE

Pressure	[MPa]	[psi]
High	0.41	59.47
Average*	0.28	40.61
Low	0.15	21.76

* Average of Hourly variation

Hourly variation [MPa]

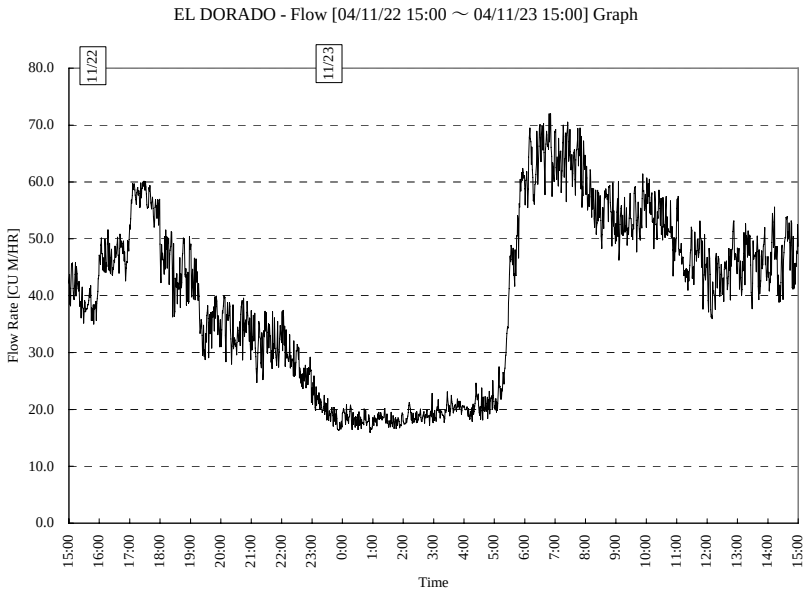
time	1	2	3	4	5	6	7	8	9	10	11	12
value	0.25	0.26	0.33	0.34	0.40	0.28	0.27	0.27	0.28	0.28	0.26	0.26
time	13	14	15	16	17	18	19	20	21	22	23	24
value	0.28	0.29	0.28	0.28	0.30	0.32	0.32	0.34	0.30	0.16	0.20	0.24



Note:

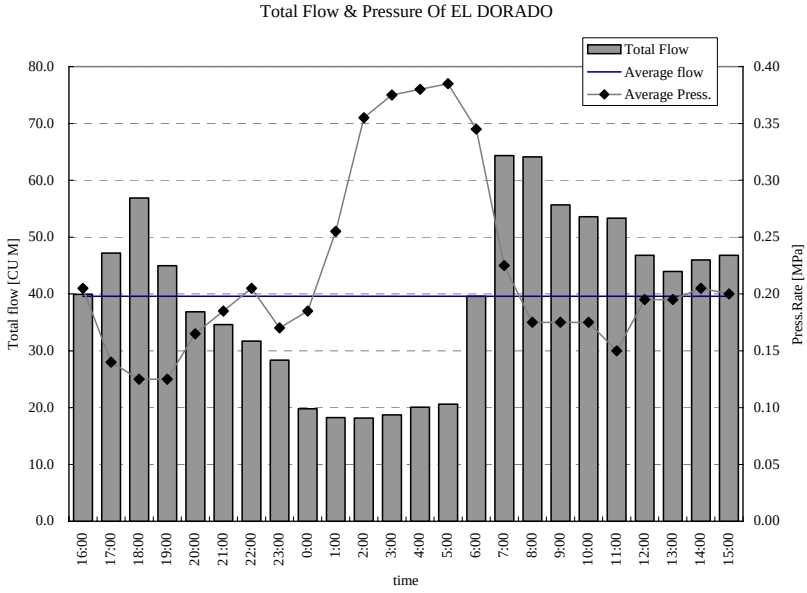
10. Micro Sector – El Dorado

Micro Sector	
EL DORADO	
Max.	
2004/11/23	06:51:00
71.971	CU M/HR
Min.	
2004/11/23	00:55:00
15.995	CU M/HR
Average.	
39.593	CU M/HR
Total.	
950.190	CU M



Minimum Night Flow		
Measurement Press.	0.36	[Mpa]
Conversion Press.	0.22	[Mpa]
Minimum Flow	15.995	[CU M/HR]
Conversion Flow	12.504	[CU M/HR]
Leakage Ratio	31.58	%

Total Flow Ave.
39.59 CU M/HR
Total Flow Max.
64.35 CU M/HR
Max.Flow ratio
1.63



Date	Time	Total Flow
2004/11/22	16:00	39.9
2004/11/22	17:00	47.2
2004/11/22	18:00	56.9
2004/11/22	19:00	45.0
2004/11/22	20:00	36.9
2004/11/22	21:00	34.6
2004/11/22	22:00	31.7
2004/11/22	23:00	28.3
2004/11/23	0:00	19.8
2004/11/23	1:00	18.2
2004/11/23	2:00	18.2
2004/11/23	3:00	18.7
2004/11/23	4:00	20.1
2004/11/23	5:00	20.6
2004/11/23	6:00	39.6
2004/11/23	7:00	64.4
2004/11/23	8:00	64.1
2004/11/23	9:00	55.7
2004/11/23	10:00	53.6
2004/11/23	11:00	53.3
2004/11/23	12:00	46.8
2004/11/23	13:00	44.0
2004/11/23	14:00	46.0
2004/11/23	15:00	46.8

Pressure Measurement Data

MICRO SECTOR: El Dorado High Elevation Zone

DATE: 2004/NOV/22 --- 2004/NOV/23

LOCATION: A Near the Inlet

COORDENADAS: Este 581595 Norte 1341513 Elev. m

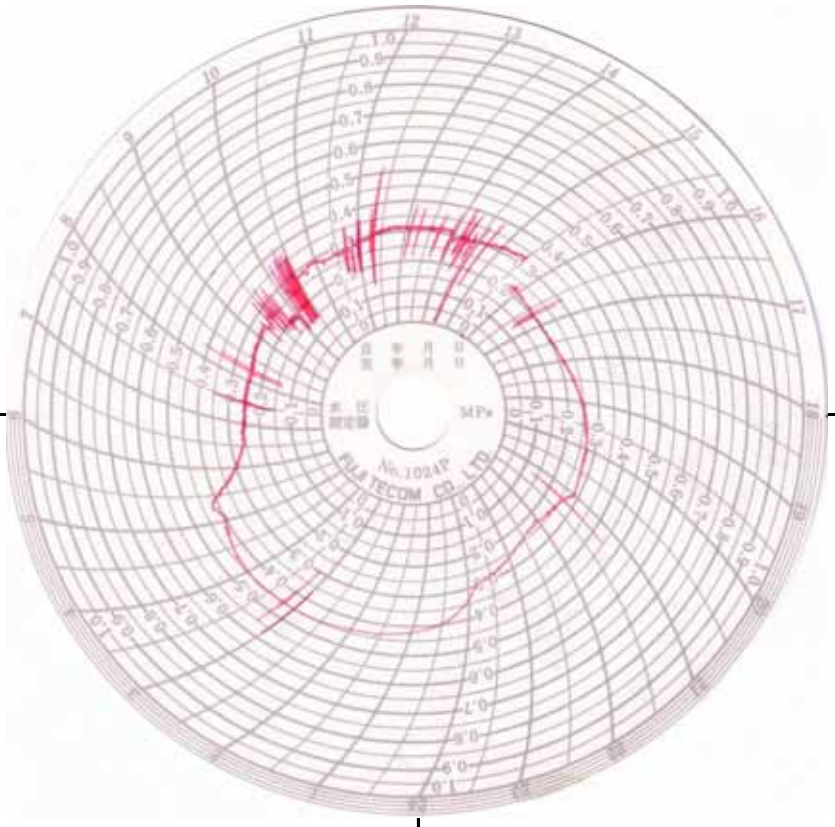
MEASURED VALUE

Pressure	[MPa]	[psi]
High	0.45	65.27
Average*	0.30	43.51
Low	0.20	29.01

* Average of Hourly variation

Hourly variation [MPa]

time	1	2	3	4	5	6	7	8	9	10	11	12
value	0.42	0.44	0.45	0.45	0.40	0.30	0.25	0.25	0.25	0.20	0.29	0.29
time	13	14	15	16	17	18	19	20	21	22	23	24
value	0.31	0.30	0.31	0.22	0.20	0.20	0.25	0.26	0.28	0.24	0.26	0.35



Note:

Pressure Measurement Data

MICRO SECTOR: El Dorado High Elevation Zone

DATE: 2004/NOV/22 --- 2004/NOV/23

LOCATION: B Parte Final

COORDENADAS: Este 581961 Norte 1340937 Elev. m

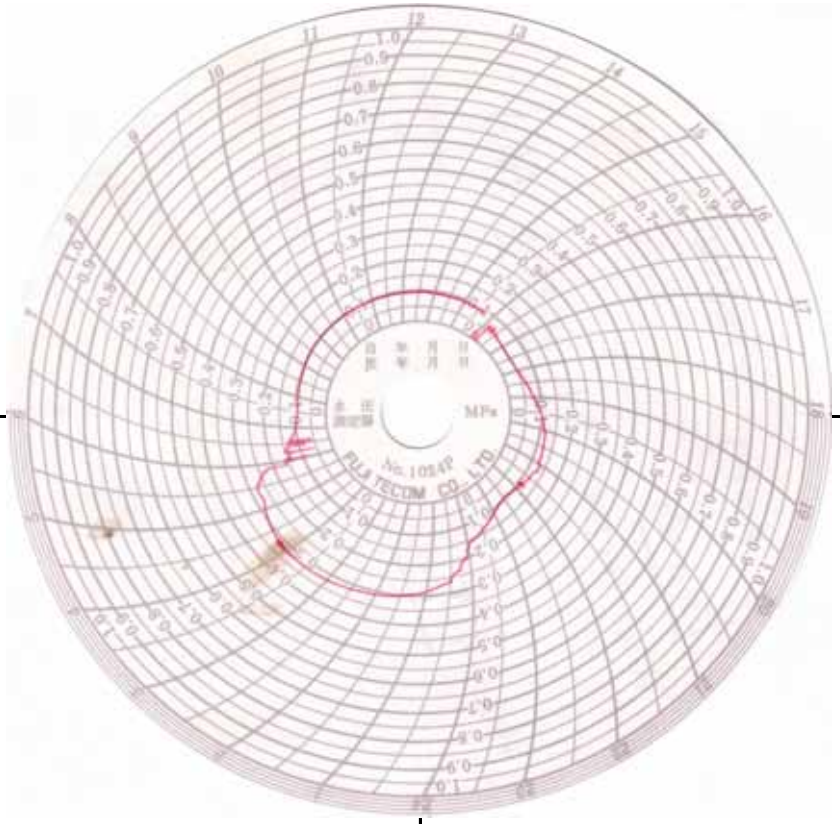
MEASURED VALUE

Pressure	[MPa]	[psi]
High	0.32	46.41
Average*	0.14	20.31
Low	0.05	7.25

* Average of Hourly variation

Hourly variation [MPa]

time	1	2	3	4	5	6	7	8	9	10	11	12
value	0.29	0.31	0.31	0.32	0.29	0.15	0.10	0.10	0.10	0.10	0.10	0.10
time	13	14	15	16	17	18	19	20	21	22	23	24
value	0.10	0.10	0.10	0.06	0.05	0.05	0.08	0.11	0.13	0.10	0.11	0.16



Note:

11. Micro Sector – Los Arcos After Leak Repair

Micro Sector	
LOS ARCOS	
Max.	
2004/11/25	10:15:00
32.772	CU M/HR
Min.	
2004/11/25	2:00:00
5.687	CU M/HR
Average.	
15.542	CU M/HR
Total.	
370.700	CU M

Minimum Night Flow		
Measurement Press.	0.36	[Mpa]
Conversion Press.	0.20	[Mpa]
Minimum Flow	5.687	[CU M/HR]
Conversion Flow	4.239	[CU M/HR]
Leakage Ratio	27.44	%

Balance [Flow1-Flow2]

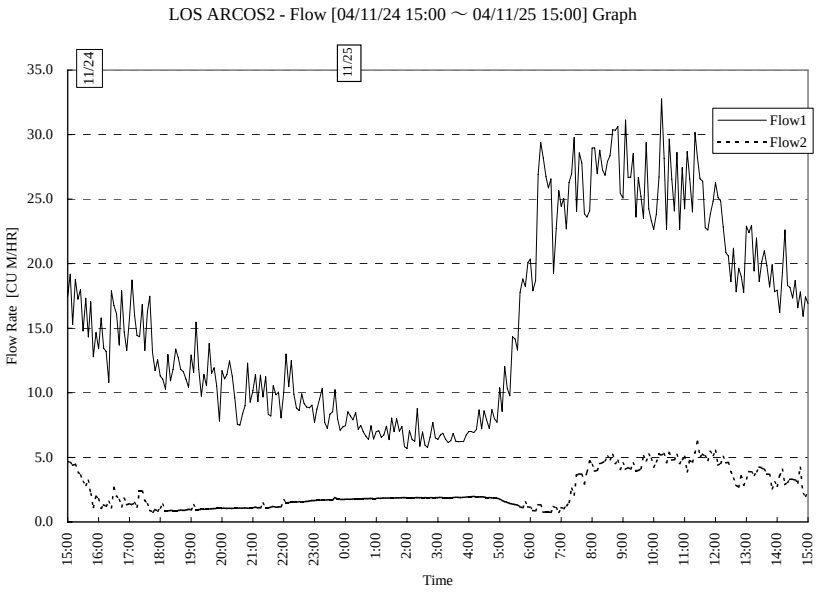
Max.	
2004/11/24	10:15:00
28.089	CU M/HR
Min.	
2004/11/25	2:00:00
3.823	CU M/HR

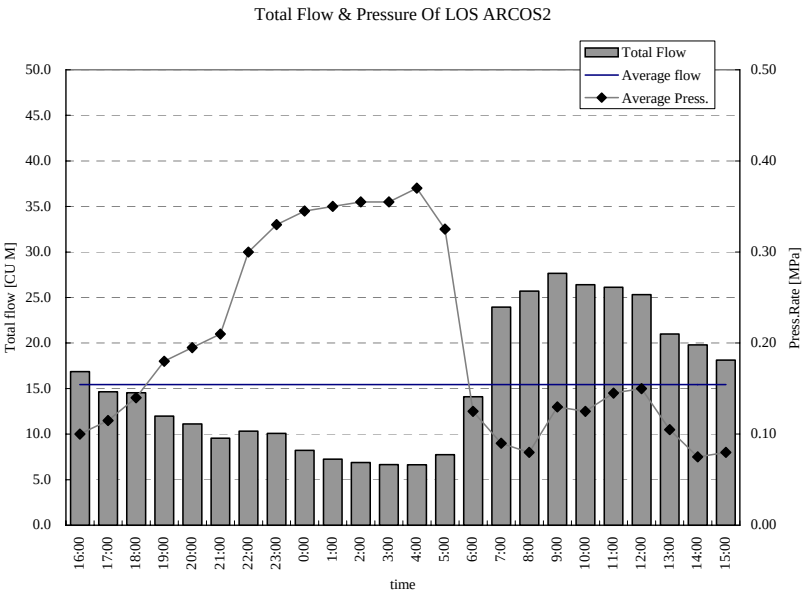
Minimum Night Flow[-INIFOM]		
Measurement Press.	0.36	[Mpa]
Conversion Press.	0.20	[Mpa]
Minimum Flow	3.823	[CU M/HR]
Conversion Flow	2.849	[CU M/HR]
Leakage Ratio	21.87	%

Total-Flow2[INIFOM] 312.74

Total Flow Ave.
15.45 CU M/HR
Total Flow Max.
27.65 CU M/HR
Max.Flow ratio
1.79

Date	Time	Total Flow
2004/11/24	16:00	16.87
2004/11/24	17:00	14.65
2004/11/24	18:00	14.55
2004/11/24	19:00	11.99
2004/11/24	20:00	11.11
2004/11/24	21:00	9.55
2004/11/24	22:00	10.33
2004/11/24	23:00	10.08
2004/11/25	0:00	8.21
2004/11/25	1:00	7.25
2004/11/25	2:00	6.88
2004/11/25	3:00	6.65
2004/11/25	4:00	6.63
2004/11/25	5:00	7.74
2004/11/25	6:00	14.11
2004/11/25	7:00	23.96
2004/11/25	8:00	25.71
2004/11/25	9:00	27.65
2004/11/25	10:00	26.41
2004/11/25	11:00	26.13
2004/11/25	12:00	25.31
2004/11/25	13:00	21.00
2004/11/25	14:00	19.80
2004/11/25	15:00	18.13





Pressure Measurement Data

MICRO SECTOR: LOS ARCOS — Low Elevation Zone

DATE: 2004/NOV/24 --- 2004/NOV/25

LOCATION: A Entrada 50metros al este

COORDENADAS: Este 575001 Norte 1343011 Elev. m

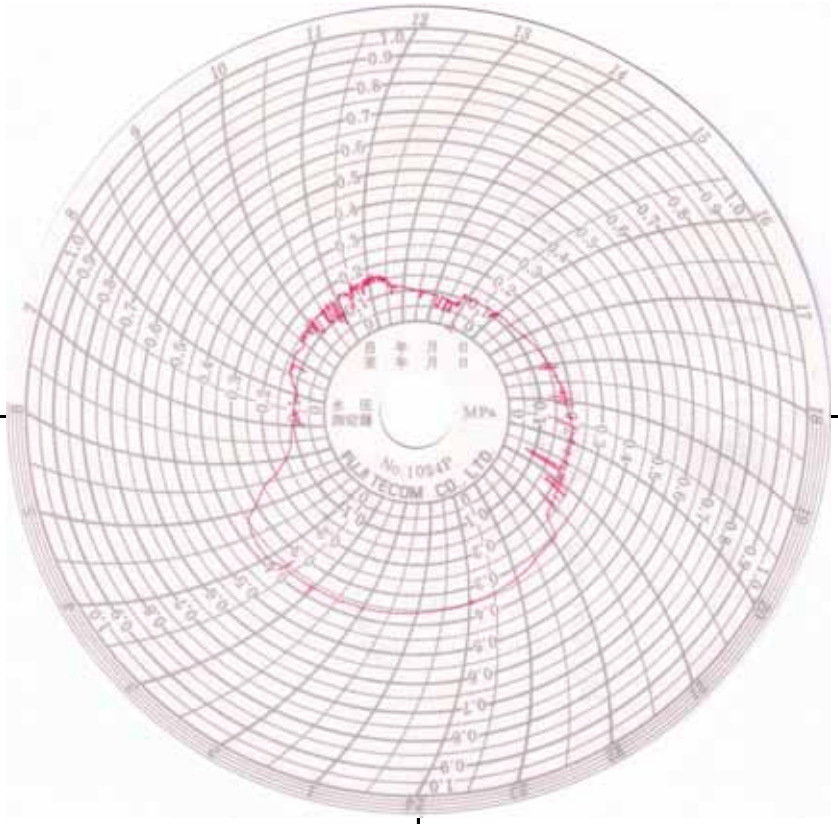
MEASURED VALUE

Pressure	[MPa]	[psi]
High	0.43	62.37
Average*	0.21	30.46
Low	0.05	7.25

* Average of Hourly variation

Hourly variation [MPa]

time	1	2	3	4	5	6	7	8	9	10	11	12
value	0.35	0.36	0.36	0.38	0.31	0.15	0.10	0.10	0.14	0.15	0.15	0.16
time	13	14	15	16	17	18	19	20	21	22	23	24
value	0.11	0.09	0.11	0.11	0.13	0.15	0.18	0.20	0.22	0.30	0.34	0.35



Note:

Pressure Measurement Data

MICRO SECTOR: LOS ARCOS Low Elevation Zone

DATE: 2004/NOV/24 --- 2004/NOV/25

LOCATION: B Entrada al Hospital Lenin Fonseca 4c Este 2c. Al sur ultima casa

COORDENADAS: Este 575194 Norte 1342774 Elev. m

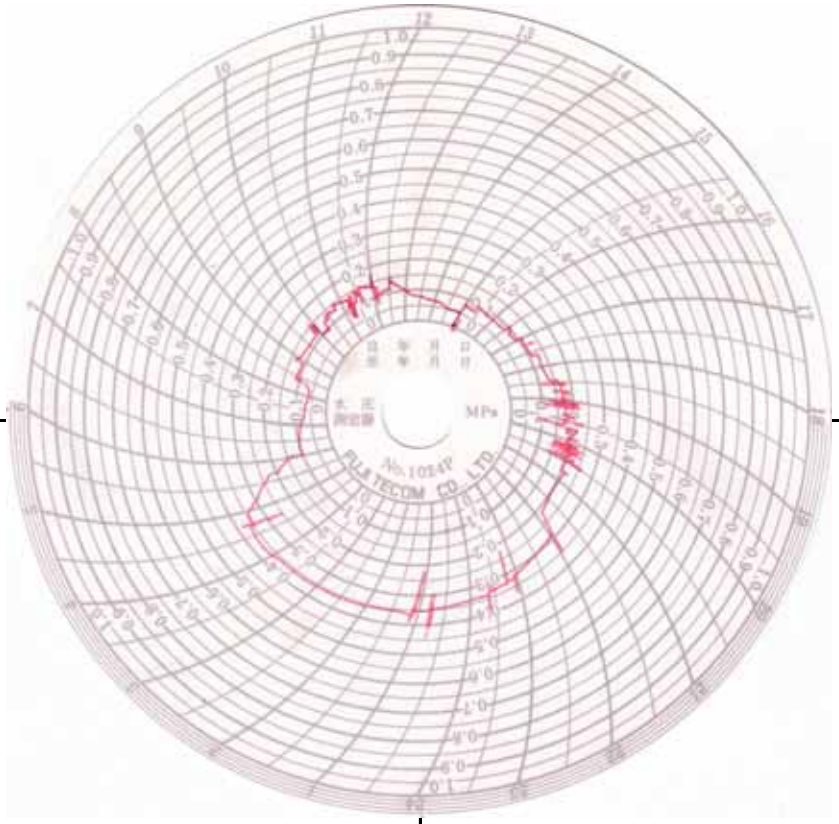
MEASURED VALUE

Pressure	[MPa]	[psi]
High	0.36	52.21
Average*	0.19	27.56
Low	0.05	7.25

* Average of Hourly variation

Hourly variation [MPa]

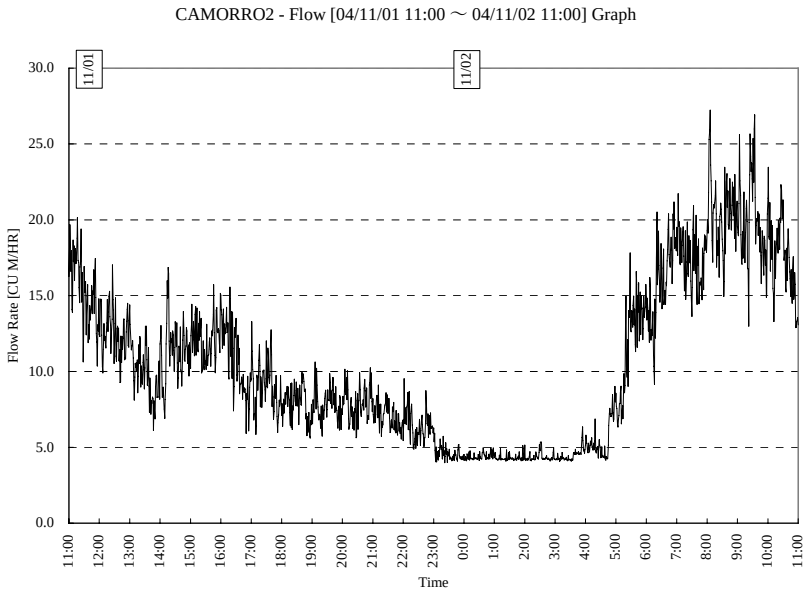
time	1	2	3	4	5	6	7	8	9	10	11	12
value	0.35	0.35	0.35	0.36	0.34	0.10	0.08	0.06	0.12	0.10	0.14	0.14
time	13	14	15	16	17	18	19	20	21	22	23	24
value	0.10	0.06	0.05	0.09	0.10	0.13	0.18	0.19	0.20	0.30	0.32	0.34



Note:

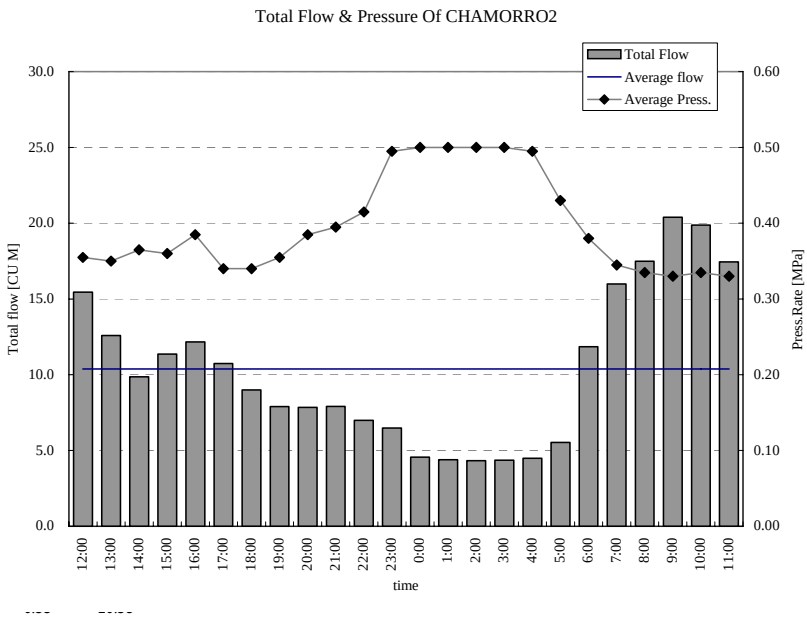
12. Micro Sector – Villa P. J. Chamorro After Leak Repair

Micro Sector	
CHAMORRO2	
Max.	
2004/11/02	08:06:00
27.239	CU M/HR
Min.	
2004/11/01	23:22:00
3.983	CU M/HR
Average.	
10.379	CU M/HR
Total.	
249.003	CU M



Minimum Night Flow		
Measurement Press.	0.50	[Mpa]
Conversion Press.	0.40	[Mpa]
Minimum Flow	3.983	[CU M/HR]
Conversion Flow	3.563	[CU M/HR]
Leakage Ratio	34.34	%

Total Flow Ave.	
10.38	CU M/HR
Total Flow Max.	
20.39	CU M/HR
Max.Flow ratio	
1.97	



Date	Time	Total Flow
2004/11/1	12:00	15.4
2004/11/1	13:00	12.6
2004/11/1	14:00	9.9
2004/11/1	15:00	11.4
2004/11/1	16:00	12.2
2004/11/1	17:00	10.7
2004/11/1	18:00	9.0
2004/11/1	19:00	7.9
2004/11/1	20:00	7.8
2004/11/1	21:00	7.9
2004/11/1	22:00	7.0
2004/11/1	23:00	6.5
2004/11/1	0:00	4.6
2004/11/2	1:00	4.4
2004/11/2	2:00	4.3
2004/11/2	3:00	4.4
2004/11/2	4:00	4.5
2004/11/2	5:00	5.5
2004/11/2	6:00	11.8
2004/11/2	7:00	16.0
2004/11/2	8:00	17.5
2004/11/2	9:00	20.4
2004/11/2	10:00	19.9
2004/11/2	11:00	17.4

Pressure Measurement Data

MICRO SECTOR: CHAMORRO — Low Elevation Zone

DATE: 2004/NOV/01 --- 2004/NOV/02

LOCATION: A ENTRADA

COORDENADAS: Este 582899 Norte 1343569 Elev. m

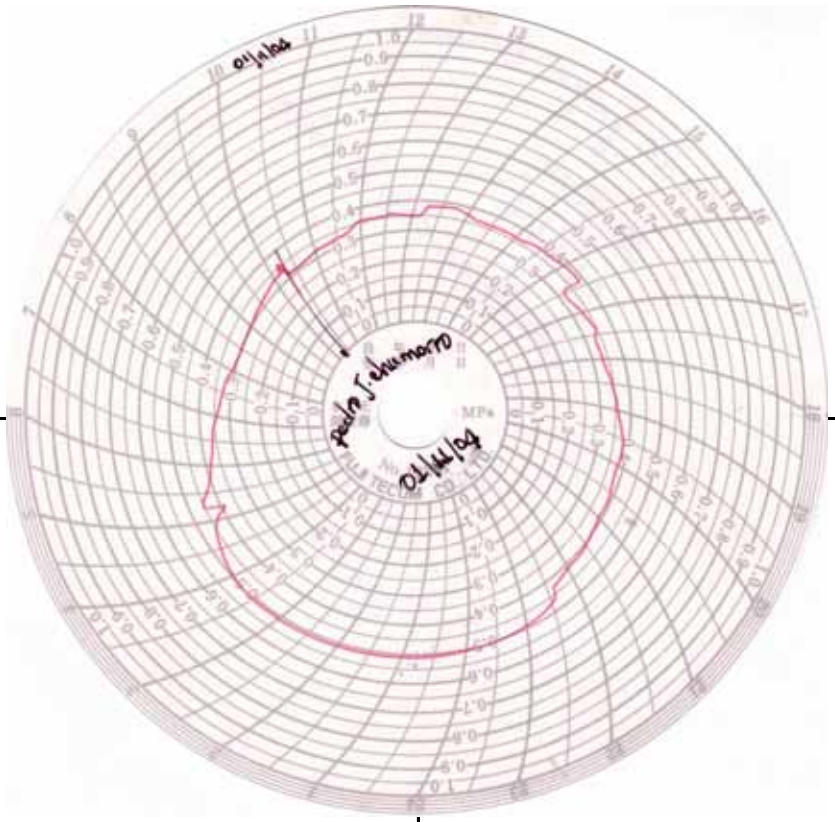
MEASURED VALUE

Pressure	[MPa]	[psi]
High	0.51	73.97
Average*	0.39	56.56
Low	0.30	43.51

* Average of Hourly variation

Hourly variation [MPa]

time	1	2	3	4	5	6	7	8	9	10	11	12
value	0.50	0.50	0.50	0.50	0.44	0.38	0.35	0.31	0.30	0.33	0.32	0.35
time	13	14	15	16	17	18	19	20	21	22	23	24
value	0.35	0.37	0.36	0.38	0.34	0.34	0.35	0.38	0.39	0.41	0.49	0.50



Note:

Pressure Measurement Data

MICRO SECTOR: CHAMORRO Low Elevation Zone

DATE: 2004/NOV/01 --- 2004/NOV/02

LOCATION: B Customer No.37000

COORDENADAS: Este 583020 Norte 1343769 Elev. m

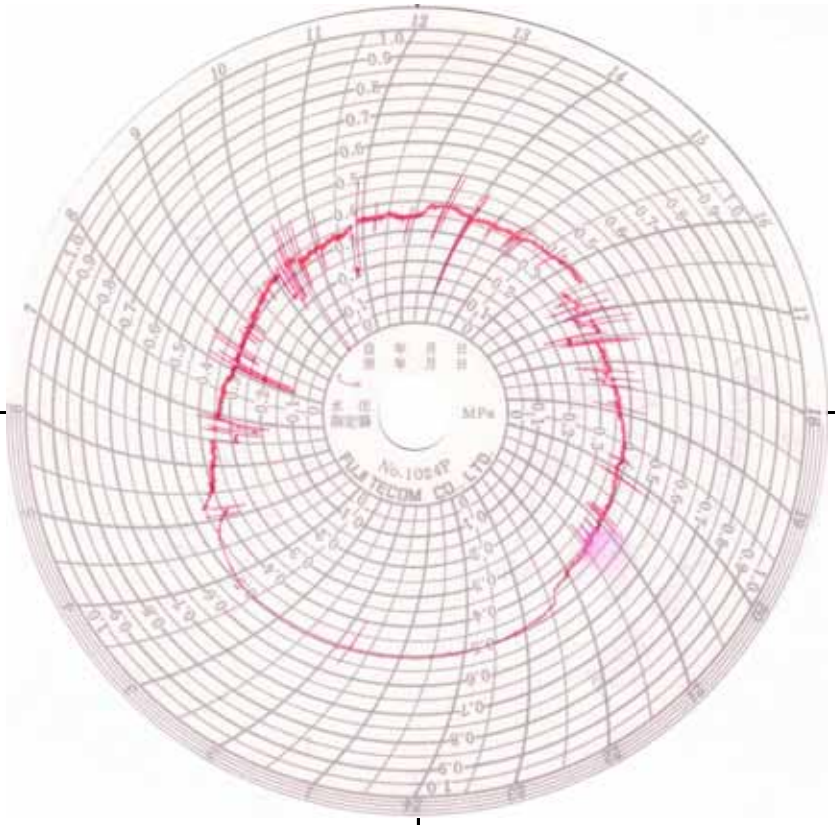
MEASURED VALUE

Pressure	[MPa]	[psi]
High	0.50	72.52
Average*	0.40	58.02
Low	0.25	36.26

* Average of Hourly variation

Hourly variation [MPa]

time	1	2	3	4	5	6	7	8	9	10	11	12
value	0.50	0.50	0.50	0.49	0.42	0.38	0.34	0.36	0.36	0.34	0.33	0.36
time	13	14	15	16	17	18	19	20	21	22	23	24
value	0.35	0.36	0.36	0.39	0.34	0.34	0.36	0.39	0.40	0.42	0.50	0.50

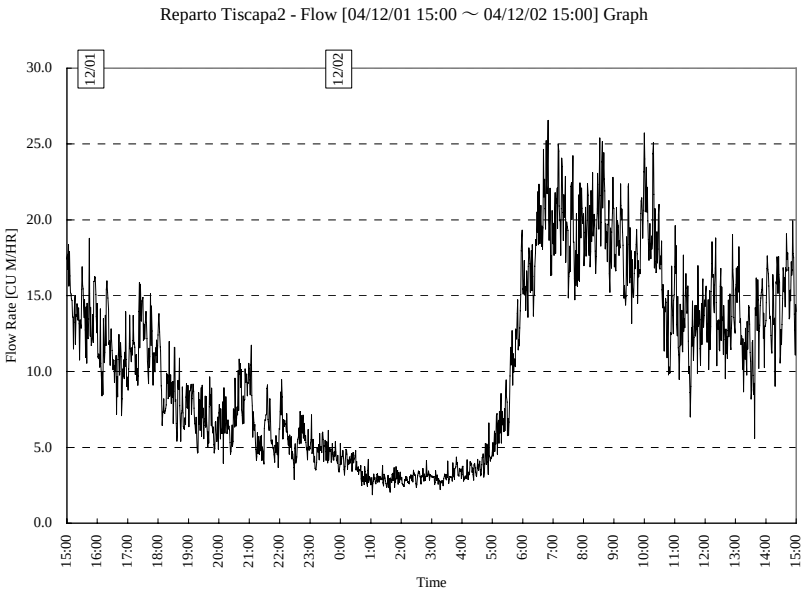


Note:

13. Micro Sector – Reparto Tiscapa After Leak Detection and Leak Repair

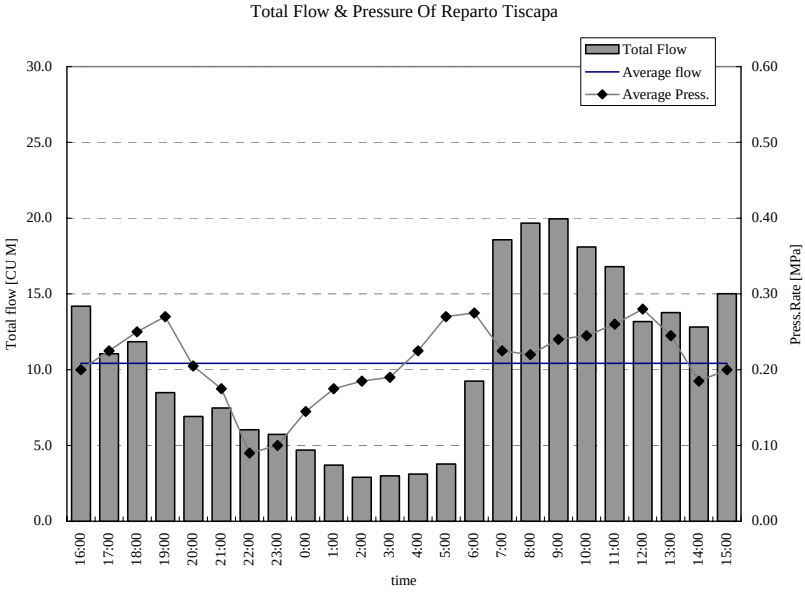
Micro Sector	
Reparto Tiscapa2	
Max.	
2004/12/02	06:50:00
26.556	CU M/HR
Min.	
2004/12/02	01:03:00
1.879	CU M/HR
Average.	
10.423	CU M/HR
Total.	
250.044	CU M

*1minute data



Minimum Night Flow		
Measurement Press.	0.18	[Mpa]
Conversion Press.	0.22	[Mpa]
Minimum Flow	1.879	[CU M/HR]
Conversion Flow	2.077	[CU M/HR]
Leakage Ratio	19.94	%

Total Flow Ave.	
10.42	CU M/HR
Total Flow Max.	
19.96	CU M/HR
Max.Flow ratio	
1.92	



Date	Time	Total Flow
2004/12/1	16:00	14.2
2004/12/1	17:00	11.0
2004/12/1	18:00	11.9
2004/12/1	19:00	8.5
2004/12/1	20:00	6.9
2004/12/1	21:00	7.5
2004/12/1	22:00	6.0
2004/12/1	23:00	5.7
2004/12/2	0:00	4.7
2004/12/2	1:00	3.7
2004/12/2	2:00	2.9
2004/12/2	3:00	3.0
2004/12/2	4:00	3.1
2004/12/2	5:00	3.8
2004/12/2	6:00	9.2
2004/12/2	7:00	18.6
2004/12/2	8:00	19.7
2004/12/2	9:00	20.0
2004/12/2	10:00	18.1
2004/12/2	11:00	16.8
2004/12/2	12:00	13.2
2004/12/2	13:00	13.8
2004/12/2	14:00	12.8
2004/12/2	15:00	15.0

Pressure Measurement Data

MICRO SECTOR: Reparto Tiscapa High Elevation Zone

DATE: 2004/DEC/01 --- 2004/DEC/01

LOCATION: A Near the Inlet

COORDENADAS: Este 578973 Norte 1340561 Elev. m

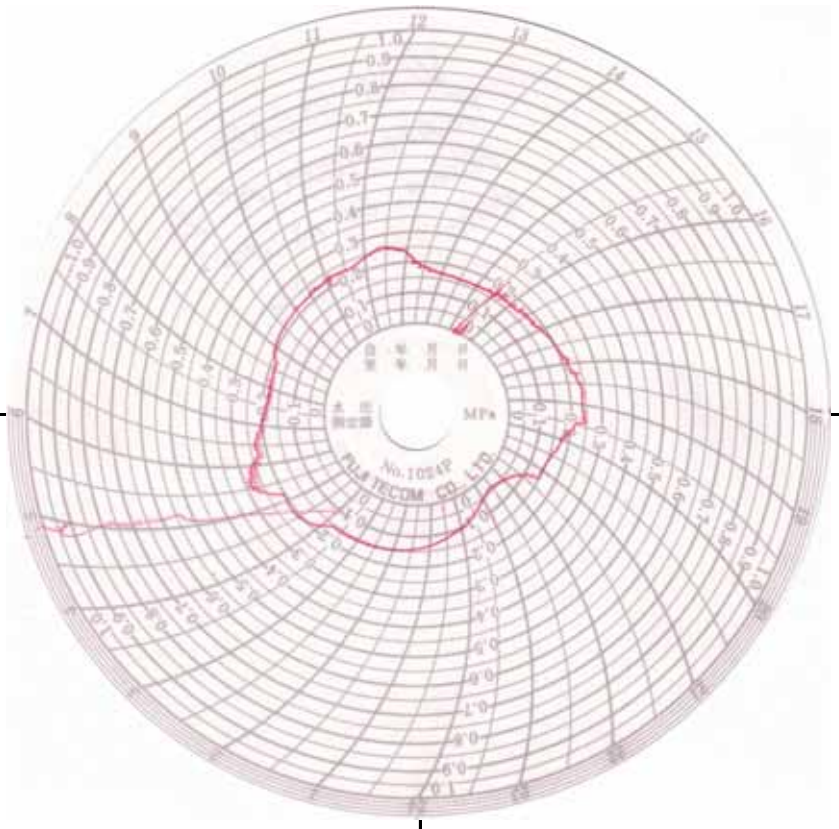
MEASURED VALUE

Pressure	[MPa]	[psi]
High	0.29	42.06
Average*	0.18	26.11
Low	0.04	5.80

* Average of Hourly variation

Hourly variation [MPa]

time	1	2	3	4	5	6	7	8	9	10	11	12
value	0.14	0.15	0.15	0.17	0.20	0.25	0.20	0.19	0.21	0.22	0.23	0.25
time	13	14	15	16	17	18	19	20	21	22	23	24
value	0.24	0.16	0.16	0.16	0.19	0.21	0.24	0.18	0.15	0.06	0.05	0.10



Note:

Pressure Measurement Data

MICRO SECTOR: Reparto Tiscapa — High Elevation Zone

DATE: 2004/DEC/01 --- 2004/DEC/01

LOCATION: B Parte Final

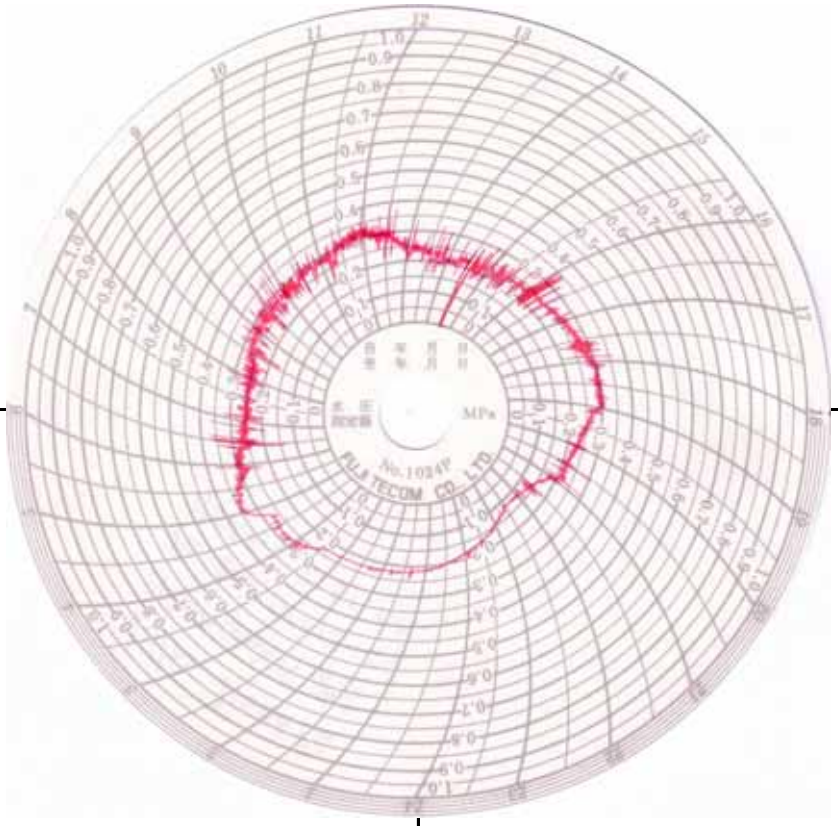
COORDENADAS: Este 579085 Norte 1340920 Elev. m

MEASURED VALUE

Pressure	[MPa]	[psi]	
High	0.34	49.31	
Average*	0.25	36.26	* Average of Hourly variation
Low	0.11	15.95	

Hourly variation [MPa]

time	1	2	3	4	5	6	7	8	9	10	11	12
value	0.21	0.22	0.23	0.28	0.34	0.30	0.25	0.25	0.27	0.27	0.29	0.31
time	13	14	15	16	17	18	19	20	21	22	23	24
value	0.25	0.21	0.23	0.24	0.26	0.29	0.30	0.23	0.20	0.12	0.15	0.19

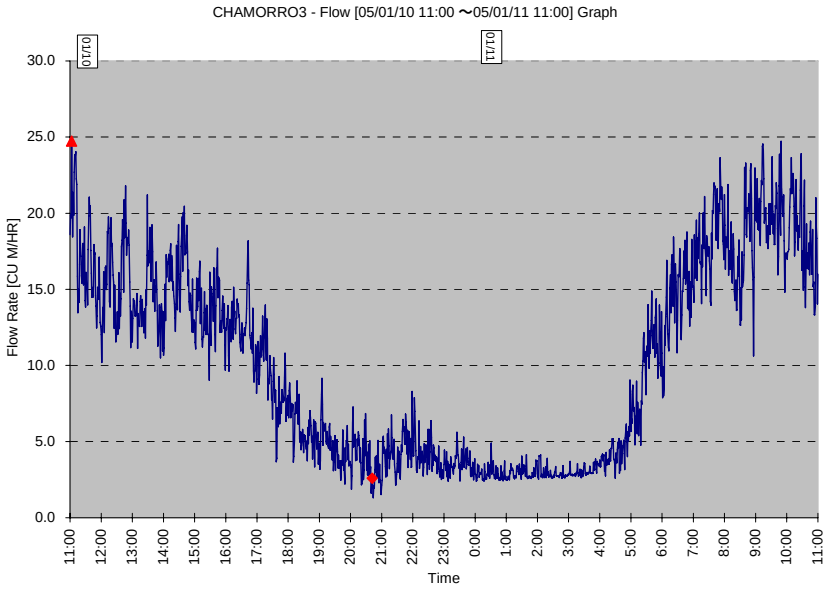


Note:

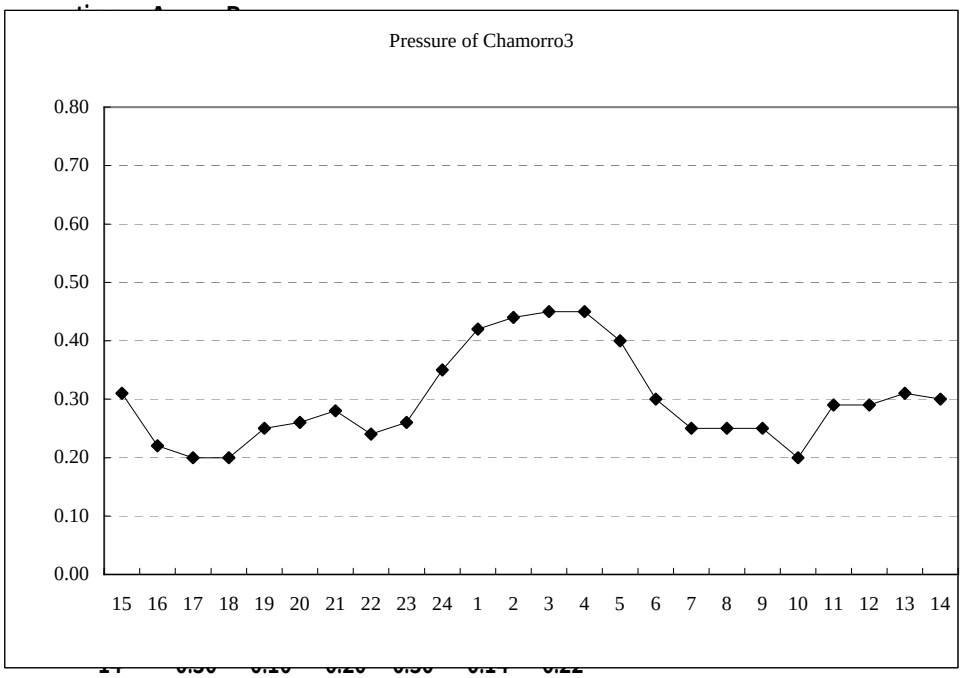
14. Micro – Sector Villa P. J. Chamorro After Leak Repair, Meter Replacement, and Disconnecting Illegal Connections

Data No.	
CHAMORRO 3	
Max.	
2005/01/10	11:03:00
24.74	CU M/HR
Min.	
2005/01/10	01:29:00
2.519	CU M/HR
Average.	
9.96	CU M/HR
Total.	
239.00	CU M

Minimum Night Flow		
Measurement Press.	0.45	[Mpa]
Conversion Press.	0.30	[Mpa]
Minimum Flow	2.519	[CU M/HR]
Conversion Flow	2.057	[CU M/HR]
Leakage Ratio	20.65	%



Pressure Measurement Data



Pressure Measurement Data

MICRO SECTOR: Chamorro — Low Elevation Zone

DATE: 2005/JAN/10 --- 2005/JAN/11

LOCATION: Entrada

COORDENADAS: Este 582873 Norte 1343781 Elev. 58 m

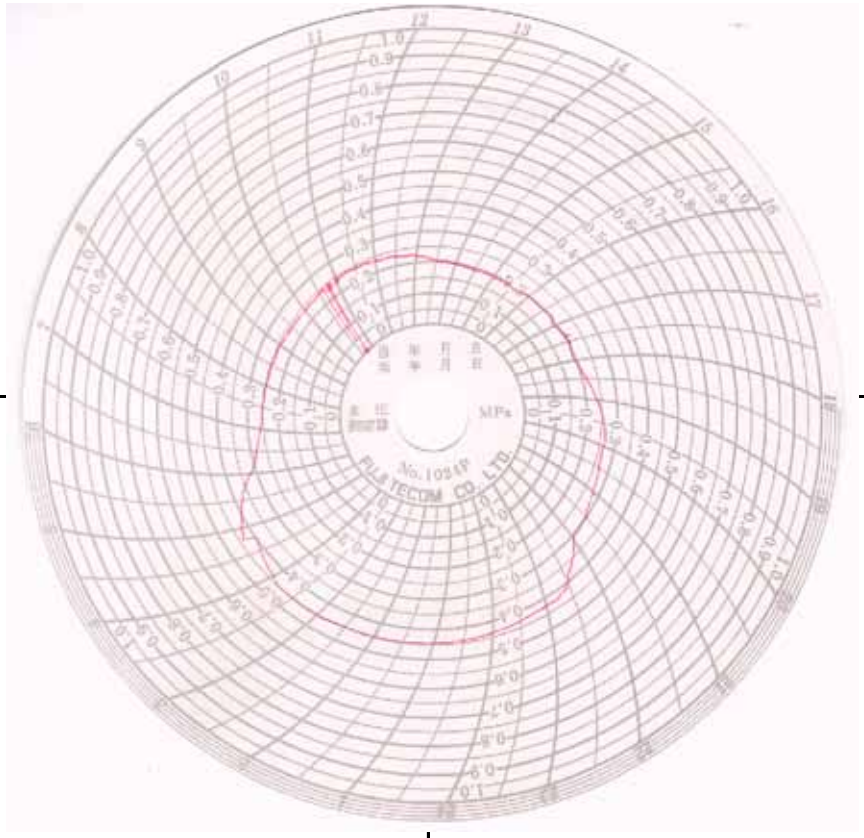
MEASURED VALUE

Pressure	[MPa]	[psi]
High	0.45	65.27
Average*	0.30	43.51
Low	0.20	29.01

* Average of Hourly variation

Hourly variation [MPa]

time	1	2	3	4	5	6	7	8	9	10	11	12
value	0.45	0.45	0.45	0.43	0.42	0.32	0.25	0.25	0.25	0.24	0.25	0.24
time	13	14	15	16	17	18	19	20	21	22	23	24
value	0.22	0.20	0.20	0.20	0.20	0.20	0.24	0.26	0.28	0.30	0.42	0.44

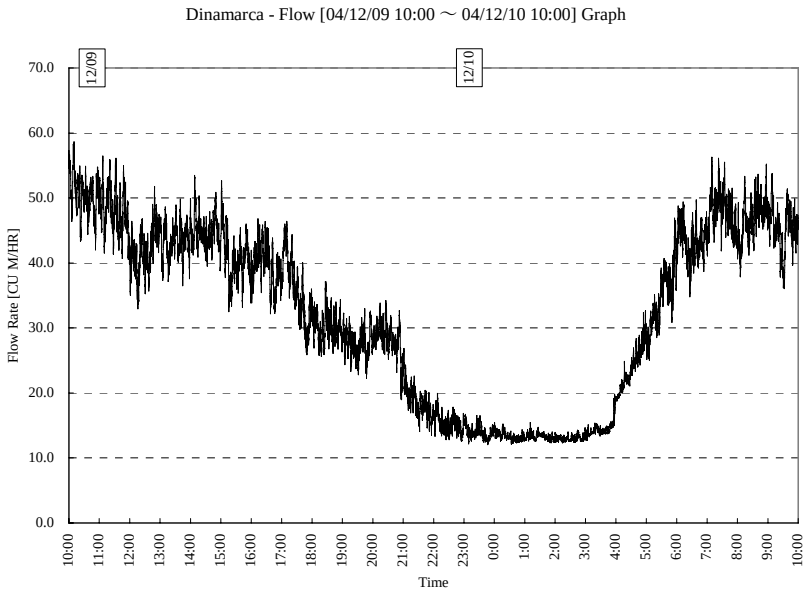


Note:

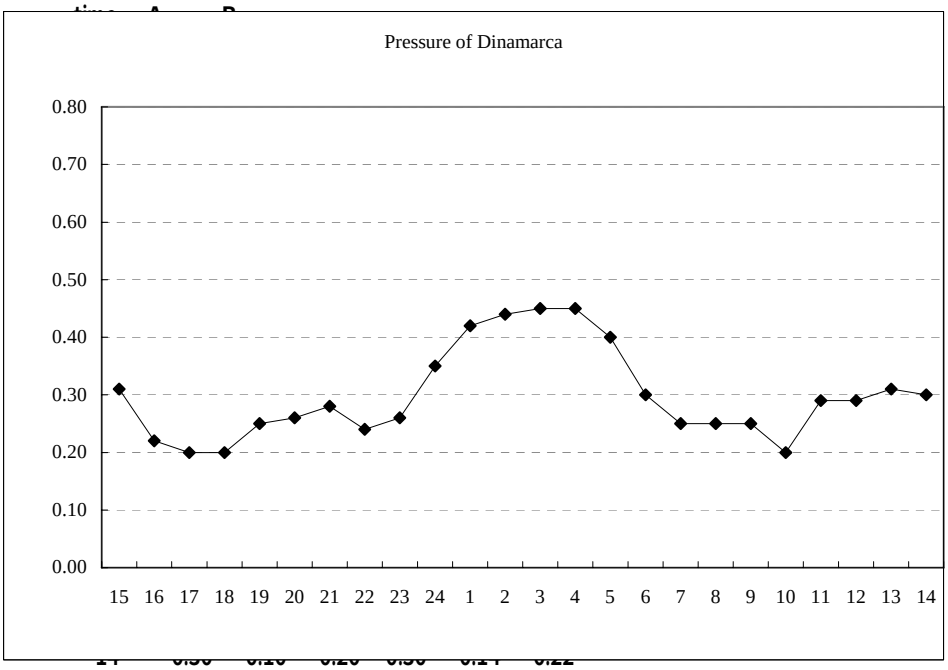
15. Asentamiento – Dinamarca

Micro Sector	
Dinamarca	
Max.	
2004/12/09	10:10:00
58.628	CU M/HR
Min.	
2004/12/10	23:47:05
12.049	CU M/HR
Average.	
32.289	CU M/HR
Total.	
774.910	CU M

Minimum Night Flow		
Measurement Press.	0.22	[Mpa]
Conversion Press.	0.22	[Mpa]
Minimum Flow	12.049	[CU M/HR]
Conversion Flow	12.049	[CU M/HR]
Leakage Ratio	37.32	%



Pressure Measurement Data



DATE: 2004/DEC/13 --- 2004/DEC/14

LOCATION: A Around Centre of the Area

COORDENADAS: Este 575640 Norte 1341819 Elev. m

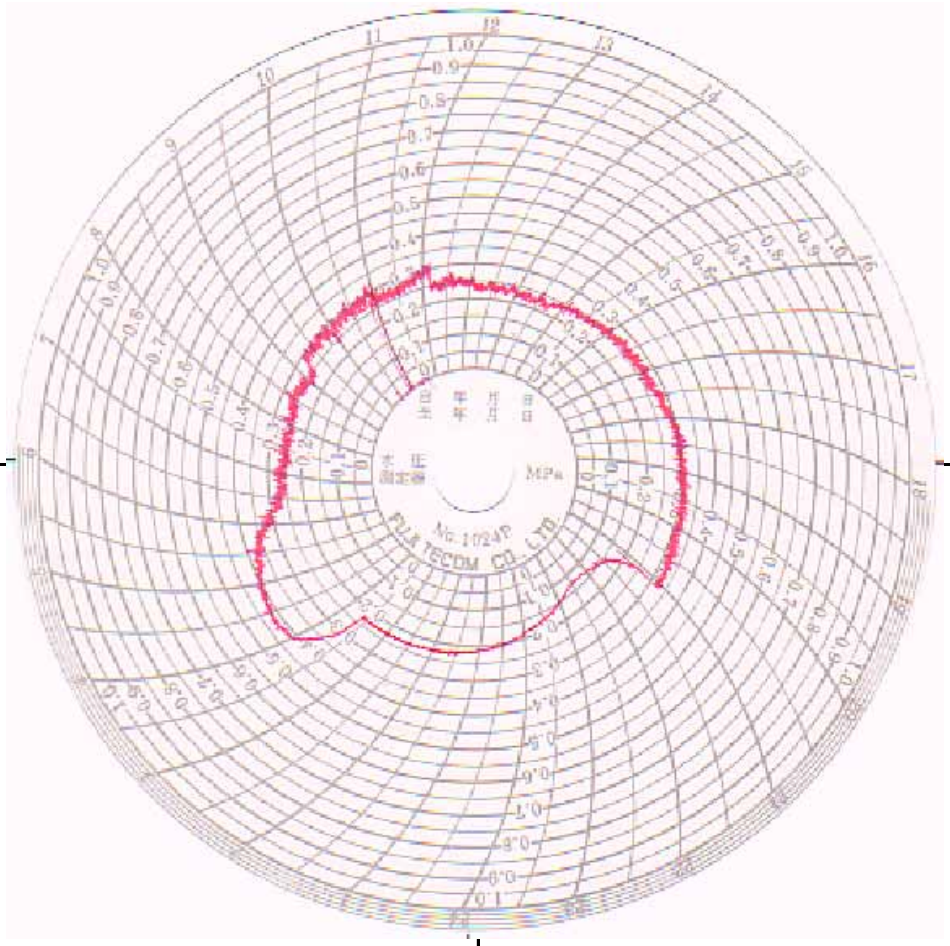
MEASURED VALUE

Pressure	[MPa]	[psi]
High	0.42	60.92
Average*	0.26	37.71
Low	0.13	18.85

* Average of Hourly variation

Hourly variation [MPa]

time	1	2	3	4	5	6	7	8	9	10	11	12
value	0.21	0.23	0.23	0.41	0.40	0.32	0.26	0.25	0.25	0.28	0.27	0.30
time	13	14	15	16	17	18	19	20	21	22	23	24
value	0.24	0.23	0.24	0.26	0.27	0.29	0.30	0.31	0.32	0.14	0.15	0.19



Note:

ANNEX 4C

Survey Photographs

ANNEX 4C SURVEY PHOTOGRAPHS

Micro Sector : Valle Dorado

Flow Measurement

Pressure Measurement

Meter Reading

Micro Sector : Los Arcos

Flow Measurement

Pressure Measurement

Meter Reading

Micro Sector : Los Arcos2

Flow Measurement

Pressure Measurement

Isolation test

Micro Sector : Mombacho

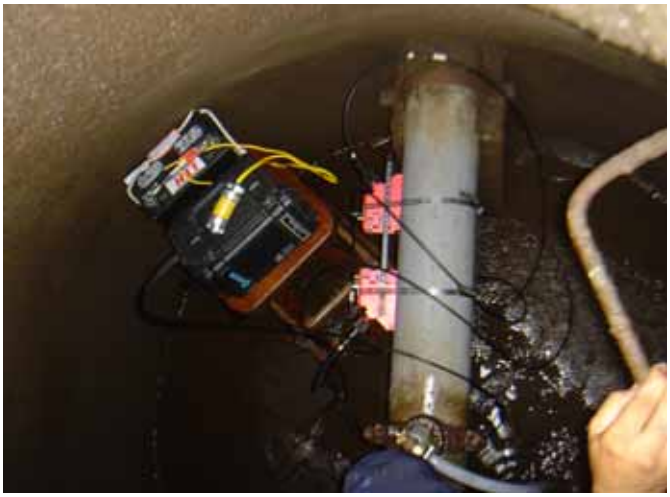
Flow Measurement

Pressure Measurement

Pipe Length Check

Micro Sector : Chamorro

Flow Measurement



Pressure Measurement

Meter Check

Micro Sector : Periodista

Flow Measurement

Pressure Measurement

Meter Reading

Micro Sector : Belmonte

Flow Meter Moving

Flow & Pressure Measurement

Meter Reading

Micro Sector : Lomas del Valle

Flow Measurement

Meter Reading

Pressure Measurement

Micro Sector : El Eden

Flow Measurement

Pressure Measurement

Meter Reading

Micro Sector : Reparto Tiscapa

Flow Measurement

Pressure Measurement

Meter Reading

Micro Sector : Reparto Tiscapa

Night Survey

Leakage Survey

Micro Sector : El Dorado

Flow Measurement

Pressure Measurement

Meter Reading

Site Name : Dinamarca

Flow Measurement

Flow Measurement

Flow Measurement