Evaluation Items	Possible Cause and Effect		Landfill Expansion (Cerro Patacon Final Disposal Site)		Transfer Stations (unknown)	
	During Construction	During Operation	Rank	Reasons	Rank	Reasons
Conditions	discharge and riverbed condition	discharge and riverbed condition due to inflow from the site		water bodies, even if creeks are diverted. A monitoring program should be established.		wastes and washing areas need to be strictly followed.
Coastal Zone	Impacts on Coastal Environment	Impacts on Coastal Environment	D	Area is far from Coastal zone	D	Required areas are small and will probably be far from coastal zone.
Fauna and Flora	Obstruction of natural species and extinction of them due to loss of habitat		B	A national park is near the landfill and will animals sometimes cross the area	D	Required areas are too small to cause a major impact on flora or fauna
Meteorology	Changes in temperature or winds	Changes in temperature or winds	D	The scale of the project is not large enough to cause any change in meteorology.	D	The scale of the project is not large enough to cause any change in meteorology.
Landscape/ Aesthetics	Change in landscape	Decrease in aesthetic value due to landfill	B/A	Landfill work will result in a change in landscape	C	Even though required areas are small, they could impact aesthetics
Pollution						
Air Pollution	Deterioration of air quality due to the increased traffic	Deterioration of air quality due to the increased traffic and dust from wastes delivered by trucks, landfill gases, and smoke from operation	B	Landfill should be properly operated to avoid fires, explosions, and control of gases needs to be considered	B	Traffic in areas selected can be expected to increase.
Water Pollution	Deterioration of water quality of surface or ground water due to silt or debris from land preparation	Deterioration of water quality of surface or ground water due to silt and leachate from the site	B	Soil and leachate control measures as well as monitoring need to be established.	B	Control of liquids from wastes and washing area need to be strictly followed.
Soil Contamination		Contamination of soil due to leakage of leachate	B	Leachate control measures need to be established and followed.	B	Control of liquids from wastes and washing areas need to be strictly followed.
Noise and Vibration	Noise and vibration caused by the construction operation	Noise and vibration caused by the operation	D	Sites are distant from major population areas.	B	Traffic and noises will increase near areas selected.
Land Subsidence	Land subsidence due to the land deformation.		D	Subsidence would be limited to selected areas, as the ground of the site is firm.	D	Required areas are too small to cause major subsidence problems.
Offensive Odor		Odor caused by wastes during operation	B	Wastes should be covered by soil.	B	Odors could become disturbing if removal is not conducted on schedule.

11.5.3 Environmental Impact Assessment of the Final Disposal System

a. Description of the Proposed Project

This section describes the proposed project, the Final Disposal System.

a.1. Background

The project of Final Disposal System is a part of the Master Plan (M/P). The need to ensure capacity for the final disposal of wastes until 2015 was established as one of the targets in the M/P. Current capacity at the landfill has been estimated at 1.8 million cubic meters or

equivalent to approximately 3 to 4 years. Thus, the Study conducted preliminary design of a new landfill in the current final disposal site.

a.2. Objectives of the Project

The prime objective of the project is **to establish an appropriate final disposal system** where final disposal capacity by 2015 is ensured and quality of operation meets with norms established in the country. This is one of policies to lead the principal goal of the Master Plan, i.e., to establish a sound Solid Waste Management by 2015 in the Municipality of Panama.

a.3. Justification of the Project

a.3.1 Legal Justification

Law No. 41 dated August 27th, 1999, transfers the administration, operation and exploitation of the services provided by Dirección Metropolitana de Aseo (Metropolitan Cleaning Office, or DIMA) to the municipalities of Panama, San Miguelito and Colón. With the enforcement of this law, the Urban and Domiciliary Cleansing Office (DIMAUD) was created in each of the municipalities of Panama, San Miguelito and Colón.

For purposes of compliance with the law, it is stipulated in the same law that the municipalities mentioned above have powers, responsibilities and functions to direct, plan, research, inspect, operate and exploit urban and household cleansing services. As for the Cerro Patacon Landfill, it is also stipulated that the municipality of Panama has administrative responsibility of the Cerro Patacon Landfill and the Mayor administering a sanitary landfill can subcontract its operation to third parties.

Consequently, the Municipality of Panama has responsibilities to appropriately operate the Cerro Patacon Landfill and to ensure final disposal of waste generated from the municipality. te project aims to realize the both issues.

a.3.2 Social Justification

The need for an appropriate place to dispose of solid wastes is a problem of all cities in the World, especially after a municipality reaches a certain size. As populations in towns and cities become larger, the amount of solid wastes generated increase and impacts caused by disposing of such a large amount of waste become serious. Such serious impacts deteriorate natural environment, living conditions and socio-economic activities.

According to current estimates, the daily amount of solid wastes disposed of at the Cerro Patacon Landfill is around 1,200 tons per day. The project will provide a solution to the need to provide an appropriate facility to dispose of solid wastes until 2015.

a.4. Location and Land Ownership

The 130 ha Cerro Patacon Final Disposal Site is located at the Ancon Corregimiento in Panama District, at approximately 5 km from the Via Ricardo J. Alfaro, within a polygon defined by UTM coordinates N1002030, E657540; N1002000, E657900; N1000000, E656900, y N1000000 E658100. The area is within a land reverted to the Republic of Panama during implementation of the Panama Canal Treaties of 1977, and adjacent to the Las Cruces National Park.

The whole project site belongs to Panama Inter-Oceanic Region Authority (ARI), although the Municipality of Panama has a right to operate final disposal of waste in the Cerro Patacon Final Disposal Site.

a.5. Description of the Work

a.5.1 Project Outline

The new landfill will have capacity of 6.4 million cubic meters. It will be developed in 4 phases. Table 11-51 describes the outline of the project.

Table 11-51: Outline of the Project of Final Disposal System

Items	Facilities				
	Overall	Phase 1	Phase 2	Phase 3	Phase 4
Construction site	Cerro Patacon Area				
Construction period	-	2005 to early 2006	2007 to early 2008	2009 to early 2010	2011
Operation period	2006 to 2015	early 2006 to early 2008	early 2008 to early 2010	early 2010 to end of 2011	2012 to 2015
Area	Site area :28 ha Filling area : 20.4 ha	6.9 ha	6.5 ha	6.3 ha	20.4 ha
Landfill waste	Municipal waste				
Landfill capacity	6,400,000 m^3	1,300,000m^3	1,200,000m^3	1,100,000m^3	2,800,000m^3
Access	Existing road and internal road Length of internal road : 2,570 m	Length of internal road : 1,300 m	Length of internal road : 800m	Length of internal road : 470m	-
Waste transport control facilities	Gate : 2 (existing), Weighbridge : 2 (existing), Car washing : 1 (existing), Site office :1, Work shop :1				
Leachate management	**Seepage control works**: installation of 1.5 mm HDPE synthetic liner with 10 mm geotextile (under and upper of synthetic liner), installation of soil layer for protection of synthetic liner				
	Collection and treatment system				
	Collection pipe: 6,690m(dia. 200 to 900mm)	2,070 m	2,020m	1,830m	770m
	Treatment system Regulation pond : 24,000 m^3,Treatment capacity : 800 m^3/day (oxidation ditch with chemical sedimentation, sand filtration and activated carbon absorption) Intake water quality : BOD 10,000 mg/l, COD 18,000 mg/l, Org-N 200 mg/l, NH_3-N 200 mg/l, P 30mg/l Treated water quality ; BOD 35 mg/l, COD 100 mg/l, Org-N 10 mg/l, NH_3-N 3 mg/l, P 5mg/l (comply the ANAM discharge limit)				
Landfill gas management	Gas ventilation pipe (PVC 200 mm) : 92 nos.	23 nos.	22 nos.	21 nos.	26 nos.
Rain water	Trapezoidal lined ditch (wide	1,190 m	700 m	410 m	-

management	800 to 1,700 mm): 2,300 m and daily cover soil				
Landfill operation	Cell method with compaction, daily soil cover thickness15cm, final soil cover thickness 60cm				
Aesthetic design	Daily soil cover				
Closure and post-closure	Final soil cover 60 cm Greening by seeding the final cover with grass				

a.5.2 Project Site

The project site is a part of the existing Cerro Patacon Final Disposal Site where two areas have been developed as landfills, Etapa 1 and Etapa 2. Then, the new landfill is called as Etapa 3. The project site involves a part within the Cerro Patacon Final Disposal Site and an additional about 9 ha that is next to the former part but out of the Cerro Patacon Final Disposal Site.

Currently, soil for covering waste is excavated from a part of the project site. Rest of the site is covered with grass and sparse trees.

There is a small hill at the north and a shallow valley at the south in the project site. Around the project site, there is a hill at the north, the existing landfill (Etapa 1) at the south, a river at the east and other existing landfill (Etapa 2) at the west. Profile of the project site is as follows.

- The maximum height: 106 masl
- The minimum height: 43 masl

- Area: about 28 ha

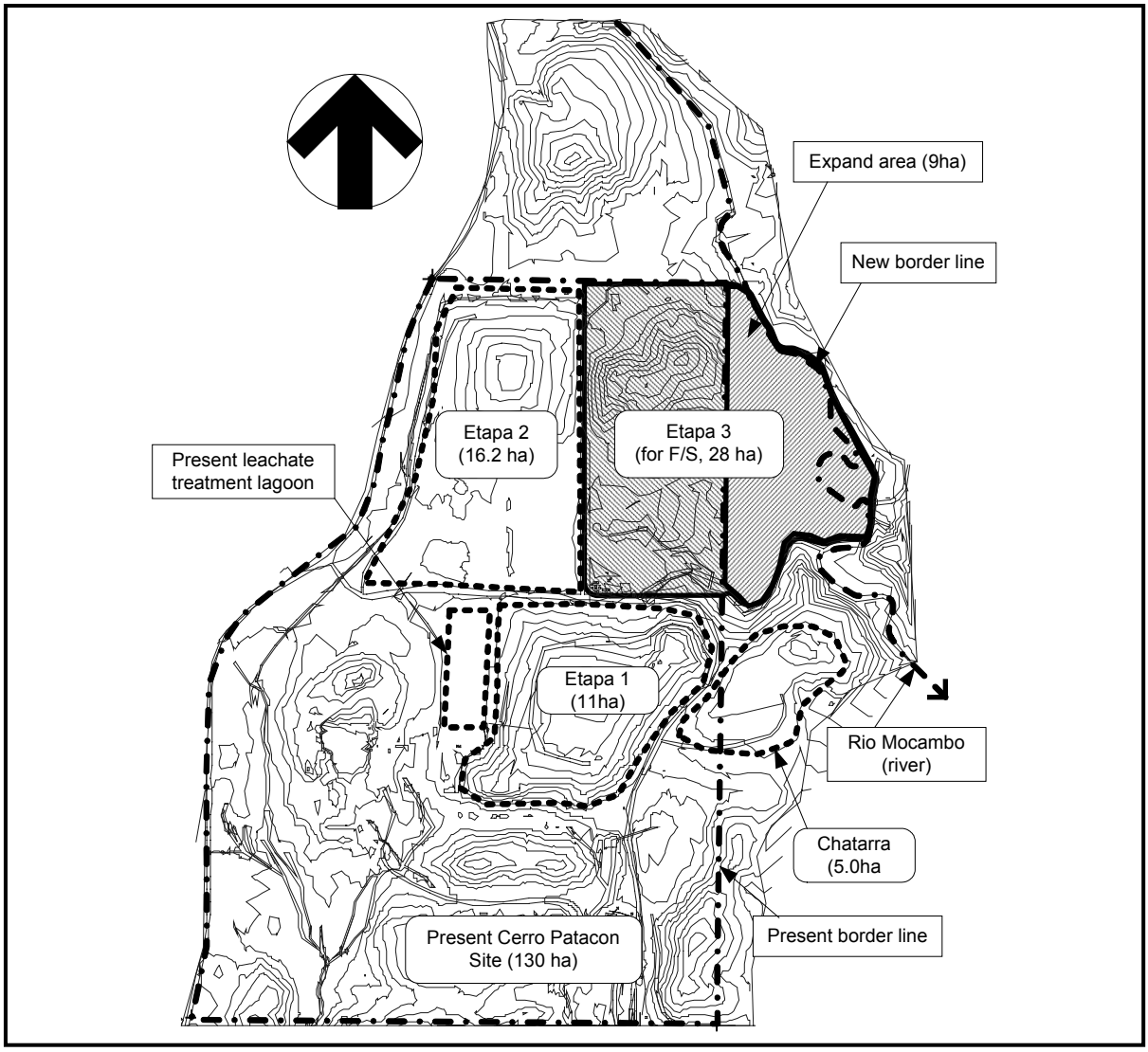


Figure 11-20: Project Site

a.5.3 Types of Waste to be disposed of

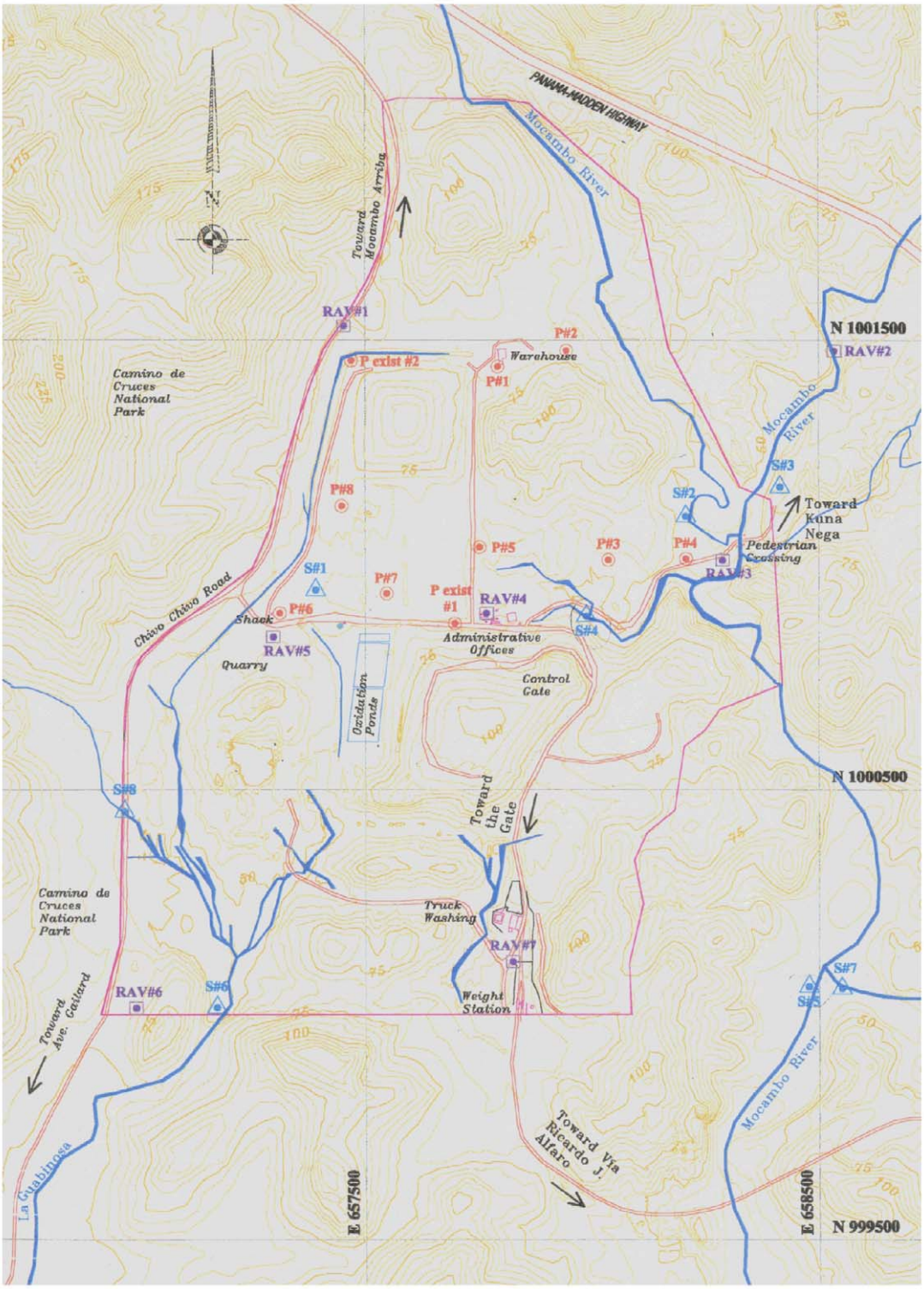
Wastes to be disposed of in the new landfill are all municipal solid wastes except hazardous waste.

b. Natural and Socio-economic Environment

This section describes the environmental and socio-economic aspects of the project site and its surrounding mainly based on an environmental baseline survey conducted in July to September 2002 by local companies under supervision of the Study Team in the scheme of the Study. Table 11-52 outlines the survey.

Table 11-52: Items of Environmental Baseline Survey

General information	
Required items	a) Wind direction b) Wind velocity c) Temperature d) Humidity e) Rainfall f) Solar radiation, sunshine hour
Geology	
Boring Survey:	8 boreholes, about 10m respectively, in and around the Cerro Patacon Final Disposal Site. Test and data required are penetration test, loading test, groundwater level, in-situ permeability test, internal soil test (triaxial compression test, consolidation test)
Topsoil investigation:	100 units at about 2 m depth over 100 ha in and around Cerro Patacon Final Disposal Site.
Surface water	
Sampling:	8 samples in and around Cerro Patacon Final Disposal Site
Analysis items:	Flow volume, temperature, pH, electric conductivity, turbidity, color, alkalescency, oil content, number of colon bacillus, BOD5, COD, SS, ammoniac nitrogen, total nitrogen, major ions (Na+, Ca2+, HCO3-, SiO2, Cl-), total phosphorus, heavy metals (cadmium, cyanogen, lead, total chromium, hexavalent chromium, arsenic, total mercury, copper, zinc, iron, manganese), PCB
Groundwater	
Sampling:	10 samples (2 samples from the two monitoring wells and 8 samples from boreholes for geological survey)
Analysis items:	Pumping-up volume, temperature, pH, electric conductivity, turbidity, color, alkalescency, oil content, number of colon bacillus, BOD5, COD, SS, ammoniac nitrogen, total nitrogen, major ions (Na+, Ca2+, HCO3-, SiO2, Cl-), total phosphorus, heavy metals (cadmium, cyanogen, lead, total chromium, hexavalent chromium, arsenic, total mercury, copper, zinc, iron, manganese), PCB
Air pollutants	
Survey site:	7 points in and around Cerro Patacon Final Disposal Site
Analysis items:	sulfur dioxide, nitrogen dioxide, suspended particulate matter, odor
Noise and Vibration	
Survey site:	7 points that are the same as for Air pollutants
Analysis items:	noise and vibration
Fauna and Flora	
Survey site:	about 200 ha of in and around Cerro Patacon Final Disposal Site



: Surface water sampling points : Groundwater sampling points : Air, noise and vibration sampling points

Figure 11-21: Location Map of Baseline Survey (Surface Water, Groundwater, Air, Noise and Vibration)

b.1. Natural Environment

b.1.1 Meteorology

Precipitation, Temperature and Wind

Climate in the area has been classified as Tropical Savannah type according Koppen, with average annual rainfall of around 2,100 mm and average maximum temperature of 27.5 °C and an average minimum of 25.7°C. Winds in the area tend to be low, with an average high in the month of March of around 8.5 km/hr, primarily from the North and Northeast.

Table 11-53: Annual Precipitation (1992-2001)

Unit: (mm)

Year	Balboa FAA Station (A Type Station) Latitude: 08° 58' 08'' N Longitude: 79° 32' 58'' W Height 10 masl	Pedro Miguel Station (PV Type Station) Latitude: 09° 01' 22'' N Longitude: 79° 37' 02'' W Height 30 masl
1992	2,207.26	2,044.70
1993	2,443.48	2,197.10
1994	2,100.58	1,968.50
1995	2,875.28	1,971.04
1996	2,451.10	2,367.28
1997	1,905.00	1,668.76
1998	1,953.26	2,189.48
1999	1,940.56	2,270.76
2000	1,927.86	2,138.68
2001	1,648.02	1,963.42
Average	2,148.84	2,077.97

Source: Panama Canal Authority, Engineering Division (2002).
Note: A Type Station registers rain, temperature, relative humidity, pressure, wind, solar radiation, sun exposure hours
PV Type Station measures precipitation amount

Table 11-54: Average Monthly Precipitation (1992-2001)

Unit: mm

Month	Balboa Station FAA			Pedro Miguel Station		
	Average	Maximum	Minimum	Average	Maximum	Minimum
January	55.88	170.18	0.0	40.64	144.78	0.0
February	27.94	99.06	0.0	15.24	81.28	0.0
March	40.64	91.44	0.0	27.94	142.24	0.0
April	66.04	127.00	0.0	78.74	162.56	17.78
May	276.86	487.68	96.52	238.76	381.00	154.94
June	266.70	566.42	137.16	261.62	459.74	121.92
July	218.44	462.28	119.38	228.60	299.72	119.38
August	185.42	299.72	71.12	233.68	342.90	142.24
September	271.78	490.22	142.24	238.76	337.82	149.86
October	289.56	431.80	167.64	304.80	353.06	218.44
November	287.02	411.48	157.48	279.40	355.60	167.64
December	162.56	251.46	10.16	119.38	259.08	5.08

Source: Panama Canal Authority, Engineering Division (2002)

Table 11-55: Average Annual Temperature (1992 – 2001)

Unit: °C

Year	Temperature
1992	26.70
1993	27.00
1994	27.00
1995	26.66
1996	26.01
1997	26.88
1998	27.08
1999	26.02
2000	26.10
2001	26.37
Annual Average	26.6

Source: Panama Canal Authority, Engineering Division (2002)

Table 11-56: Average Monthly Temperature (1992 – 2001)

Unit: °C

Month	Average	Maximum	Minimum
January	26.55	27.83	25.38
February	27.05	27.94	26.11
March	27.38	28.66	26.50
April	27.66	28.50	27.00
May	27.05	27.94	26.27
June	26.66	27.33	25.88
July	26.61	27.50	25.83
August	26.27	27.33	25.16
September	26.11	27.00	25.33
October	26.11	26.55	25.55
November	25.83	26.33	25.38
December	26.11	27.33	25.00
Average	26.61	27.55	25.78

Source: Panama Canal Authority, Engineering Division (2002)

Table 11-57: Average Monthly Direction and Wind Speed at Balboa Station (1992 – 2001)

Month	Speed (Km/h)	Heading
January	7.40	333.4° NW
February	8.21	338.6° NW
March	8.53	341.9° NW
April	7.56	336.4° NW
May	6.28	298.7° NW
June	5.47	293.7° NW
July	5.95	308.9° NW
August	5.79	308.8° NW
September	5.31	263.9° SW
October	5.47	255.4° SW
November	5.63	296.0° NW
December	6.12	325.0° NW

Source: Panama Canal Authority, Engineering Division (2002)

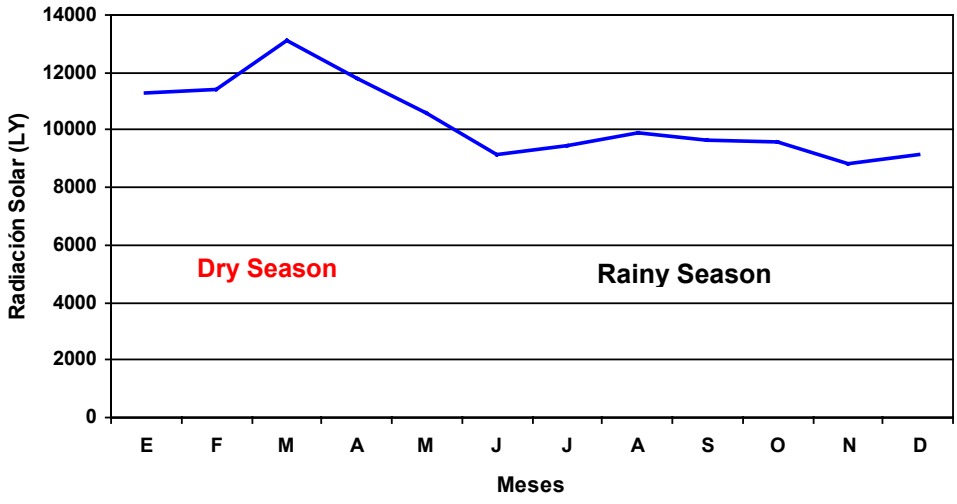
Solar Radiation, Sunshine hours and Humidity

A 10 year data (1992 – 2002) obtained from the Balboa Station FAA has determined that the average annual solar radiation for the study region is 123,914.1 Ly. It is clear that solar radiation during dry season (January, February, March and April) is higher than during rain season (rest of months except the dry season). This tendency is stronger in data of sunshine hours as shown in Figure 11-23. Average annual relative humidity is 78.0%. During dry season, average monthly humidity ranges between 67.4% and 73.0%. It increases in rain season between 79.5% and 84.6% as shown in Table 11-59.

Table 11-58: Average Annual Solar Radiation (1992-2001)

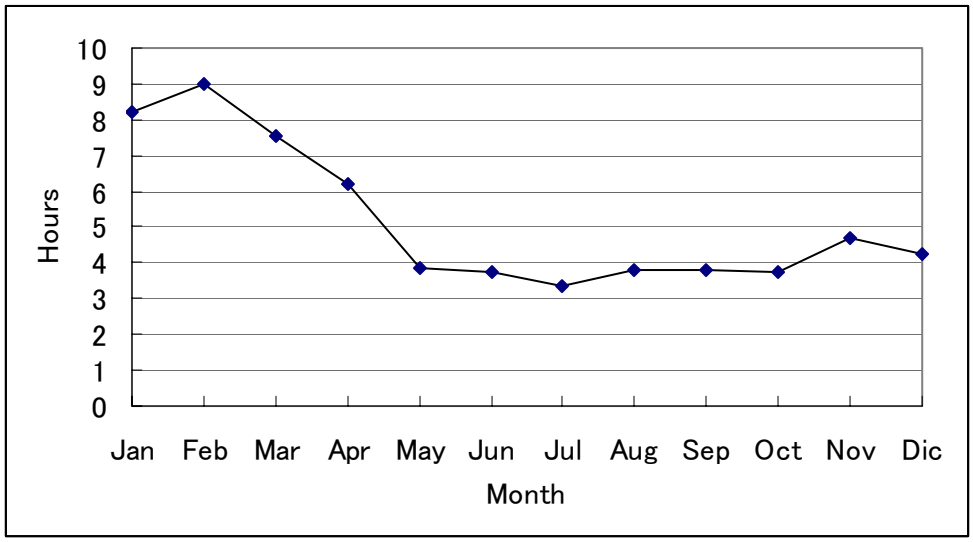
Year	Solar Radiation (Ly)
1992	127,334.3
1993	129,155.2
1994	132,265.8
1995	134,191.1
1996	119,239.8
1997	110,866.5
1998	119,757.7
1999	117,930.3
2000	121,137.4
2001	127,263.2
Annual Average	123,914.1

Source: Panama Canal Authority, Engineering Division (2002)



Source: ACP, Albrook Station

Figure 11-22: Average Daily Solar Radiation (1992-2001)



Source: Authority of the Panama Canal, Albrook Station

Figure 11-23: Average Daily Sunshine Hours (2000-2001)

Table 11-59: Average Monthly and Annual Relative Humidity

Unit: %

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Average
1992	63.9	61.6	61.5	62.1	70.5	74.3	68.8	74.0	74.0	67.9	81.9	76.7	69.8
1993	73.8	64.8	65.9	70.4	76.3	77.7	76.4	75.9	75.9	82.3	81.3	75.7	74.7
1994	68.9	65.0	65.3	66.0	75.6	77.1	75.6	78.4	77.5	77.3	77.0	70.9	72.9
1995	66.4	61.5	64.8	79.0	83.1	81.4	85.1	86.1	84.7	85.4	86.0	83.7	78.9
1996	80.1	75.2	72.8	74.2	83.7	85.3	83.6	84.0	84.9	84.1	83.2	79.9	80.9
1997	75.3	72.3	66.1	69.3	77.3	83.5	82.5	82.7	85.2	85.2	85.4	75.9	78.4
1998	70.5	70.2	64.9	70.9	81.1	84.6	84.3	84.7	82.5	82.8	84.3	84.3	78.8
1999	76.2	70.7	69.9	75.3	82.2	84.2	83.0	84.1	82.5	82.9	83.3	82.7	79.7
2000	73.7	68.8	65.4	69.8	80.4	83.0	81.8	88.8	90.0	90.0	88.9	87.3	80.6
2001	81.3	77.2	77.9	76.8	84.7	87.3	87.8	87.7	89.6	89.7	89.4	89.4	84.9
Average	73.0	68.7	67.4	71.4	79.5	81.8	80.9	82.6	82.7	82.7	84.1	80.6	78.0

b.1.2 Geology

Geological Conditions

Geological condition of the project site consists of silt and/or clay at the upper part and weathered rock at the lower part. Hydraulic conductivity of the upper part is between 10^{-4} and 10^{-6}(cm/sec). In the Study, a geological survey was conducted. Locations of drilling surveys carried out in the geological survey are shown in Figure 11-24. The base layer of the project site consists of rock. Therefore, it can be judged that the base layer will bear increased stress to be caused by waste disposition.

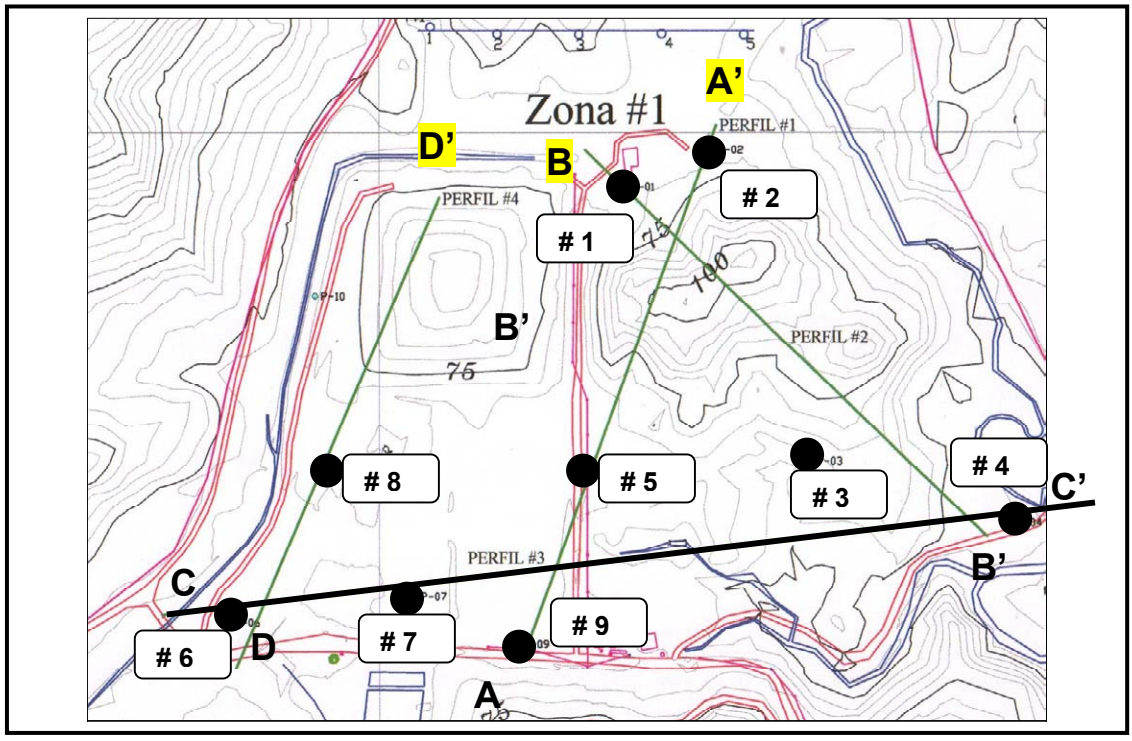


Figure 11-24: Location Map of Boring Survey

Permeability

In situ permeability tests were carried out at the drilling wells Table 11-60 shows results of the test.

Table 11-60: Results of Permeability Survey

Number of holes	LOCATION	K (m/s)	K (cm/s)	PERMEABILITY CLASS
P # 1-02	**1001434.42 N, 657796.87 E**	**8.24 E-07**	**8.24 E-05**	Very small
P # 2-02	**1001478.89 N, 657900.95 E**	**5.09 E-07**	**5.09 E-05**	Practically impermeable
P # 3-02	**1000987.18 N, 658073.14 E**	**3.59 E-08**	**3.59 E-06**	
P # 4-02	1001028.35 N, 658260.56 E	1.57 E-07	1.57 E-05	
P # 5-02	**1001090.35 N, 657757.58 E**	**2.14 E-07**	**2.14 E-05**	
P # 6-02	1000909.59 N, 657317.57 E	2.32 E-06	2.32 E-04	Very small
P # 7-02	1000940.26 N, 657542.50 E	6.84 E-08	6.84 E-06	Practically impermeable
P # 8-02	1001097.23 N, 657425.56 E	6.00 E-08	6.00 E-06	

No. 1, 2, 3, and 5 are in the project site. All of them indicate considerably lower permeability, i.e., between 10^{-5} and 10^{-6} cm/sec. The values imply that the site might not need synthetic liner at the bottom of a landfill. However, the base layer consists of the weathered rock and fissure water exists. Therefore, it can be concluded that the bottom of the landfill will require a synthetic liner, although the upper part show the low permeability.

b.1.3 Surface Water

Surface Water Quality

The surface water survey conducted at eight points around the Cerro Patacon Final Disposal Site. The most important water body around the site is the Mocambo (or Cardenas) River, which receives effluents from the landfill and neighboring communities. The water sampling and flow measurements were conducted in July and August 2002.

Table 11-61 presents the main results from the laboratory analysis. As the table shows, the results obtained are compared to Florida, U.S. standards for superficial water (recreational use, propagation and maintenance of a balanced fish and wildlife population). This was done since Panama has standards for wastewater, but not for evaluation of natural water body quality.

Many of the parameters exceed the standards used as reference from which it can be inferred that in general terms, the superficial water quality in the area is of low quality. It is evident that the superficial water in the area is impacted by human activity, since it shows considerable concentrations of fecal coliform and biochemical oxygen demand. Besides, the fieldwork showed low dissolved oxygen amounts, typical of contaminated water. This is specially true for sampling point #4, which showed very high BOD, COD, fecal coliform and phosphate levels, among others. During fieldwork it was observed that the water at this point was practically in an anaerobic condition (dissolved oxygen under 1 mg/L) and it had a muddy appearance and an unpleasant smell.

BOD concentrations in the study area varied from < 1 mg/L to 30 mg/L, whereas COD concentrations varied from 1 mg/L to 274.3 mg/L. Fecal coliform levels detected were high, they varied from 800 to 3 x 10^6 UFC / 100 ml. This indicates that the superficial waters in the study area receive organic matter and human and/or animal wastes.

Regarding heavy metal concentrations detected, some of the comparison criteria were exceeded from which it can be inferred that superficial water in the study area is moderately contaminated with these elements.

In summary, superficial water in the study area possesses a low quality from a bacteriological point of view and of general quality parameters such as turbidity, dissolved oxygen and nutrients. Contamination by human activities is evident, reflected on the levels detected on nutrients (nitrogen, phosphates), heavy metals and bacteriological parameters (BOD, Fecal coliforms, COD). Because of this, in general terms, superficial water in the study area is not adequate for recreation activities, human consumption or the maintenance of a healthy fish and wildlife population.

Table 11-61: Results of Surface Water Quality Survey

ANALYSIS	Florida*	SURFACE WATER SAMPLES							
		No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8
1. Acidity (mgCaCO3/L)	---	18.4	4.1	4.1	< 1.0	12.2	12.2	18.4	< 1.0
2. Alkalinity (mgCaCO3/L)	> 20	229.3	105.8	129.4	1070.2	168.6	126.4	131.3	65.7
3. Suspended Solids (mg/L)	----	< 1.0	< 1.0	< 1.0	85	20	< 1.0	8	30
4. Turbidity (NTUFORMAZIN)	5.7	16.8	923	7.6	213	5.5	30.8	5.9	38.7
5. Ammonium Nitrate (mgNH3/L)	<0.02	35.3	0.31	0.1	392	29.6	2.38	0.08	0.08
6. BOD5 (mg O2/L)	a.	3.7	< 1.0	< 1.0	30	15.3	12	1.9	< 1.0
7. COD (mg O2/L)	a.	5	1	2	274.3	15	15	2	1
8. Oils (mg/L)	<5.0	10	5	2	15	< 1.0	15	5	8
10. Total Phosphates (mg P/L)	0.04	0.1	0.09	0.12	0.19	0.08	0.7	0.06	0.08
11. Chlorine (mg /L)	---	137	7	4	370	13	40	2	4
12. Organic Nitrogen (mg /L)	0.7	0.99	1.34	1.07	1.8	1.39	0.89	0.32	1.15
13. Fecal Coliforms (UFC/100ml)	800	1000	3000	2 x106	3x106	5 x104	1000	800	3000
14. Calcium (mg Ca/L)	---	100	17.5	20.5	94.3	25.4	57.3	18.8	9.1
15. Sodium (mg Na/L)	---	28.3	16.8	19	28.9	20.5	30.5	17.6	26
16. PCBs (mg/L)	---	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
17. Silica (mg Si/L)	---	0.07	0.3	0.2	0.08	0.2	0.05	0.4	0.06
18. Copper (mg Cu/L)	<0.012	< 0.05	0.06	<0.05	< 0.05	< 0.05	0.97	< 0.05	0.06
19. Manganese (mg Mn/L)	---	1.5	<0.02	0.09	0.17	0.59	2.9	0.06	0.23
20. Iron (mg Fe/L)	<1.0	2.1	0.05	0.3	2.2	0.35	6.4	0.17	2
21. Zinc (mg Zn/L)	<0.1	< 0.1	0.05	0.05	< 0.1	< 0.05	< 0.05	< 0.05	< 0.1
22. Arsenic (mg As/L)	<0.05	< 0.05	< 0.05	< 0.05	<0.05	< 0.05	< 0.05	< 0.05	< 0.05
23. Lead (mg Pb/ L)	<0.003	< 0.05	< 0.05	< 0.05	<0.05	< 0.05	< 0.05	< 0.05	< 0.05
24. Cadmium (mg Cd/L)	<0.001	< 0.05	< 0.05	< 0.05	<0.05	< 0.05	< 0.05	< 0.05	< 0.05
25. Total Chromium (mg CrT / L)	---	< 0.05	< 0.05	< 0.05	<0.05	< 0.05	< 0.05	< 0.05	< 0.05
26. Chromium (VI) (mg Cr6+ /L)	<0.011	< 0.05	< 0.05	< 0.05	<0.05	< 0.05	< 0.05	< 0.05	< 0.05
27. Bicarbonate (HCO3-/L	---	1.4	1.1	1	< 1.0	2.2	2.2	1.8	< 1.0
28. Cyanide (mg CN/L)	---	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
29. Mercury (mg Hg)	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02

* Florida, U.S. standards, 62-302.530, for superficial water (recreational use, propagation and maintenance of a balanced fish and wildlife population)

Water Flow

Water flows were measured at the same points as surface water quality survey. The flows registered varied significantly, from small to important water bodies, such as the Mocambo River. The smallest flow registered was 0.018 m^3/min at sampling point No 1, while the largest flow was 14.25 m^3/min, registered at the Mocambo River (point No 5). Table 11-62 shows results of the flow measurement.

Table 11-62: Surface Water Flow

Sampling Point	Flow (m^3/s)	Flow (m^3/min)
1	0.0003	0.018
2	0.0632	3.792
3	0.1699	10.194
4	0.0197	1.182
5	0.2375	14.250
6	0.1478	8.868
7	0.0254	1.524
8	0.1152	6.912

b.1.4 Groundwater

In order to grasp groundwater conditions in the Cerro Patacon Final Disposal Site, water samples obtained from 10 wells were analyzed at the field and a laboratory of a university (Universidad Tecnologica de Panama). Besides, geological survey estimated the direction of groundwater flow in the site.

Groundwater Flow

According to the drilling survey, it is estimated that the groundwater flows from the northwest to the southeast under the project site. There will be fissure water as the rock has many cracks.

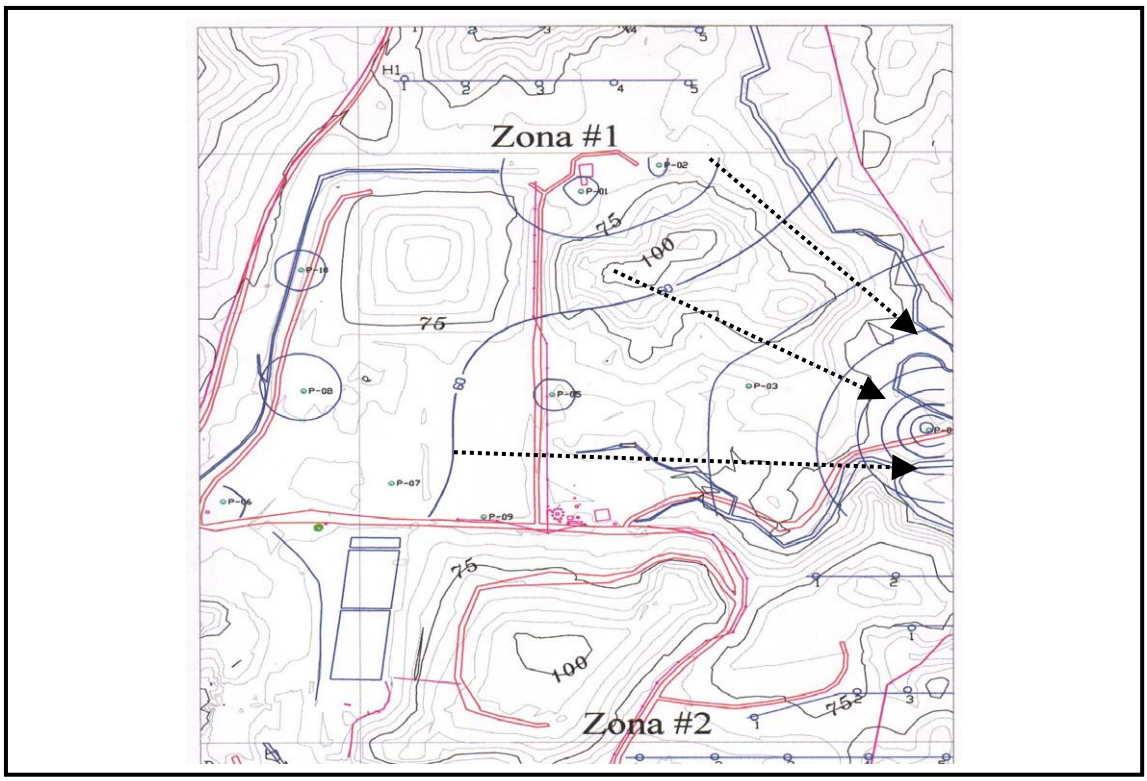


Figure 11-25: Direction of Ground Water Flow

Groundwater Quality

Table 11-63 presents the main results from the laboratory analysis for groundwater quality. Compared to superficial water quality in the study area. It can be observed that groundwater has a similar composition to the surface water, with the exception of its bacteriological quality and some general parameters. For example, bacteriological parameters analyzed were detected at lower concentrations in the groundwater BOD (1.2 – 3.8 mg/L), COD (1 – 34.3), and Fecal Coliforms (0 – 8,000 UFC / 100 ml). Nevertheless, the concentration of suspended solids (4 – 8,584 mg/L) and turbidity (0.94 – 3,110 NTU) detected in groundwater are much higher than those detected in surface water. This situation is not common, since typically the suspended solids content is lower in groundwater. This might be caused by disturbed samples. The presence of high concentrations of oils (5 – 259 mg/L), relatively high for groundwater, is also worth mentioning.

Because of the reasons described, it can be concluded that the superficial groundwater in the project area is contaminated mainly by organic material at levels lower than superficial waters and by oils.

Table 11-63: Groundwater Quality

Analysis Items	No.1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	Exist. No. 1	Exist. No. 2
1. Acidity (mgCaCO3/L)	36.7	< 1.0	< 1.0	22.4	< 1.0	< 1.0	18.4	16.3	299.9	49
2. Alkalinity (mgCaCO3/L)	46	188.2	220.5	76	88	98	448.8	229.3	933	503.7
3. Suspended Solids (mg/L)	8584	485	440	3248	2264	885	85	4	84	120
4. Turbidity (NTUFORMAZIN)	229.3	426	361	2690	1995	3110	334	2.74	0.94	191
5. Ammonium Nitrate (mgNH3/L)	0.45	0.09	0.45	3.9	0.52	0.07	0.02	0.16	2.57	0.08
6. BOD5 (mg O2/L)	< 1.0	< 1.0	1	1.6	3.8	2	3.6	< 1.0	2.2	1.2
7. COD (mg O2/L)	4	1	1	2	4	10	5	2	34.3	2
8. Oils (mg/L)	73	9	34	61	76	259	32	7	38	5
10. Total Phosphates (mg P/L)	0.16	0.12	0.3	0.57	0.1	0.3	0.12	0.08	0.05	0.08
11. Chlorine (mg /L)	9	7	2.5	24	35	54.5	36	10.5	614.8	80
12. Organic Nitrogen (mg /L)	0.35	1.8	1.47	0.35	1.42	1.42	1.15	0.46	0.56	1.31
13. Fecal Coliforms (UFC/100ml)	0	20	8000	0	0	0	120	4	0	40
14. Calcium (mg Ca/L)	5	10.9	8.4	18.2	7.1	107.6	18.2	32.3	120	44.9
15. Sodium (mg Na/L)	25	11.9	28.5	21.3	30.2	26.4	21.8	21.3	26	30.5
16. PCBs (mg/L)	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
17. Silica (mg Si/L)	0.14	0.05	0.06	0.1	0.03	0.11	0.1	0.05	0.05	0.07
18. Copper (mg Cu/L)	< 0.05	< 0.05	0.73	< 0.05	<0.05	0.1	< 0.05	0.07	<0.05	< 0.05
19. Manganese (mg Mn/L)	0.02	< 0.02	0.7	<0.02	0.05	4.1	< 0.02	3.2	80	0.6
20. Iron (mg Fe/L)	2.7	1.2	6.5	0.04	0.25	0.9	1.1	1.4	0.2	0.3
21. Zinc (mg Zn/L)	< 0.1	0.48	< 0.05	< 0.05	< 0.05	< 0.1	< 0.05	< 0.1	0.47	< 0.1
22. Arsenic (mg As/L)	<0.05	< 0.05	< 0.05	<0.05	< 0.05	< 0.05	<0.05	< 0.05	< 0.05	< 0.05
23. Lead (mg Pb/ L)	<0.05	< 0.05	< 0.05	<0.05	< 0.05	< 0.05	<0.05	< 0.05	< 0.05	< 0.05
24. Cadmium (mg Cd/L)	<0.05	< 0.05	< 0.05	<0.05	< 0.05	< 0.05	<0.05	< 0.05	< 0.05	< 0.05
25. Total Chromium (mg CrT / L)	<0.05	< 0.05	< 0.05	<0.05	< 0.05	< 0.05	<0.05	< 0.05	< 0.05	< 0.05
26. Chromium (VI) (mg Cr6+ /L)	<0.05	< 0.05	< 0.05	<0.05	< 0.05	< 0.05	<0.05	< 0.05	< 0.05	< 0.05
27. Bicarbonate (HCO3-/L	1.7	< 1.0	< 1.0	2.4	< 1.0	< 1.0	1.4	2	9.9	4
28. Cyanide (mg CN/L)	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
29. Mercury (mg Hg)	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02