

environmental evaluation aiming at a ranking of the candidate sites. This and no more is what the information is used for and should be used for.

J.2.2 Environmental Data for 11 Potential Landfill Sites

In the following, general information and technical/environmental data compiled for each of the potential landfill sites is presented in a systematic way.

a. Locality no. 1, Montenegro

aa. Locality

aaa. Localization

The potential landfill site no 1, Montenegro, is located about 70 kilometres north of Santiago, on the east side of the Pan American Highway, and about 2.5 kilometres east of the village of Montenegro, in the municipality of Til-Til. The coordinates of the centre of the area are approximately 70°48' W, 32°57'30" S. The altitude is about 850 metres above sea level.

aab. Description of area

The area is situated in the northernmost end of the Rio Maipu catchment area, just south of the passway and the water divide between this and the more northerly one. It is a valley of relatively even land between mountain ranges to the east and the west. From the foot of the mountain in the east, the landscape slopes gently towards the lower parts of the valley which also holds the Estero Montenegro, a river bed occasionally carrying water. The area is dry grassland with scattered trees.

aac. Present land use

The area is presently used for extensive cattle breeding.

ab. Land Ownership

The site and the general surrounding have one private owner, the total area being 2,835 ha. Two smaller, privately owned parcels (about 400 ha) are situated to the west and northwest, immediately east of the Pan American Highway.

ac. Physical Planning

There is no physical planning related to the area.

ad. Geology and Hydrogeology

ada. General geology

The site is underlain by colluvial deposits on a narrow strip flanked north and south by bedrock. The material consists of unsorted rock fragments and pebbles in an unconsolidated matrix of silt/clay and sand. The material has generally low to very low permeability.

adb. General hydrogeology

The hydrological regime of the area is that of a phreatic aquifer. The ground water level is generally a few to 20 metres below the surface. The ground water is, however, quite well protected against pollution from the surface due to low permeability in the upper soil layers. The generation of ground water in the area is therefore also small, see below. Specific yields of wells in the area are in the magnitude of 0-2 l/sec/meter.

adc. Ground water as source of water supply

The generation of ground water in the area is sparse, in an EIA study related to a municipal waste landfill close to the area estimated to be about 10 mm/year. As the watershed area is large some ground water will, however, be available, mainly related to wells close to the - more or less permanent - watercourses.

add. Means of water supply in the area

The ground water is abstracted for water supply both from two wells in nearby Montenegro and from a well set in Quebrada las Mazas. The former provide about 20-25 m³/day while the latter in the field visit in August 1995 was reported normally to yield more than 10 m³/day and not to have run dry for the past two years.

ae. Topsoil and Agriculture

aea. Description of topsoil

The topsoil belongs to the Rungue formation, which is generally clayey with cracks in the upper layers. The clay is montmorillonitic, plastic and adhesive, and has consolidated into a hard, rock-like structure. Gravel is inter-layered in the clay matrix. There is no visible sign of calcareous rocks.

aeb. Land use class

The whole area is in land use class VII.

af. Precipitation and Evapotranspiration

The average precipitation in the area is about 300 mm per year, mainly falling in the winter months of June - August. There is a 95% probability that the precipitation will be more than 150 mm/year and a 5% probability that it will be more than 600 mm/year.

The potential evapotranspiration in the area is about 1,700 mm/year.

ag. Watercourses - Surface Water

The Estero Montenegro runs north and west of the area, in a distance of a little more than 1 km where it is closest. Immediately north of the site is Quebrada las Mazas which runs east-west and empties into Estero Montenegro.

Crossing the area of the potential landfill site is another quebrada (not named on the map).

On the time of the field visit (7 August 1995) both quebradas were dry.

ah. Distance to sensitive activities

aha. Airports

There is no airport near the landfill site.

ahb. Towns and villages

The village of Montenegro is located about 2.5 km to the west of the site.

ahc. Single houses

There are a few houses, Las Bateas, next to the present access road to the area. These houses are located about 1 km from the site. They are, however, located much closer to the proposed landfill site for municipal waste as mentioned below.

There is also a hut next to Quebrada las Mazas where the southbound dirt road crosses the quebrada. At this location there is also a dug well which supplies water for the hut and the cattle.

ahd. Other activities

A landfill for municipal waste with a capacity of more than 200 million m³ is planned for establishment north and east of the potential site, between the road passing Las Bateas and Quebrada las Mazas.

ai. Distance from Santiago

The distance from central Santiago is about 70 km.

ak. Access by Road or Train

There is good access by the Pan American Highway which runs south-north about 2 km west of the site. The access from there will be either by the (reconstructed) dirt road via Las Bateas and the new municipal landfill site or by the road from the south and a new access road to be constructed from this (about 1 km).

The railway runs parallel to the highway and next to it. The distance from the site is thus the same as to the highway.

al. Possible Landfill on Area

A landfill could be established south of Quebrada las Mezas, with an extension north-south of about 500 metres and east-west of about 1,000 metres. The landfill will generally be shaped as a long, rounded hill to suit into the landscape. The area could thus be about 500,000 m². In order to establish a landfill this size it will be necessary to divert the occasional flow in the quebrada south of Quebrada las Mazas.

This landfill could have an average height of about 25 metres, thus allowing for a total landfill volume of about 12.5 million m³.

A smaller landfill could be established as a narrower ridge between two quebradas, thus avoiding problems with torrent rainfalls. This would allow for a landfill of about 300 x 1,000 metres of 300,000 m² which with an average height of about 18 metres would have a volume of about 5.5 million m³. The shape of the landfill would, however, not be harmonic in the landscape.

A section of the general map of the area in scale 1:25,000 (figure J.2.2a below) shows the outline and the immediate surroundings of the possible landfill site.

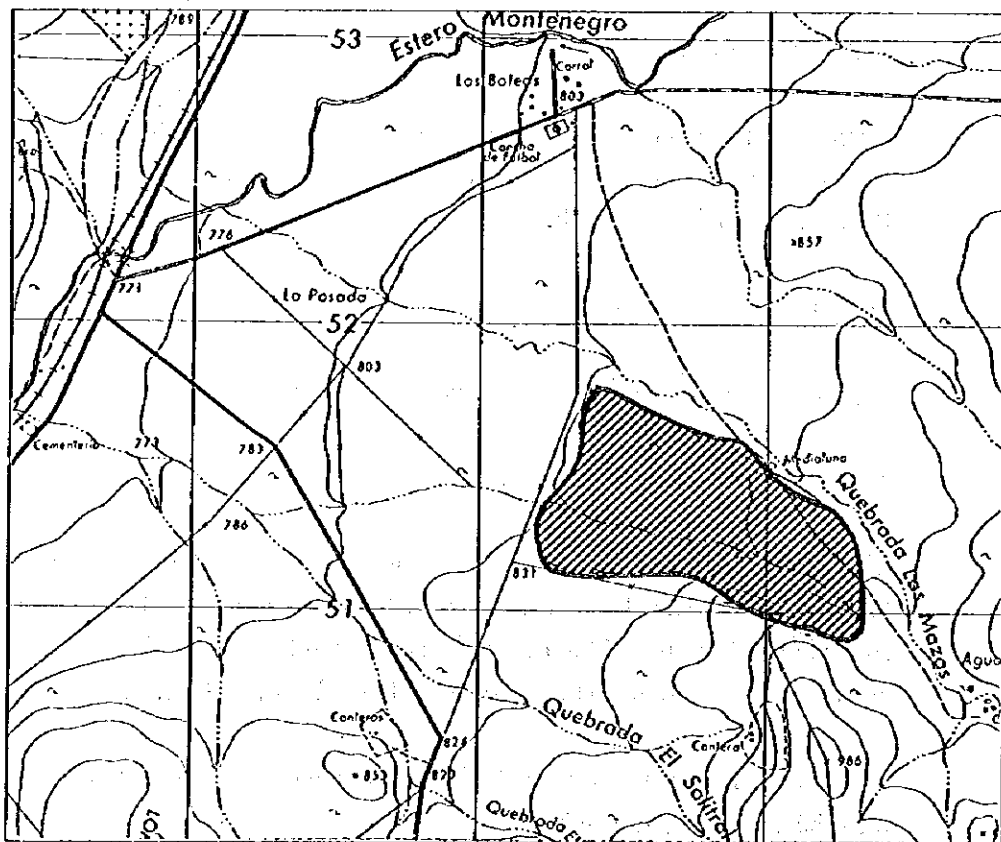


Figure J.2.2a Outline and surrounding of potential landfill site 1, Montenegro

am. Availability of Public Service

ama. Water supply

There is a public water supply in the nearby village of Montenegro. This is, however, insufficient even for the supply of Montenegro. It must therefore be assumed that a landfill at the site will have to depend on imported water.

amb. Sewage treatment

No information available.

amc. Power supply

There is no information about power supply, but it could be assumed that there is power supply at least to Montenegro and that power could be available from here.

an. Preliminary evaluation of site

The advantages and disadvantages of the locality as a future landfill site can be summarized as follows:

ana. Advantages

- No problems with land use and land use quality
- One private owner
- No planning problems
- Well-protected ground water, small source
- Low precipitation and high evapotranspiration
- Few sensitive activities
- Municipal landfill likely nearby
- Good road access
- Good train access
- Medium volume (12.5 million m³)

anb. Disadvantages

- Small quebrada crossing the area
- Large distance from Santiago (70 km)
- Problems with water supply

anc. Conclusive evaluation

The location is well fit for a landfill site for hazardous waste, especially if a municipal waste is established nearby. This is due to the small and well-protected ground water interests and the low precipitation and high evaporation as well as the good access by road and train.

b. Locality no. 2, Cerro Carneros

ba. Locality

baa. Localization

The potential landfill site no. 2, Cerro Carneros, is located about 20 km west of Santiago and about 2 km south of the Santiago - Valparaiso highway, in the municipality of Pudahuel. The built-up area of Lo Aguirre is at the roadside, also about 2 km away. The coordinates of the centre of the area are approximately 70°51'30" W, 33°28' S. The altitude is about 500 metres above sea level.

bab. Description of area

The area is situated in the central part of the Rio Maipu catchment area. From the foot of the mountain Cerro Carneros to the north, the landscape slopes gently towards the flat land in the valley around the highway. The area is dry grassland with scattered bushes and trees.

bac. Present land use

The area is presently used for extensive cattle breeding.

bb. Land Ownership

The area is owned by one private owner and has an area of 402 ha. The adjacent areas are also privately owned except a small, publicly owned plot of 8.5 ha about 1 km to the west of the site.

bc. Physical Planning

The area is within the area covered by the regulatory plan for Santiago (Ordenanza y Memoria del Plan Regulador Metropolitano de Santiago), dated 12 January 1993.

According to the dispositions in the plan, the proposed site is partly within an area for ecological reconstruction, partly within an area for mixed forestry and agricultural interests.

The intention of the proposed ecological reconstruction is first of all an afforestation of the hills, the secondary purpose being to develop the area for sport, recreation, touristic purposes, etc.

The mixed forestry and agricultural interests will allow both for agricultural industry, quarrying of non-metallic raw materials such as clay, and for infrastructure plants such as energy plants or final disposal of solid waste.

bd. Geology and Hydrogeology

bda. General geology

The site is on the boundary between colluvial deposits to the southeast and east and punitic volcanic ash deposits stretching northwards. Farther south there is bedrock. Both the colluvium and the ash deposits have low to very low permeabilities.

bdb. General hydrogeology

The hydrological regime of the area is that of a confined aquifer, water levels in some places above ground. The water bearing strata consists of fine sand to fine gravel. The ground water is quite well protected against pollution from the surface due to the clayey formations in the topsoil. Specific yields of wells in the area are in the magnitude of 0-6 l/sec/meter.

bdc. Ground water as source of water supply

See bdd. below.

bdd. Means of water supply in the area

There is a no specific information about water supply in the area, but according to EMOS it can be assumed that there are either single wells or public water supply based on wells in the rural areas.

be. Topsoil and Agriculture

bea. Description of topsoil

The topsoil in the area belongs to the Cuesta de Barriga Piedmont formation (southern part of area) and Pudahuel formation (northern part).

The general feature of the Cuesta de Barriga Piedmont is soil consisting of coarse loam of alluvial-colluvial origin, slightly plastic and adhesive, moderately deep, slightly inclined which rest on a colluvial substratum of gravel and stone in a sandy clay loam matrix at a depth of 100 to 110 cm. In the actual locality the topsoil is fine sandy loam.

The general feature of the Pudahuel formation is clayey formations on top of sandy ones. They will harden when dry and be firm when humid. In the actual locality it is a somewhat calcareous, sandy loam of little thickness, moderately drained, saline, and almost flat.

beb. Land use class

The whole area is in land use class IV. The southern, sloping part nearest to the foot of the hill is class IV e and the flatter northern part is class IV w.

bf. Precipitation and Evapotranspiration

The average precipitation in the area is about 330 mm per year, mainly falling in the winter months of June - August. There is a 95% probability that the precipitation will be more than 160 mm/year and a 5% probability that it will be more than 600 mm/year.

The potential evapotranspiration in the area is about 1,400 mm/year.

bg. Watercourses - Surface Water

There are no visible watercourses in the area, but the map shows a couple of quebradas starting on the mountainside and ending further down. It is likely that torrent rain will create such occasional flows.

bh. Distance to sensitive activities

bha. Airports

The Chilean national airport Aeropuerto Arturo Merino Benítez is situated about 9 km to the northeast of the site. The direction of approach and departure of flights is, however, north-south, and the site is about 7 km from that line.

bhb. Towns and villages

There are no villages in the vicinity. The only inhabited area nearby is Lo Aguirre along the highway, about 2 km from the site.

bhc. Single houses

A couple of houses/buildings are located about 1 km to the west of the site, partly behind the foot of the hills.

bi. Distance from Santiago

The distance from central Santiago is 22 km.

bj. Access by Road or Train

The access is good from the Santiago-Valparaíso highway. It is not possible to turn left at the present access road due to a traffic divider in the middle of the highway, which would force traffic to first turn right at the access road to the mine on the north side of the road and then drive back about 1 km. The access through the populated area is, however, by all means questionable. It should be assumed that the traffic to the landfill should turn left and use an existing, presently closed access road from the highway a little further east where there is no traffic divider and thus no such problems. This access road will - as will the one open during the field visit - need some improvement.

There is no access by train.

bk. Possible Landfill on Area

It is suggested to establish a landfill at the low slopes of the hills, because this is the best way to promote environmental protection issues. The problems related to water can be much more easily met on a gentle slope than on a flat area. Besides, the future - but not yet initiated - afforestation of the hills is not contrary to running a landfill on the

site for a limited period of time.

The area established as a landfill site could be an egg-shaped one, extending about 1,100 metres north-south and some 600 metres east-west. The effective area could thus be about 500,000 m², and with an average height of about 40 metres the volume could sum up to 20 million m³. The slopes of the artificial hill would fit well into the existing landscape. Some deviation of quebradas should be anticipated.

A section of the general map of the area in scale 1:25,000 (figure J.2.2b overleaf) shows the outline and the immediate surroundings of the possible landfill site.

bl. Availability of Public Service

bla. Water supply

No information available.

blb. Sewage treatment

No information available.

blc. Power supply

Power supply along the Santiago - Valparaíso highway 2 km to the north. Power supply masts erected along secondary access road, but no wires yet.

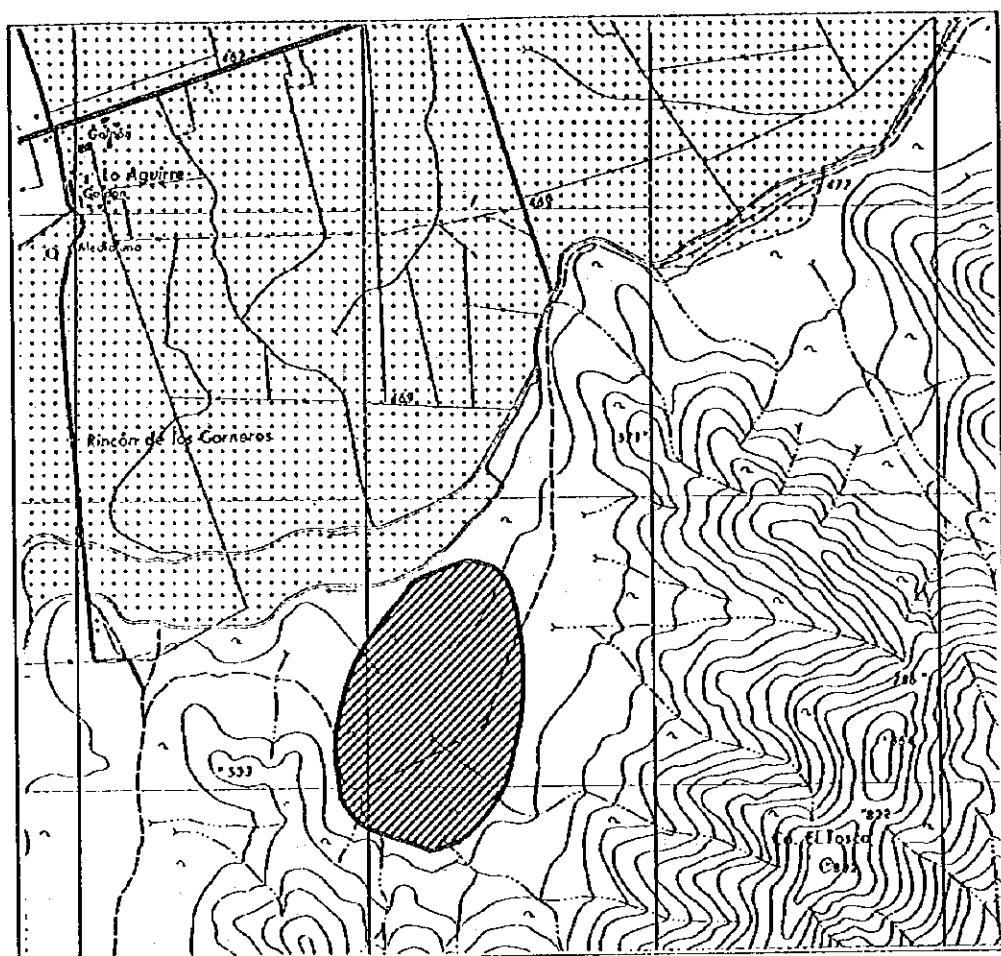


Figure J.2.2b Outline and surrounding of potential landfill site 2, Cerro Carneros

bm. Preliminary evaluation of site

The advantages and disadvantages of the locality as a future landfill site can be summarized as follows:

bma. Advantages

- No problem with land use and land use quality
- The present planning requirements not an obstacle
- Well-protected ground water
- Low precipitation and medium evapotranspiration
- Few sensitive activities
- Good road access
- Short distance from Santiago (22 km)

- Large volume (20 million m³)

bmb. Disadvantages

- Probably minor quebradas crossing the area

bmc. Conclusive evaluation

The location is well fit for a landfill site for hazardous waste, due to the well-protected ground water, the low precipitation and medium evaporation, the short distance from Santiago, and the good road access.

c. Locality no. 3, Quilapilún (Tres Orejas)

ca. Locality

caa. Localization

The potential landfill site no. 3, Quilapilún, is located about 50 km north of Santiago and about 5 km east of the road 57 between Santiago and San Felipe, in the municipality of Colina. The coordinates of the centre of the area are approximately 70°38'20" W, 33°06'10" S. The altitude is about 850-900 metres above sea level.

cab. Description of area

The area is situated in the northern part of the Rio Maipu catchment area. From the foot of the mountains to the south and west, the landscape slopes gently towards west. There are also mountains to the north of the area, although not very close, as the area is limited to the north by a road and a fence pulling east-west. The mountains on all sides reach an altitude of 1,300 - 1,500 metres above sea level. Immediately adjacent to the site to the northwest is the low hill of Cerro Flojera. The area is dry grassland with scattered bushes and trees.

cac. Present land use

The area is presently used for extensive cattle breeding.

cb. Land Ownership

There is one private owner of the site area and a vast area around it, with a total area of 6,457 ha.

cc. Physical Planning

There is no physical planning related to the area.

cd. Geology and Hydrogeology

cda. General geology

The site lies on the boundary between colluvial deposits stretching to the north and bedrock in the south.

cdb. General hydrogeology

The hydrological regime of the area is that of an confined aquifer with ground water levels a little below the terrain. The water bearing strata consists of calcareous clays with sand and gravel, with water bearing strata 20-40 metres below the ground surface. The ground water is probably quite well protected against pollution from the surface due to the clayey formations. General specific yields of wells in the area is small, in the magnitude of 0-2 l/sec/meter.

cdc. Ground water as source of water supply

There is no specific information available, but based on general information from EMOS it can be assumed that it is possible to establish single wells in rural areas, although the yield will be low.

cdd. Means of water supply in the area

The water supply to the nearby farmhouses - which is also collected in a reservoir for irrigation purposes - is a small stream which has been diverted from a watercourse formerly running more northerly than the present one.

ce. Topsoil and Agriculture

cea. Description of topsoil

The topsoil belongs to the Rungue formation, which is generally clayey with cracks in the upper layers. The clay is montmorillonitic, plastic and adhesive, and has consolidated into a hard, rock-like structure. Gravel is inter-layered in the clay matrix. There is no visible sign of calcareous rocks (no reaction with hydrochloric acid). In the actual location the texture is very fine to medium fine with depths between 40 and 70 cm.

ceb. Land use class

The land use classes of the area are IV e and VI e.

cf. Precipitation and Evapotranspiration

The average precipitation in the area is about 300 mm per year, mainly falling in the winter months of June - August. There is a 95% probability that the precipitation will be more than 140 mm/year and a 5% probability that it will be more than 600 mm/year.

The potential evapotranspiration in the area is about 1,800 mm/year.

cg. Watercourses - Surface Water

Along the fence limiting the area to the north - and of the north side of it - there is a small stream which is an artificial diversion of a watercourse further uphill. The purpose of this is to serve as water supply to the farmhouses along the access road and as watering of the cattle in grazing in the area and well as for irrigation purposes. Risk of contamination of this water supply can be avoided by piping it along the landfill site.

There are several quebradas intersecting the area from the hillsides to the east and south, discharging into the Quebrada la Rinconada. Some of these can be avoided by a proper layout of the landfill, but some will have to be intercepted to avoid risks of flooding during torrent rain.

ch. Distance to sensitive activities

cha. Airports

There is no airport in the area.

chb. Towns and villages

There are no towns and villages within more than 5 km from the area.

chc. Single houses

There are a couple of farmhouses along the access road, southwest of Cerro Flojera, which will be within 2-300 metres from the site, depending on size. Another house is situated to east of the site on the hillside, also within 2-300 metres from the site.

ci. Distance from Santiago

The distance from central Santiago is about 50 km.

cj. Access by Road or Train

There is good access to the area on the main road from Santiago to San Felipe (road 57). From this road there is only a poor dirt road which will need proper improvement to serve as future access road. The distance from road 57 is about 5 km.

There is no access by train.

ck. Possible Landfill on Area

There are two options for the construction of a landfill in the area:

The smaller site would be situated at the foot of the slopes. It would be an area of about 1,000 metres east-west and 750 metres north-south, totalling 750,000 m², constructed as an artificial hill continuing the mountain in the east and south. The slopes would be relatively steep all the way around, and a cut-off of the quebradas at the foot of the hill should be foreseen. The average height could amount to about 40 metres, resulting in a total volume of about 30 million m³.

The larger site would incorporate the slopes to the east and southeast. This would mean that the mountain would be extended from the east and westwards, but leaving

a ravine between the landfill and the mountain to the south to avoid some of the problems related to the diversion of the quebradas. This would create a landfill somewhat more irregular in shape and with an area of about 1,100,000 m². The average height would increase considerably, being 80 metres or more and resulting in a total volume of 90-100 million m³.

A section of the general map of the area in scale 1:25,000 (figure J.2.2c overleaf) shows the outline and the immediate surroundings of the possible landfill site.

cl. Availability of Public Service

cla. Water supply

No information available. Access to public water supply most unlikely.

clb. Sewage treatment

No information available.

clc. Power supply

No information available.

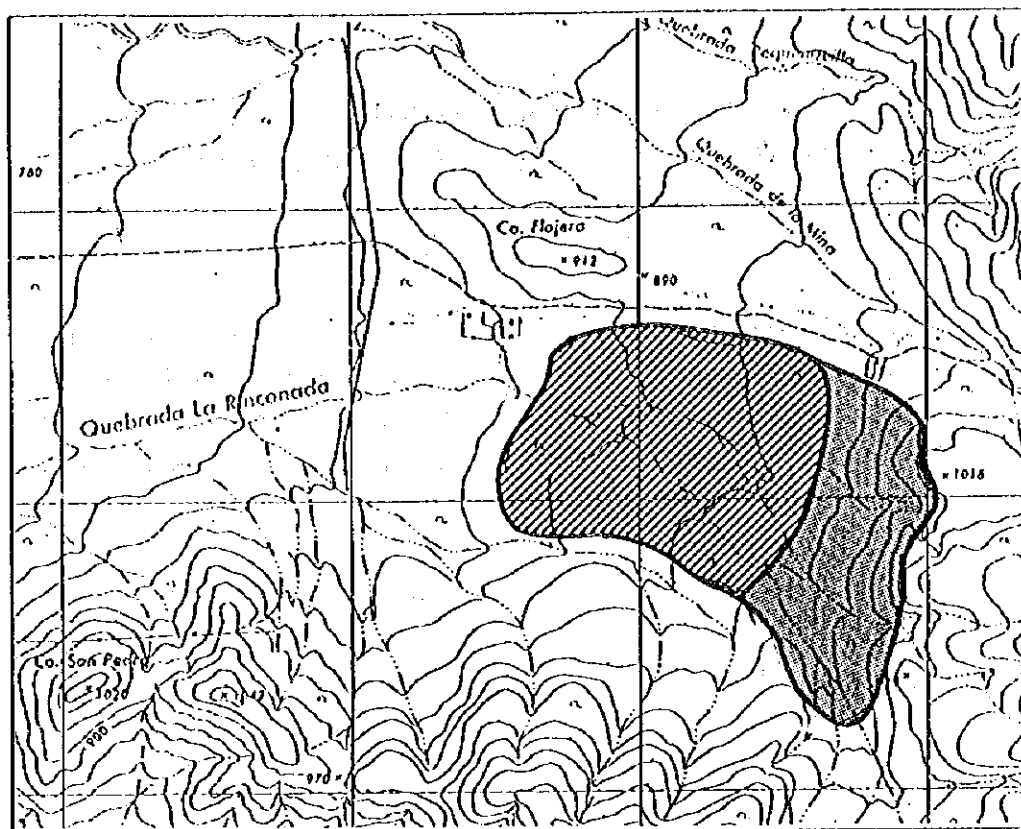


Figure J.2.2c Outline and surrounding of potential landfill site 3, Quilapilún (Tres Orejas)

cm. Preliminary evaluation of site

The advantages and disadvantages of the locality as a future landfill site can be summarized as follows:

cma. Advantages

- No problems with land use and land use quality
- One private owner
- No planning problems
- Probably well-protected ground water, small source
- Low precipitation and high evapotranspiration
- Few sensitive activities
- Good road access, although far from main road
- Very large volume (30-100 million m³)

cmb. Disadvantages

- Quebradas crossing the area

- Medium distance from Santiago (50 km)
- Problems with water supply and power supply likely

cmc. Conclusive evaluation

The location is well fit for a landfill site for hazardous waste. The main advantages is the small and probably well-protected ground water resource, the low precipitation and high evaporation, and the very large volume available (if this is needed). Some practical problems in relation to access road and public services can, however, be foreseen.

d. Locality no. 4, Estación Puangue

da. Locality

daa. Localization

The potential landfill site no. 4, Estación Puangue, is located about 70 km west of Santiago and about 3 km north of the road 78 between Santiago and San Antonio, in the municipality of Melipilla. The coordinates of the centre of the area are approximately 71°19'45" W, 33°37'40" S. The altitude is about 150 metres above sea level.

dab. Description of area

The area is situated in the western part of the Rio Maipu catchment area. It is on the northern side of a railway line (between Santiago and San Antonio) and at the foot of low hills (about 500 metres above the sea to the north and 350-400 to the west and southwest). The overall impression of the area is that it is very undulating and intersected by many quebradas (a small stream trickling at the time of visit (10 August 1995)). There are, however, smaller relatively flat parts in between. Part of the area, also on the northern side of the railway, is cultivated. On the south side of the railway and towards the river (Estero Puangue) most is cultivated and there is a farm next to. The actual area is grassland but it seems to be more fertile than similar areas in the north. It could be assumed that the main reason that the area in question is not cultivated is due to the generally rather steep slopes.

dac. Present land use

The area is presently used for extensive cattle breeding.

db. Land Ownership

There is one private owners of the two parcels on which the landfill will be situated. The areas of the parcels are 810 ha and 395 ha. The neighbouring area of 42 ha is probably owned by the same family (same family name).

dc. Physical Planning

There is no planning related to the area.

dd. Geology and Hydrogeology

dda. General geology

The upper layer consists of a compacted and half-hardened ash deposit on fragments of country rock and pumicitic pebbles. The maximum depth of this deposit is about 5 metres. Underneath lies metamorphic bedrock towards the north and west. Old alluvial gravel and sand deposits are presumable to be found at depth towards the southeast, i.e. towards the Estero Puangue. On the northern perimeter colluvial deposits overlay the volcanic ash deposits.

ddb. General hydrogeology

The hydrogeological conditions are those of a phreatic aquifer in strata with low specific yield due to high clay contents in the soil. The clay content will be as much as 50% at some levels. It can generally be assumed that the water bearing strata will be well protected against pollution from the surface. The specific yields are as low as 0.1-0.2 l/sec/meter.

ddc. Ground water as source of water supply

See ddd. below.

ddd. Means of water supply in the area

Although the specific yield is low, the public water supply in the area is based on ground water abstraction from deep wells in the aquifer. Depths of 50-70 metres seem to be common. The wells are generally located close to the river (Estero Puangue) where the ground water level can be assumed to be the highest.

de. Topsoil and Agriculture

dea. Description of topsoil

The topsoil in the area belongs to the Lo Vásques and the Piedmont Lo Vásques formations.

The general features of the Lo Vásques formation is sandy clayey loam, with clay content increasing with depth. The soil is plastic and adhesive, with quartz fragments which also become more abundant with depth. The substratum - deeper than 115 cm - consists of decomposed granodiorite bedrock. At the actual location the sandy clayey loam is 40-70 cm thick, well drained, slightly eroded, with slopes between 10 and 20%, and very uneven.

The general features of the Piedmont Lo Vásques formation is a sandy clay with a gravel content that increase with depth. The soil is plastic and adhesive. At the actual location it is generally loam between 70 and 90 cm thick, well drained, with slopes between 3 and 6%.

deb. Land use class

The land use classes of the area is IV e and VI e.

df. Precipitation and Evapotranspiration

The average precipitation in the area is about 400 mm per year, mainly falling in the winter months of May - August. There is a 95% probability that the precipitation will be more than 200 mm/year and a 5% probability that it will be more than 700 mm/year.

The potential evapotranspiration in the area is about 1,500 mm/year.

dg. Watercourses - Surface Water

As mentioned under dab. above, the area is intersected by many small watercourses, some of them dry and some of them carrying little water on the time of the field visit. These watercourses will all empty into Estero Puangue.

dh. Distance to sensitive activities

dha. Airports

There are no airports in the area.

dhb. Towns and villages

There are no build-up areas in the vicinity. The nearest one is Puangue at the road about 3.5 km to the south.

dhc. Single houses

There is a farmhouse with appurtenant building and housing for workers next to the access road, about 500 metres south of the area.

di. Distance from Santiago

The distance from central Santiago is about 70 km.

dj. Access by Road or Train

There is good access on the highway Santiago - San Antonio, road no. 78. From this road there is a well-kept dirt road leading about 2.5 km to the north. Past the farm area another dirt road of about 1 km leads to the site. Just before reaching there it crosses the railway.

The area is immediately adjacent to the railway Santiago - San Antonio.

dk. Possible Landfill on Area

Due to the steep slopes and the watercourses intersecting the area it is not possible to construct a major landfill - at least only applying large civil works.

The possible landfill on the site could be constructed between two main quebradas,

continuing the natural slopes into a artificial hill. The area of this landfill would be about 500 x 500 metres or about 250,000 m². With an average height of about 25 metres this would result in a volume of about 6 million m³.

A section of the general map of the area in scale 1:25,000 (figure J.2.2d below) shows the outline and the immediate surroundings of the possible landfill site.

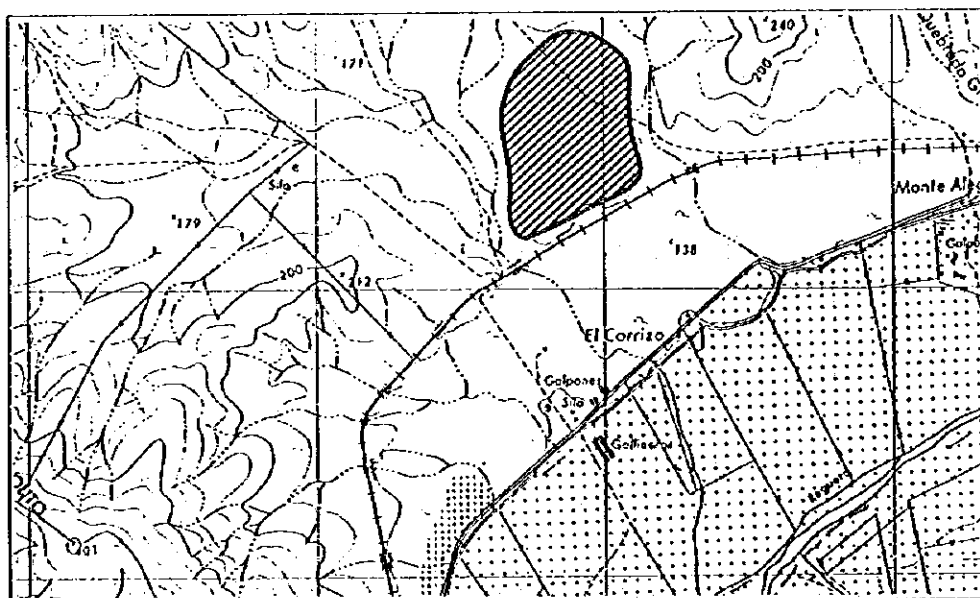


Figure J.2.2d Outline and surrounding of potential landfill site 4, Estación Puangue

dl. Availability of Public Service

dla. Water supply

There is a public water supply in Puangue about 5 km to the southeast. No information available on water supply to nearby farm.

dlb. Sewage treatment

No information available.

dlc. Power supply

No information has been obtained, but it can be assumed that there is power supply to the farmhouses less than 1 km from the site.

dm. Preliminary evaluation of site

The advantages and disadvantages of the locality as a future landfill site can be summarized as follows:

dma. Advantages

- No problems with land use and land use quality
- One private owner
- No planning problems
- Probably well-protected ground water
- Medium precipitation and evapotranspiration
- Few sensitive activities, although farmhouses and farmland nearby
- Good road access
- Good train access

dmb. Disadvantages

- Many quebradas in the area
- Large distance from Santiago (70 km)
- Small volume (6 million m³)

dmc. Conclusive evaluation

The location is not too well fit for a landfill site because the volume is relatively small and the quebradas and the relatively high precipitation in the area may create problems. The access by road and train is, however, good, and the natural ground water protection seems good.

c. Locality no. 5, San Diego

ea. Locality

ean. Localization

The potential landfill site no. 5, San Diego, is located about 70 km west of Santiago and about 1.5 km south of the road 78 between Santiago and San Antonio, in the municipality of Melipilla. The coordinates of the centre of the area are approximately 71°22' W, 33°39'30" S. The altitude is 125 -175 metres above sea level.

eab. Description of area

The area is situated in the western part of the Rio Maipu catchment area. The area is on the eastern slope of a group of low hills, about 200 metres above the sea to the west, and with the flat land around the Estero Puangue to the east and south. To the north the area is limited by Estero San Diego which flows into Estero Puangue, and immediately to the east by an irrigation canal. At the time of the visit there was little water in the two esteros. The actual area is grassland with scattered trees which seems less green than is the case for site no. 4. It is intersected by minor gullies, less than 1 meter deep and less than 0.5 meter wide.

eac. Present land use

The area is presently used for extensive cattle breeding.

eb. Land Ownership

The parcel where the landfill could be located - with an area of 203 ha - has one private owner. To the north and south, in a distance of about 500 metres, there are two more parcels with private owners.

ec. Physical Planning

There is no physical planning related to the area.

ed. Geology and Hydrogeology

eda. General geology

The site is located on a high level, old fluvial terrace made of stratified conglomerate, sandstone, siltstone and claystone beds. The material is generally half hardened and has low permeability in a thickness of several metres. These strata rest on bedrock and have been partially covered by pumitic ash which has been eroded and washed out in recent times.

edb. General hydrogeology

The hydrogeological conditions are those of a phreatic aquifer in strata with low specific yield due to high clay contents in the soil. The clay content will be as much as 50% at some levels. It can generally be assumed that the water bearing strata will be well protected against pollution from the surface. The specific yields are as low as 0.1-0.2 l/s/m.

edc. Ground water as source of water supply

See edd below.

edd. Means of water supply in the area

Although the specific yield is low, the public water supply in the area is based on ground water abstraction from deep wells in the aquifer. Depths of 50-70 metres seem to be common. The wells are generally located close to the river (Estero Puangue) where the ground water level can be assumed to be the highest.

ee. Topsoil and Agriculture

eea. Description of topsoil

The topsoil in the area belongs to the Alhue formation. The general features of this is a fine sandy loam which is neither plastic nor adhesive, and which is hardened to an almost impermeable layer a little below the surface. At the actual location the sandy loam layer is thin, with imperfect drainage and light slopes, 1-3%.

ceb. Land use class

The land use classes of the area is VI w, VII e and VII s.

cf. Precipitation and Evapotranspiration

The average precipitation in the area is about 400 mm per year, mainly falling in the winter months of May - August. There is a 95% probability that the precipitation will be more than 200 mm/year and a 5% probability that it will be more than 700 mm/year.

The potential evapotranspiration in the area is about 1,500 mm/year.

cg. Watercourses - Surface Water

Except for the Estero San Diego, Estero Puangue and the irrigation canal at the foot of the slope there are not watercourses in the area. Some quebradas flow into Estero Puangue from the hills, but they do not intersect the actual area.

ch. Distance to sensitive activities

cha. Airports

There are no airport in the area.

ehb. Towns and villages

The nearest build-up area is Puangue at the main road, about 2.5 km to the west.

ehc. Single houses

There are some farmhouses and alike along the road G-800, about 500 metres east and northeast of the area.

ei. Distance from Santiago

The distance from central Santiago is about 70 km.

ej. Access by Road or Train

There is good access on the highway Santiago - San Antonio, road no. 78. From this road there is a road leading about 1.5 km to the south and passing the bridge Ponte Negro over Estero San Diego. Right after that there is direct access to the area.

There is no access by train to the area. The only option for transport by train would be to make a transfer at the Estación Puangue at the Santiago - San Antonio railway. This railway station is about 2.5 km from the site.

ek. Possible Landfill on Area

It will be possible to establish a landfill on the area which is a natural continuation and extension of the hills in the western part of the area out into the valley. The landfill would be of an almost triangular, forming an artificial hill. The extension would be about 1,200 metres west-east and 700 metres north-south, with a total area of about 450,000 m². This could be done without intersecting any quebradas. The average height could be about 35 metres, thereby resulting in a volume of about 15 million m³.

A section of the general map of the area in scale 1:25,000 (figure J.2.2e overleaf) shows the outline and the immediate surroundings of the possible landfill site.

el. Availability of Public Service

ela. Water supply

There is a public water supply in Puangue about 3 km to the east. No information available on water supply to nearby farm.

elb. Sewage treatment

No information available.

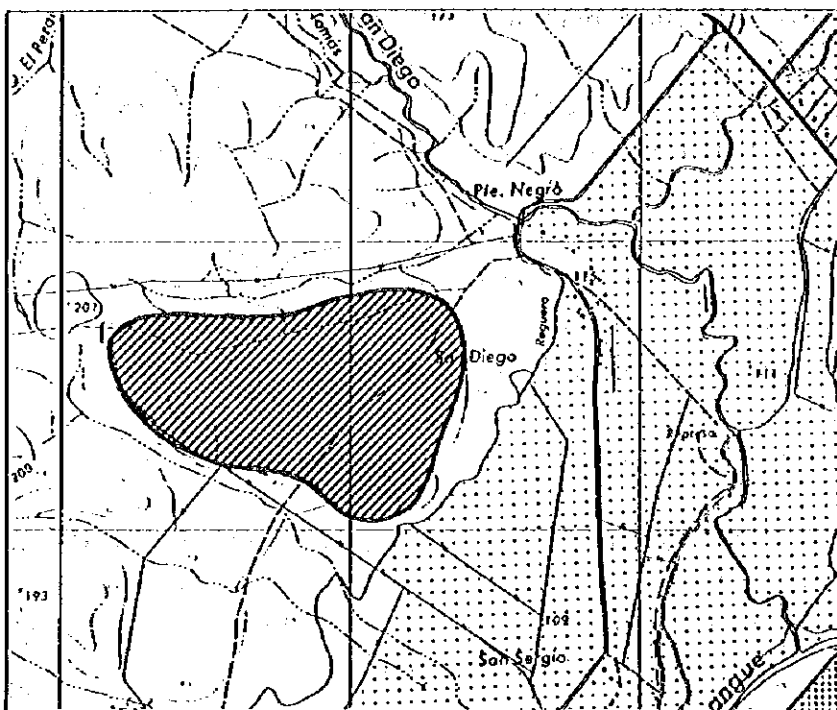


Figure J.2.2e Outline and surrounding of potential landfill site 5, San Diego

etc. Power supply

No information has been obtained, but it can be assumed that there is power supply to the farmhouses less than 1 km from the site.

em. Preliminary evaluation of site

The advantages and disadvantages of the locality as a future landfill site can be summarized as follows:

ema. Advantages

- No problems with land use and land use quality
- One private owner
- No planning problems
- Probably well-protected ground water and insignificant source
- Medium precipitation and evapotranspiration
- No watercourses crossing the area
- Few sensitive activities

- Good road access
- Medium volume (15 million m³)

emb. Disadvantages

- Large distance from Santiago (70 km)

emc. Conclusive evaluation

The location is well fit for a landfill site for hazardous waste, although the relatively high precipitation may create some problems. The probably good natural ground water protection will partly compensate for this, and it is an advantage that there are no watercourses crossing the area and that the road access is good.

f. Locality no. 6, Santa Amelia

fa. Locality

faa. Localization

The potential landfill site no. 6, Santa Amelia, is located about 70 km west of Santiago and about 2 km south of the road 78 between Santiago and San Antonio, in the municipality of Melipilla. The coordinates of the centre of the area are approximately 71°20' W, 33°41'10" S. The altitude is 150 - 200 metres above sea level.

fab. Description of area

The area is situated in the western part of the Rio Maipu catchment area. The area is flat in the north, and slopes gently upwards toward the low hills (ridge about 250 metres above the sea) to the south. Further to the north the area is limited by the gorge of the Estero Santa Amelia. To the east and west the area is limited by smaller gorges with quebradas flowing into Estero Santa Amelia. There are no watercourses on the plain, but there may be some quebradas on the southern slopes. The area is dry grassland with scattered trees.

fac. Present land use

The area is presently used for extensive cattle breeding.

fb. Land Ownership

The site is part of two relatively small, privately owned parcels, 56 ha and 92 ha, respectively. Immediately west, north and east of the site there are about 10 parcels, owned by different private owners.

fc. Physical Planning

There is no physical planning related to the area.

fd. Geology and Hydrogeology

fda. General geology

The site is on bedrock with a thin topsoil. To the north there are volcanic ash deposits.

fdb. General hydrogeology

There is no information on the general hydrogeological conditions in the area. Based on general knowledge and the information in section fda. and fea. it can be assumed that there is little - if any - ground water to be found in the area and that precipitation will discharge as storm water or seep into the upper layers and from there into the watercourses.

fdc. Ground water as source of water supply

No information available. Referring to fdb. above it is, however, unlikely that ground water abstraction will be relevant.

fdd. Means of water supply in the area

No direct information available, but it is known that there is a public water supply in Puangue. This may extend to the populated areas along the access road.

fe. Topsoil and Agriculture

fea. Description of topsoil

The topsoil in the area belongs to the Lo Vásques and the Alhue formations.

The general features of the Lo Vásques formation is sandy clayey loam, with clay content increasing with depth. The soil is plastic and adhesive, with quartz fragments which also become more abundant with depth. The substratum - deeper than 115 cm - consists of decomposed granodiorite bedrock. At the actual location the sandy clayey loam is 40-70 cm thick, well drained, slightly eroded, with slopes between 10 and 20%, and strongly undulated.

The general features of the Alhue formation is a fine sandy loam which is neither plastic nor adhesive, and which is hardened to an almost impermeable layer a little below the surface. At the actual location the sandy loam layer is medium deep (40-70 cm), well drained, small hills, 10-20% slopes, strongly undulated.

feb. Land use class

The whole area is in land use class VI e.

ff. Precipitation and Evapotranspiration

The average precipitation in the area is about 400 mm per year, mainly falling in the winter months of May - August. There is a 95% probability that the precipitation will be more than 200 mm/year and a 5% probability that it will be more than 700 mm/year.

The potential evapotranspiration in the area is about 1,500 mm/year.

fg. Watercourses - Surface Water

There are no watercourses crossing the area, only a couple of quebradas which seem to both start and end at the slopes to the north.

fh. Distance to sensitive activities

fha. Airports

There is no airport in the area.

fhb. Towns and villages

The village of Puangue along the main road is about 2.5 km to the north. The access road takes off, however, from the main road in Puangue.

There are several houses at the access road along the Estero Santa Amelia. These houses - which according to their number must be considered at the same level as a village - are lies 500 - 1,000 metres northwest of the area.

fhc. Single houses

Except for the houses at the access road there are no houses nearby.

fi. Distance from Santiago

The distance from central Santiago is about 70 km.

fj. Access by Road or Train

There is good access on the highway Santiago - San Antonio, road no. 78. From this road there is a local road from Puangue about 2.5 km to the south and west leading to the area. This road is rather poor and is flanked by houses both in Puangue and where it winds along Estero Santa Amelia. Due to the existence of the gorge of Estero Santa Amelia and the farmland north of that it is hardly possible to establish a road access.

There is no access by train to the area. The only option for transport by train would be to make a transfer at the Estación Puangue at the Santiago - San Antonio railway. This railway station is about 5 km from the site.

fk. Possible Landfill on Area

There are two options for the construction of a landfill in the area:

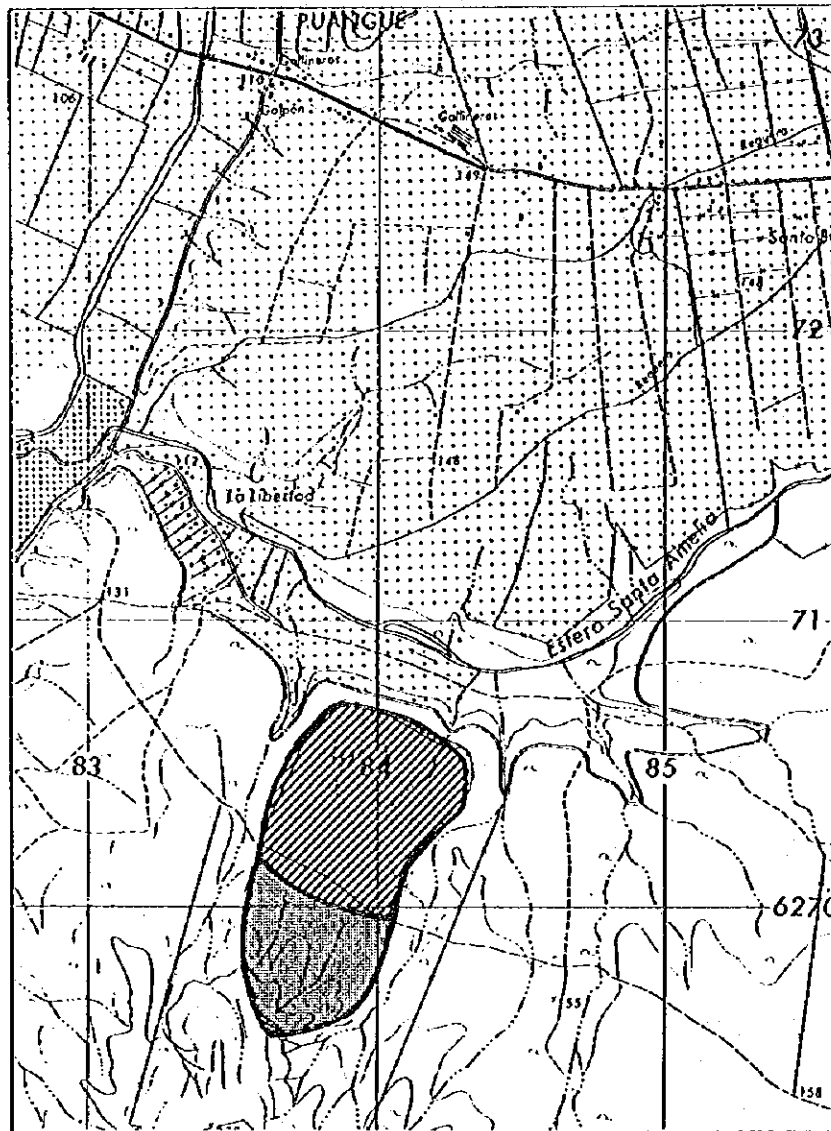


Figure J.2.2f Outline and surrounding of potential landfill site 6, Santa Amelia

The smaller site would be situated on the flat area at the foot of the slopes. It would be an area of about 700 metres north-south and 500 metres east-west, totalling 350,000 m², constructed as an artificial hill as an extension of the hills in the north. The slopes would be relatively steep all the way around and continue naturally in the landscape into the quebradas/enteros to the east, north and west. To the south it would be easy - if necessary - to intercept the quebradas from the slopes. The average height could amount to about 25 metres, resulting in a total volume of about 9 million m³.

The larger site would incorporate the slope to the north. This would mean that the hill-ridge would be extended with a spur to the north, but the area would still be limited by the quebradas as above to the west, north and east. One advantage of this would be that the quebradas on the slopes would be incorporated in the landfill which would therefore not be intercepted by any quebradas. This would result in a landfill the size of about 1,100 x 500 metres and with an area of about 50,000 m². The average height would increase to around 35 metres and the resulting volume would be about 17 million m³.

A section of the general map of the area in scale 1:25,000 (figure J.2.2f on previous page) shows the outline and the immediate surroundings of the possible landfill site.

fl. Availability of Public Service

fla. Water supply

No information directly available, but it is known that there is a public water supply in Puangue. This may extend to the populated areas along the access road and from there be extended to a landfill on the site.

flb. Sewage treatment

No information available.

flc. Power supply

No information available.

fm. Preliminary evaluation of site

The advantages and disadvantages of the locality as a future landfill site can be summarized as follows:

fma. Advantages

- No problems with land use and land use quality
- No planning problems
- Not-too-well-protected ground water, but probably insignificant source
- Medium precipitation and evapotranspiration
- Medium volume (17 million m³)

fmb. Disadvantages

- Two private owners of site area, many parcels close to site
- Large distance from Santiago (70 km)
- Many houses along the access road and nearby
- Access road of poor quality and difficult/impossible to improve

fmc. Conclusive evaluation

The location is not fit for a landfill site for hazardous waste because of the problems related to the access road and the dwellings along this road. The large amount of private landowners in the area is also likely to create problems.

g. Locality no. 7, Mandinga

ga. Locality

gaa. Localization

The potential landfill site no. 7, Mandinga, is located about 78 km southwest of Santiago and about 15 km southwest of the town of Melipilla next to the road G-60 between Melipilla and San Pedro, in the municipality of Melipilla. The coordinates of the centre of the area are approximately 71°18'40" W, 33°48'45" S. The altitude is 100 - 175 metres above sea level.

gab. Description of area

The area is situated in the western part of the Rio Maipu catchment area. The area is the northern forerunner of low mountains reaching an altitude of 600 - 800 metres 2 - 4 km to the south. It slopes gently from an altitude of 150 - 175 metres towards the watercourse Estero Popeta (carrying water at the date of the visit, 10 August 1995) 1 - 2 km to the northeast at about 75 metres above sea level. The actual area is a smaller part of a landscape of the same type stretching southeastwards and westwards along the estero. The slopes are intersected with quebradas from the hills, but at the time of the visit none were carrying water. The vegetation is grassland with bushes and trees.

gac. Present land use

The present use of the area and the surrounding areas is extensive cattle breeding.

There is cultivated land and farmhouses next to the river.

gb. Land Ownership

The land ownership cannot be established. The area south of Estero Popeta has until recently been one large parcel, but it has been singled out into 65 parcels and a map showing the ownership has not yet been provided.

gc. Physical Planning

There is no physical planning related to the area.

gd. Geology and Hydrogeology

gda. General geology

The site is on bedrock with a thin topsoil. To the north there are volcanic ash deposits.

gdb. General hydrogeology

There is no information on the general hydrogeological conditions in the area. Based on general knowledge and the information in section gda. and gea. it can be assumed that there is little - if any - ground water to be found in the area and that precipitation will discharge as storm water or seep into the upper layers and from there into the watercourses.

gdc. Ground water as source of water supply

No information available. Referring to gdb. above it is, however, unlikely that ground water abstraction will be relevant at the site. It may take place along the Estero Popeta about 1 km to the northeast.

gdd. Means of water supply in the area

Information was obtained that there is a public water supply in Mandinga, about 2 km to the northeast, based on a water from a surface reservoir at Estero Popeta.

ge. Topsoil and Agriculture

gea. Description of topsoil

The topsoil in the area belongs to the Alhue formation.

The general features of the Alhue formation is a fine sandy loam which is neither plastic nor adhesive, and which is hardened to an almost impermeable layer a little below the surface. At the actual location the fine sandy loam layer is medium deep (40-70 cm), well drained, small hills, slight to steep slopes (3-20%), strongly undulated.

geb. Land use class

The area is in land use class VI e.

gf. Precipitation and Evapotranspiration

The average precipitation in the area is about 520 mm per year, mainly falling in the winter months of May - August. There is a 95% probability that the precipitation will be more than 260 mm/year and a 5% probability that it will be more than 950 mm/year.

The potential evapotranspiration in the area is about 1,600 mm/year.

gg. Watercourses - Surface Water

There are no permanent watercourses in the area, but it is crossed by several quebradas which may occasionally carry water.

gh. Distance to sensitive activities

gha. Airports

There is no airport in the area.

ghb. Towns and villages

There is a relatively densely populated farmland area along and on both sides of the Estero Popeta 1 - 2 km to the north and northeast of the site.

ghc. Single houses

There are no single houses close to the area.

ghd. Other activities

The landfill of the municipality of Melipilla is situated at the other side of the road, about 6-700 metres north of the site. The site is crossed - southwest-northeast - by a high-voltage transmission line.

gi. Distance from Santiago

The distance to the area from central Santiago is about 78 km.

gj. Access by Road or Train

There is good access by road via the highway Santiago - San Antonio to Melipilla and from Melipilla on the paved road to the south. The site is situated next to this road, and a short access road could easily be established.

gk. Possible Landfill on Area

Establishing a landfill of a little irregular shape from the extended ridge and down the slope would give the benefit of intercepting most of the quebradas crossing the area in their full course. The landfill thus constructed would be of a triangular shape, widest at the top and narrowing towards the valley, creating an artificial hill which would extend the existing ridge into the valley. The extent would be about 1,500 metres north-south and 750 metres east-west, with a total area of 600,000 m². The average height could not be more than 25 metres if the finished landfill should fit properly into the terrain, thus resulting in a volume of about 15 million m³.

A section of the general map of the area in scale 1:25,000 (figure J.2.2g below) shows the outline and the immediate surroundings of the possible landfill site.

gm. Preliminary evaluation of site

The advantages and disadvantages of the locality as a future landfill site can be summarized as follows:

gma. Advantages

- No problems with land use and land use quality
- No planning problems
- Ground water probably well protected and small source
- High precipitation and medium to high evapotranspiration
- Most quebradas crossing the area can be incorporated in landfill
- No sensitive activities
- Very good road access
- Medium volume (15 million m³)
- Probably good access to public services

gmb. Disadvantages

- Ownership cannot be established at present
- Very large distance from Santiago (78 km)

gmc. Conclusive evaluation

The location is relatively well fit for a landfill site for hazardous waste, because the ground water resource is probably small and well-protected, which to some extent remedies the high precipitation and medium evaporation. It is also an advantage that the access road is very good, although this site is the one of all locations farthest off from Santiago. The unknown ownership may prove a disadvantage.

h. Locality no. 8, Escorial Norte

ha. Locality

haa. Localization

The potential landfill site no. 8, Escorial Norte, is located about 45 km south of Santiago and about 3 km southeast of the village of Huelquén, in the municipality of Paine. The coordinates of the centre of the area are approximately 70°37' W, 33°50'40" S. The altitude is about 450 metres above sea level.

hab. Description of area

The area is the flat foreland of the low mountains Loma de Quelén to the east and north. To the northwest, west and south the area is surrounded by cultivated agricultural land or pasture land. Immediately around the area - but not crossing it - are small watercourses or irrigation canals which carried water at the time of the visit (10 August 1995). The Estero Escorial is about 1 km south of the area, flowing westwards into the Rio Angostura. The area is grassland with trees and bushes, but much more fertile than the corresponding areas in the north.

hac. Present land use

The area is presently used for intensive cattle breeding.

hb. Land Ownership

The area has one private owner. The total area is 512 ha in different land use categories.

hc. Physical Planning

There is no physical planning related to the area.

hd. Geology and Hydrogeology

hda. General geology

The area consists almost entirely of unconsolidated alluvial sands in a deposit of high permeability. These alluvial sands may at certain depths be separated by low-permeable clay layers.

hdb. General hydrogeology

The hydrology/hydrogeology of the region is characterized by a flat terrain intersected by watercourses and with sand/gravel layers closest to the surface. Further down - from 25 to 100 metres below the ground - there may be clay layers above aquifers. This will result on confined aquifers with a ground water level close to or above the surface.

The upper strata will have a tendency to saturation in case of heavy rain, resulting in overflow to the small watercourses nearby.

hdc. Ground water as source of water supply

There are several wells in the area, some of them as deep as 160 metres. The specific yield is very variable, between 0.5 and 5 l/sec/meter.

hdd. Means of water supply in the area

Public and private water supply in the area will depend both on ground water abstraction and surface water sources.

he. Topsoil and Agriculture

hea. Description of topsoil

The topsoil in the area belongs to the Pintué formation.

The general features of the Pintué formation is a sandy loam, neither plastic nor adhesive. It is relatively thick, stratified, gently sloping, and rests on a lacustrine, clayey substratum in a depth of more than 2 metres. At the actual location the sandy loam is less thick (40-70 cm), very well drained, with stones.

heb. Land use class

The area is in the land use class VI e.

hf. Precipitation and Evapotranspiration

The average precipitation in the area is about 550 mm per year, mainly falling in the winter months of May - September. There is a 95% probability that the precipitation will be more than 240 mm/year and a 5% probability that it will be more than 890 mm/year.

The potential evapotranspiration in the area is about 1,500 mm/year.

hg. Watercourses - Surface Water

The area is surrounded by small watercourses and/or irrigation canals which have their origin in the low hills to the north and east. These watercourses are probably most used for irrigation, but obviously also for watering cattle. Further north there is a reservoir for the supply of potable water to Huelquén.

hh. Distance to sensitive activities

hha. Airports

There is no airport in the area.

hhb. Towns and villages

The village of Huelquén is situated about 3 km to the northwest of the site.

hhc. Single houses

There are no houses next to the site. The nearest houses are the farmhouses at the main road where the access road starts, about 1.5 km to the west.

hi. Distance from Santiago

The distance from central Santiago is about 45 km.

hj. Access by Road or Train

There is a direct, paved access road, G-515, from Santiago to Huelquén. As this is rather narrow and leads through populated areas, a more suitable road access would be on the Pan American Highway to Paine and from there on the G-531 eastward. The immediate access road is presently an internal farm road (dirt road) among the farmhouses.

There is no possibility for direct train access to the site, but as the railway runs along the Pan American Highway it must be possible to apply railway transport as far as Paine.

hk. Possible Landfill on Area

A landfill on the area would follow the limitations set by the small watercourses. This would result in an artificial hill of triangular shape, about 1,000 metres north-south and 700 metres east-west. The total area would be about 400,000 m². With an estimated average height of 30 metres this would result in a landfill volume of about 12 million m³.

A section of the general map of the area in scale 1:25,000 (figure J.2.2h overlaid) shows the outline and the immediate surroundings of the possible landfill site.

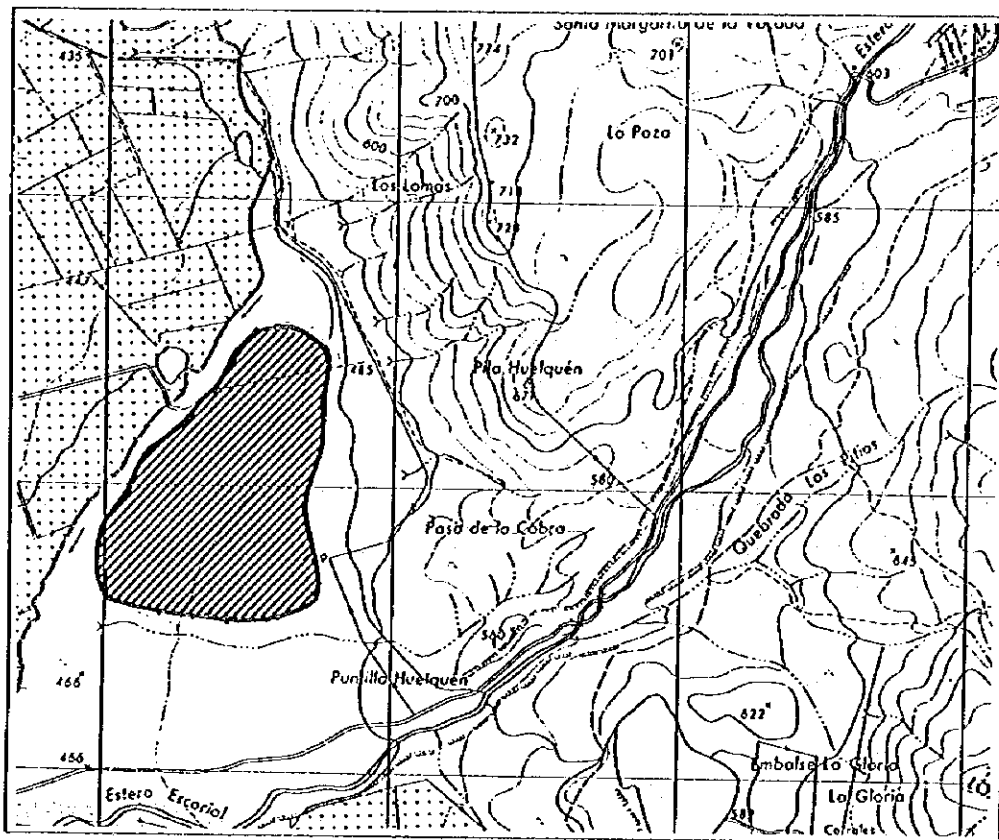


Figure J.2.2h Outline and surrounding of potential landfill site 8, Escorial Norte

hl. Availability of Public Service

hla. Water supply

There is a public water supply in the village of Huelquén about 3 km to the northwest.

hlb. Sewage treatment

No information available - but there is obviously no public sewers between the site and the northbound road to Huelquén.

hlc. Power supply

No information available, but there is no power supply closer than the farmhouse 2 km to the west.

hm. Preliminary evaluation of site

The advantages and disadvantages of the locality as a future landfill site can be summarized as follows:

hma. Advantages

- No problems with land use and land use quality
- One private owner
- No planning problems
- Few sensitive activities
- Medium distance from Santiago (45 km)
- Reasonable road access
- Medium volume (12 million m³)

hmb. Disadvantages

- High precipitation and medium evapotranspiration
- Quebradas/canals around the area, probably irrigation and maybe water supply purposes
- Long final access road through farmland
- Problems with public service likely

hmc. Conclusive evaluation

The location might be used for a landfill site for hazardous waste, but there is severe doubt about ground water protection and watercourses, and the relatively high precipitation in the region may create problems.

i. Locality no. 9, Rincón los Rulos

ia. Locality

iaa. Localization

The potential landfill site no. 9, Rincón los Rulos, is located about 50 km south of Santiago and about 9 km southeast of the town Paine, in the municipality of Paine. The coordinates of the centre of the area are approximately 70°42' W, 33°53' S. The altitude is 400 - 450 metres above sea level.

iab. Description of area

The area is a semi-circular gorge surrounded by the mountain group Cerros de Chada and situated in the northwest part of this mountain group. In the gorge the terrain is relatively even, sloping gently from the foothills towards the opening to the west. The slopes rise steeply at all sides, reaching altitudes of 600 metres to the north, 7-800 metres to the east and more than 1,200 metres to the south (Cerro Challay). The area only opens to the west where it is bordered by agricultural land. The vegetation is dry grassland with quite dense bushes and low trees.

iac. Present land use

The area is presently used for extensive cattle breeding.

ib. Land Ownership

There is one private owner of the site and its surroundings. The total area is 1,116 ha.

ic. Physical Planning

There is no physical planning related to this area.

id. Geology and Hydrogeology

ida. General geology

The site is a colluvial deposit filling a depression that opens to the northwest. It is surrounded on all other sides by bedrock. The opening to the northwest makes contact between the colluvial deposits in the depression and the alluvial sands and gravels deposited by Rio Angostura in the west.

idb. General hydrogeology

There is no specific information about the hydrogeology in the area. Based on the description of the geology and the topsoil (section ida. and ica.) it can, however, be assumed that the area is well drained towards the plain to the northwest of the hills. The ground water level in the area will thus be determined by the one in the plain. It can be assumed that there are no deposits resulting in ground water protection against leachate from a landfill in the area.

idc. Ground water as source of water supply

No specific information available. Bases on general information from EMOS and information mentioned above it may be assumed that there could be some basis for ground water abstraction for water supply in the area.

idd. Means of water supply in the area

No information available. See comments under idc. above.

ie. Topsoil and Agriculture

ica. Description of topsoil

The topsoil in the area belongs to the Pintué formation.

The general features of the Pintué formation is a sandy loam, neither plastic nor adhesive. It is relatively thick, stratified, gently sloping, and rests on a lacustrine, clayey substratum in a depth of more than 2 metres. At the actual location the sandy loam is

thin (20-40 cm), very well drained, with stones and moderately sloping at the foot of the surrounding hills, and moderately thick (40-70 cm), very well drained, with few stones and almost flat further against the opening to the northwest.

ieb. Land use class

The land use classes of the area are IV s in the bottom and VII e at the foothills.

if. Precipitation and Evapotranspiration

The average precipitation in the area is about 500 mm per year, mainly falling in the winter months of May - September. There is a 95% probability that the precipitation will be more than 240 mm/year and a 5% probability that it will be more than 900 mm/year.

The potential evapotranspiration in the area is about 1,400 mm/year.

ig. Watercourses - Surface Water

There are no permanent watercourses in the area. A quebrada leading out from the area was dry at the time of the visit (10 August 1995). There were signs of quebradas on the slopes, but they seem only to a limited extent to discharge as surface water. It is more likely that they drain off through the rather coarse soil in the bottom of the gorge as ground water.

ih. Distance to sensitive activities

iha. Airports

There is no airport in the area.

ihb. Towns and villages

There are no densely populated areas nearby.

ihc. Single houses

There are a few houses along the last part of the access road. The closest is about 500 metres from the site, and there are 2 or 3 more within 1 km.

ii. Distance from Santiago

The distance from central Santiago is about 50 km.

ij. Access by Road or Train

There is access on Pan American Highway till south of Paine. From here road G-505, a gravel road of fair quality, leads about 3 km east till it reaches the mountains. An access road of very poor quality along the slope, passing a few houses, leads the last 1.5 km to the site.

There is no possibility of direct access by train, but as the southbound railway from Santiago runs along the Pan American Highway it must be possible to apply railway transport as far as Paine and maybe further.

ik. Possible Landfill on Area

It is most likely that establishing a landfill that reaches up the slopes of the surrounding hills - although maybe technically possible - will result in serious water problems in the wet season. It is therefore assumed that a landfill should be established as an artificial hill on the bottom of the area, with a cut-off draining ditch along the perimeter. This would result in an almost circular, cone-shaped hill with a diameter of about 800 metres, which means an area of about 500,000 m². The total height could be about 100 metres, the average height 35 metres, leaving a total volume of about 17 million m³.

A section of the general map of the area in scale 1:25,000 (figure J.2.2i overleaf) shows the outline and the immediate surroundings of the possible landfill site.

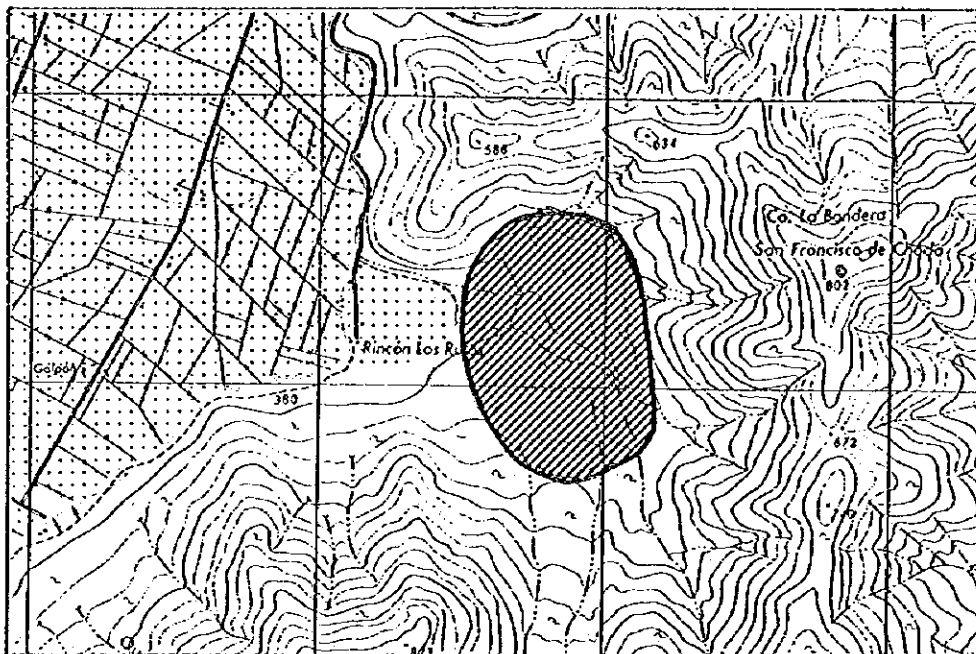


Figure J.2.2i Outline and surrounding of potential landfill site 9, Rincón los Rulos

ii. Availability of Public Service

ila. Water supply

No information available.

ilb. Sewage treatment

No information available.

ilc. Power supply

No specific information available. It is, however, likely that there is general power supply in the residential area along the access road about 2 km to the west.

im. Preliminary evaluation of site

The advantages and disadvantages of the locality as a future landfill site can be summarized as follows:

ima. Advantages

- No problems with land use and land use quality
- One private land owner
- No planning problems
- Few sensitive activities
- Medium distance from Santiago (50 km)
- Good road access on Pan American Highway - maybe indirect train access
- Medium volume (17 million m³)

imb. Disadvantages

- High precipitation and medium evapotranspiration
- Poor ground water protection
- Quebradas from the hillsides around the area - water problems likely
- Long final access road through populated farmland
- Problems with public services

imc. Conclusive evaluation

The location is deemed to be unfit for a landfill site for hazardous waste, mainly due to the poor ground water protection, the water coming from the hillsides and the relatively high precipitation in the region.

k. Locality no. 10, Las Canteras

ka. Locality

kaa. Localization

The potential landfill site no. 10, Las Canteras, is located about 20 km north of Santiago and about 4 km east of the road 57 between Santiago and San Felipe, in the municipality of Colina. The coordinates of the centre of the area are approximately 70°39'30" W, 33°18'10" S. The altitude is about 550 metres above sea level.

kab. Description of area

The area is flat and open, at the foot of the Cerro Gardo to the east. Except for this mountain and the low Cerro la Rodrigues somewhat to the north, the surroundings are also flat land. There is cultivated land both to the west and south of the area, and to the north there is open grassland with trees, the same feature as the area itself. The grass seemed rather green and well-grown which is in good agreement with the impression of the area as rather fertile, irrigated land with a high ground water level - there was water in irrigation canals and ponds (7 August 1995).

kac. Present land use

The area is presently used for corrals and round-up area for cattle for the farmland (southern part) around as well as for farmland (northern part). The first-mentioned activities are fenced off from the adjacent land to the north by a stone wall.

kb. Land Ownership

The area of the site and to the north and east has one private owner, to total area of the parcel is 816 ha. There are two small parcels to the west at a distance of about 500 metres, with two individual, private owners. The parcel south of the access road has a fourth, private owner.

kc. Physical Planning

There is no physical planning related to the area.

kd. Geology and Hydrogeology

kda. General geology

The site is underlain by alluvial sand and gravel deposits, widening towards the north and flanked to the northeast and southwest by bedrock.

kdb. General hydrogeology

The general hydrogeology in the region is strongly influenced by the clayey soil and subsoils, generally with clay contents between 20 and 50%. The ground water is therefore well protected against pollution, but at the same time the wells have a low specific yield, generally 1-5 l/sec/meter.

kdc. Ground water as source of water supply

See kdd. below.

kdd. Means of water supply in the area

There is no specific information on this, but it can be assumed that the rather densely populated area must have a public water supply. Whether this relies on ground water or surface water as its raw water source is, however, not known.

ke. Topsoil and Agriculture

kea. Description of topsoil

The topsoil of the area belongs to the Chicureo formation.

The general features of the Chicureo formation is a clayey soil with montmorillonite and calcareous gravel, downwards with a gradually increasing content of loam. It is highly plastic and adhesive. The soil will harden when dry and is firm when humid. It is probably of lacustrine origin with colluvial influence. At the actual location the formation is strongly clayey, thick (>90 cm), well-drained and with a gentle slope, almost flat.

keb. Land use class

The area is in land use class II s. The area to the north is class III s.

kf. Precipitation and Evapotranspiration

The average precipitation in the area is less than 300 mm per year, mainly falling in the winter months of June - August. There is a 95% probability that the precipitation will be more than 160 mm/year and a 5% probability that it will be more than 600 mm/year.

The potential evapotranspiration in the area is about 1,350 mm/year.

kg. Watercourses - Surface Water

There are no watercourses crossing the area. There are quebradas around, and there is an irrigation pond immediately west of the site. The surrounding area is intensively irrigated for cultivation.

kh. Distance to sensitive activities

kha. Airports

There is no airport in the area.

khb. Towns and villages

There are no town or villages in the vicinity of the site. Housing development is, however, planned north of and close to the most likely access road in the north, cf. section kk.

khc. Single houses

There are a few farmhouses south and west of the site.

khd. Other activities

Production of explosives takes place in a valley about 2 km southwest of the site and is therefore of no importance for a future landfill.

ki. Distance from Santiago

The distance from central Santiago is about 20 km.

kj. Access by Road or Train

There is good road access on road 57 from Santiago. From this road there are two possibilities:

The road along the northern slope of Cerro Pan de Azúcar / Cerro la Campana is very bumpy and twists. Besides, the lower slopes of the mountains is rather densely populated. It is therefore not fit for being access road.

The better alternative will be road G-161 further north. This is a straight road with

little population at the sides. Access will take place on the smaller road from Valle Hermoso.

There is no railway access to the area.

kk. Possible Landfill on Area

Establishing a landfill on the area could be done avoiding the existing road and the quebradas by constructing it as a long, artificial hill along the road. This would not fit well into the landscape but is the only reasonable solution. The extension could be 1,100 metres northwest-southeast and 400 metres northeast-southwest. The area would thus be around 400,000 m², and with an average height of about 20 metres the total volume would be 8 million m³.

A section of the general map of the area in scale 1:25,000 (figure J.2.2k overleaf) shows the outline and the immediate surroundings of the possible landfill.

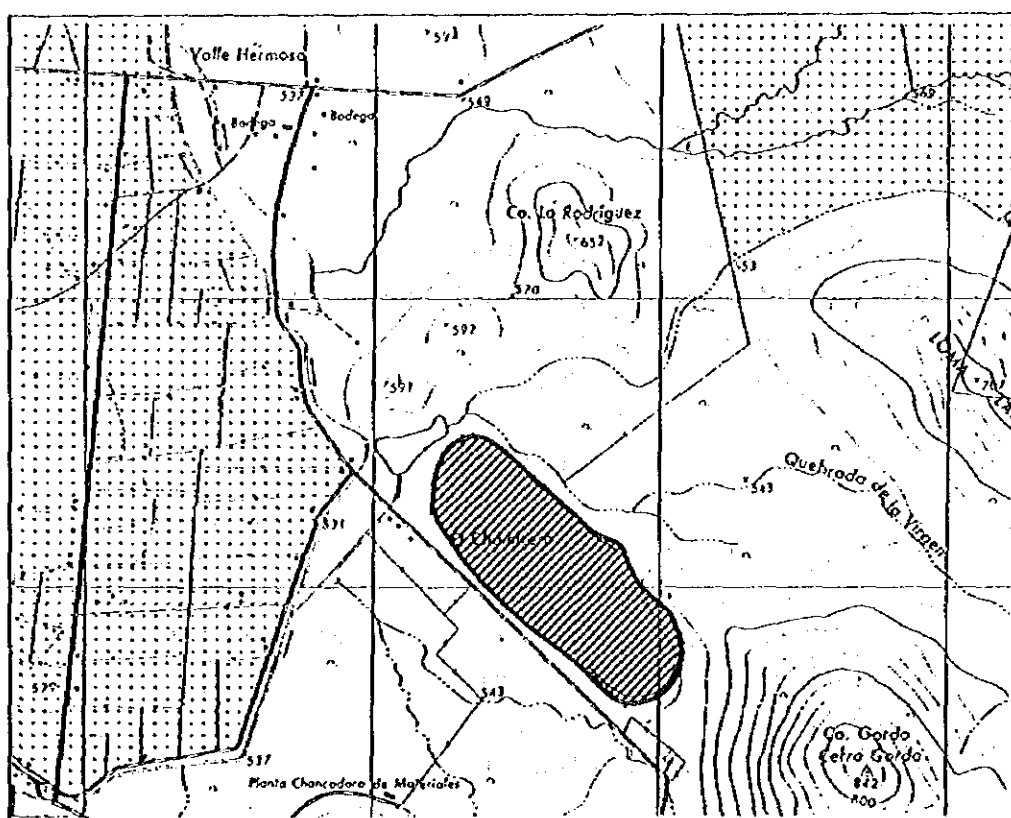


Figure J.2.2j Outline and surrounding of potential landfill site 10, Las Canteras

kl. Availability of Public Service

kla. Water supply

Based on general assumptions, see section kd. above, it can be assumed that there will be access to public water supply.

klb. Sewage treatment

No information available.

klc. Power supply

No information available, but considering the rather densely populated area and the prospect of urban development it can be assumed that power is at hand nearby.

km. Preliminary evaluation of site

The advantages and disadvantages of the locality as a future landfill site can be summarized as follows:

kma. Advantages

- No planning problems
- Well-protected ground water
- Low precipitation and medium evapotranspiration
- No watercourses/quebradas crossing the area
- Short distance from Santiago (20 km)
- Few sensitive activities
- Access to public services likely

kmb. Disadvantages

- Land use quality corresponds to good agricultural soil
- Irrigation pond close to the area
- Problems with road access
- Small volume (8 million m³)

kmc. Conclusive evaluation

The location is deemed unfit for a landfill site for hazardous waste because the area is classified as agricultural soil of good quality. The problems with the last stretch of the access road and the vicinity of cultivated farmland is also deemed to be severe obstacles.

l. Locality no. 11, El Convento

la. Locality

laa. Localization

The potential landfill site no. 11, El Convento, is located about 30 km west of Santiago and about 12 km north of the Santiago - Valparaíso highway, road 68, in the municipality of Pudahuel. The coordinates of the centre of the area are approximately 70°54'20" W, 33°20'15" S. The altitude is about 500 metres above sea level.

lab. Description of area

The area is part of a wide valley cutting into the southern part of the Coastal Range (Cordillera de la Costa) from the east. To the north and south the area is limited by rather high and steep mountain, reaching altitudes of 1,200 - 1,300 metres. To the west the mountain are even higher, reaching more than 2,000 metres, but the valley immediately west of the area is rather flat or gently sloping. To the east there is cultivated land extending past the airport and all the way to Santiago. The northern part of the valley is presently grassland with bushes and trees, intersected by quebradas, while the southern part is also cultivated agricultural land.

lac. Present land use

The area is presently used for breeding of cattle and horses. The northern part of the area is used as storage and sorting area for the quarries in the mountains. Staff working at the site seems to live there.

lb. Land Ownership

The area is state owned. The parcels around are owned by five private persons/companies.

lc. Physical Planning

The area is included in the general nature protection of the Cordillera de la Costa, as this is specified in the decree no. 438, dated 30 December 1975, from the Ministry of Agriculture. The decree forbids the felling of trees and thus also other activities in the area, but it does also give the National Forest Corporation (Corporación Nacional Forestal (CONAF)) power to allow exceptions from this if it is for the good of the public. The decree is thus not a non-negotiable obstacle to the construction of a landfill in the area.

ld. Geology and Hydrogeology

lda. General geology

The site and the surrounding area lies entirely within colluvial material making up the gentle slopes and the floor of the valley.

ldb. General hydrogeology

The general hydrogeology is that of a phreatic ground water level. The relatively coarse material gives rise to wells with relatively high specific yields, about 10 l/sec/meter. Farther east the soil becomes more clayey and the specific yields lower. The natural ground water protection from the soil is deemed poor.

ldc. Ground water as source of water supply

There are many wells in the area between the site and Santiago, indicating that the ground water is a good and reliable source of water supply in the rural areas outside Santiago.

idd. Means of water supply in the area

There is no specific information about the water supply in the area, but based on general information from EMOS it can be assumed that this will be a public water supply with ground water as the source.

le. Topsoil and Agriculture

lea. Description of topsoil

The topsoil in the area belong to the Chicauma formation.

The general features of the Chicauma formation is loamy sand underlain by an alluvial substratum of sand, gravel and stones, generally found below 160 cm. The soil is neither plastic nor adhesive. At the actual locality the sandy loam is rather coarse-grained and folded, but eroded down into a plain, and very well drained.

leb. Land use class

The area is in land use class IV s.

lf. Precipitation and Evapotranspiration

The average precipitation in the area is less than 300 mm per year, mainly falling in the winter months of June - August. There is a 95% probability that the precipitation will be more than 130 mm/year and a 5% probability that it will be more than 600 mm/year.

The potential evapotranspiration in the area is about 1,350 mm/year.

lg. Watercourses - Surface Water

The mountains to the north, west and south are the basis for several quebradas. These quebradas confluence into two main ones along the northern and souther side of the valley, while there are none in the flat land in between.

lh. Distance to sensitive activities

lha. Airports

The Chilean national airport Aeropuerto Arturo Merino Benítez is situated about 9 km east of the site. The direction of approach and departure of flights is, however, north-south. There is therefore no chance that a landfill at the site will mean any risk to the airport.

lhb. Towns and villages

There are no densely populated area near to the site.

lhc. Single houses

There are a few farmhouses east of the site, but none within a distance of 3-400 metres. There are a couple of houses inhabited by staff from the storage facility of the quarries on the site.

li. Distance from Santiago

Distance from central Santiago is about 32 km.

lj. Access by Road or Train

There is access by the Santiago - Valparaíso highway to 5 km west of Pudahuel. From here the access road is a gravel/dirt road of varying, but generally rather poor quality. The road leads through intensively cultivated farmland with many farmhouses along the road. The total driving distance on these roads from the highway is 17 km. When returning to Santiago it is not possible to turn left on the Santiago - Valparaíso highway - one has to drive 2-3 km to the west and make a U-turn.

There is no possibility of access by railway.

lk. Possible Landfill on Area

It is not possible to establish a proper landfill in the area. This is due to the fact that most of the area foreseen to be potential for localization of a landfill has been put under cultivation since the map of the area was produced. The potential area is therefore limited both by the cultivated land to the east and south and by the quebradas intersecting the area. The area free for landfilling would only be 10-20 ha and establishing a landfill could not take place without large problems in relation to activities in the surroundings.

The area with an indication of the landfill area thought of appears

A section of the general map of the area in scale 1:25,000 (figure J.2.21 overleaf) shows the area.

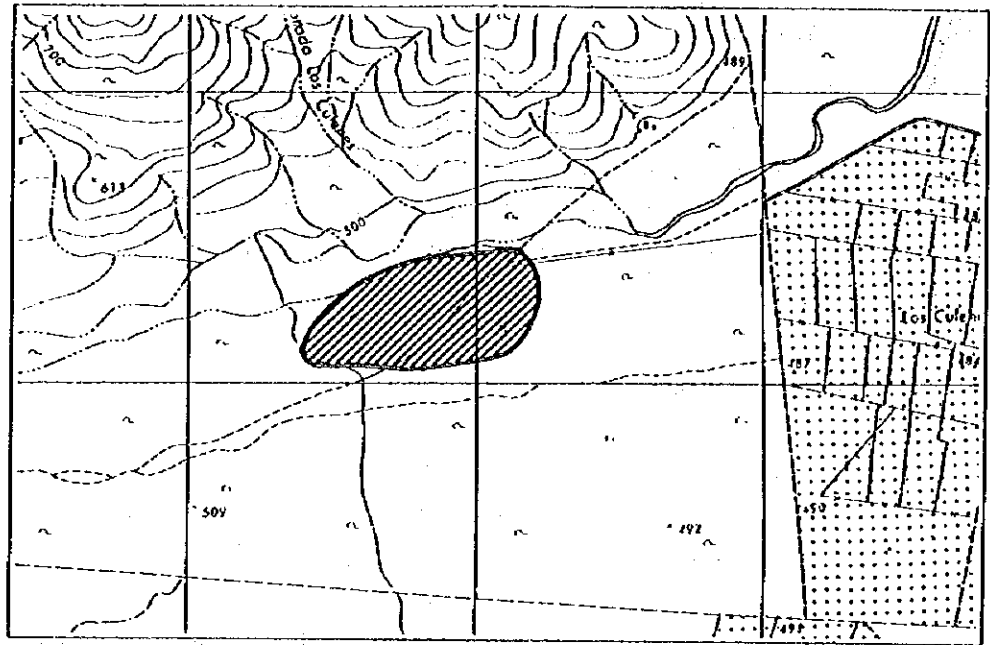


Figure J.2.2k Area for candidate landfill site 11, El Convento

II. Availability of Public Service

IIa. Water supply

No specific information available, but it is most likely that a public water supply is available not too far away.

IIb. Sewage treatment

No information available.

IIc. Power supply

No specific information available, but it was evident that there is power supply in the area.

Im. Preliminary evaluation of site

The advantages and disadvantages of the locality as a future landfill site can be summarized as follows:

Ima. Advantages

- No problem with land use and land use quality
- State owned parcel, but five private neighbours
- Low precipitation and medium evapotranspiration
- Short to medium distance from Santiago (32 km)
- Access to public services likely

Imb. Disadvantages

- Restrictions on land use due to nature conservation may be an obstacle
- Poorly protected and relatively important ground water resource
- Quebradas in the area limits construction possibilities
- Farming activities and housing nearby
- Poor access road, long transport through populated areas, left-turn on the highway when returning to Santiago not possible
- Very small volume, landfill construction hardly possible

Imc. Conclusive evaluation

The location is deemed unfit for a landfill site for hazardous waste, mainly due to the small area which makes landfill construction irrelevant, but also due to poor access road and other activities, and poor ground water protection.

J.2.3 Comparative Evaluation and Recommendation

a. Conclusive evaluation for each site

The conclusive evaluation for each of the localities - as this can be found in section J.2.2a-1 above - is repeated below.

1. Montenegro

The location is well fit for a landfill site for hazardous waste, especially if a municipal waste is established nearby. This is due to the small and well-protected ground water interests and the low precipitation and high evaporation as well as the good access by road and train.

2. Cerro Carneros

The location is well fit for a landfill site for hazardous waste, due to the well-protected ground water, the low precipitation and medium evaporation, the short distance from Santiago, and the good road access.

3. Quilapilún (Tres Orejas)

The location is well fit for a landfill site for hazardous waste. The main advantages is the small and probably well-protected ground water resource, the low precipitation and high evaporation, and the very large volume available (if this is needed). Some practical problems in relation to access road and public services can, however, be foreseen.

4. Estación Puangue

The location is not too well fit for a landfill site because the volume is relatively small and the quebradas and the relatively high precipitation in the area may create problems. The access by road and train is, however, good, and the natural ground water protection seems good.

5. San Diego

The location is well fit for a landfill site for hazardous waste, although the relatively high precipitation may create some problems. The probably good natural ground water protection will partly compensate for this, and it is an advantage that there are no watercourses crossing the area and that the road access is good.

6. Santa Amelia

The location is not fit for a landfill site for hazardous waste because of the problems related to the access road and the dwellings along this road. The large amount of private landowners in the area is also likely to create problems.

7. Mandinga

The location is relatively well fit for a landfill site for hazardous waste, because the ground water resource is probably small and well-protected, which to some extent remedies the high precipitation and medium evaporation. It is also an advantage that the access road is very good, although this site is the one of all locations farthest off from Santiago. The unknown ownership may prove a disadvantage.

8. Escorial Norte

The location might be used for a landfill site for hazardous waste, but there is severe doubt about ground water protection and watercourses, and the relatively high precipitation in the region may create problems.

9. Rincón los Rulos

The location is deemed to be unfit for a landfill site for hazardous waste, mainly due to the poor ground water protection, the water coming from the hillsides and the relatively high precipitation in the region.

10. Las Canteras

The location is deemed unfit for a landfill site for hazardous waste because the area is classified as agricultural soil of good quality. The problems with the last stretch of the access road and the vicinity of cultivated farmland is also deemed to be severe obstacles.

11. El Convento

The location is deemed unfit for a landfill site for hazardous waste, mainly due to the small area which makes landfill construction irrelevant, but also due to poor access road and other activities, and poor ground water protection.

b. Comparative evaluation of the potential landfill sites

For a comparative evaluation the main issues from each of the 11 sites is summarized in Table J.2.3a overleaf. An advantage or disadvantage is illustrated by characters ranging from "++" (best) to "--" (poorest). For some issues - such as distance to central Santiago - the exact value is specified.

The total evaluation for each of the sites is made on the background of a "weighed average" of the single issues. Some issues may be negative to a degree that outweighs otherwise positive issues, such as is for example the case for the poor access to site number 6.

Table J.2.3a Comparative evaluation table for landfill sites

Evaluation Issue	Site number	1	2	3	4	5	6	7	8	9	10	11
Land use and land use quality		+	++	++	+	+	++	++	+	+	--	++
Land ownership		+	+	+	+	+	-	0	+	+	+	+
Physical planning		++	+	++	++	++	++	++	++	++	+	0
Ground water / ground water protection		++	++	+	++	++	+	+	+	--	+	--
Precipitation / evapotranspiration		+	+	+	0	0	0	0	-	-	+	+
Watercourses		0	+	+	0	++	+	++	-	-	-	-
Sensitive activities		+	++	+	0	++	0	++	+	+	-	-
Distance from Santiago (km)		70	22	50	70	70	70	78	45	50	20	32
Access road		++	++	+	++	++	--	++	0	0	0	-
Access train		+	--	--	++	0	--	--	0	0	--	--
Landfill volume (million m ³)		13	20	30	6	15	17	15	12	17	8	?
Public service		-	0	-	-	-	-	+	0	-	+	+
Total evaluation		++	++	++	0	+	-	+	-	-	-	--
Suggested priority		2	1	3	6	5	-	4	-	-	-	-

c. Recommendation

The suggested priority for the potential sites for localization of a industrial hazardous waste landfill is indicated in table J.2.3a above.

It will be seen that for several of the potential sites no priority is indicated. This is because these sites are not deemed fit for the localization of a hazardous waste landfill in any case.

For the remaining ones, which are situated either north or immediately west of Santiago (site 1, 2 and 3) or west of Santiago in the Melipilla-region (site 4, 5 and 7), a suggested priority is indicated.

For clarification it should be emphasized that the ranking it to some extent conditional. Although there is no doubt that site no 2, Cerro Carneros, should receive the top priority, there might be some doubt whether site no. 1, Montenegro, or site no. 3, Quilapilún, should be second priority. This may depend on for example whether the municipal landfill at Montenegro be constructed, which will be much in favour of a

industrial waste landfill on the same locality as these two landfills could thereby benefit from the same facilities, and one more landfill would not mean much to general inconveniences.

In order to provide for this doubt, a final order of priority as shown in table J.2.3b is suggested:

Table J.2.3b Suggested order of priority for landfill sites

Site name	Site number	Priority
Montenegro	1	2-3
Cerro Carneros	2	1
Quilapilún	3	2-3
Estación Puangue	4	6
San Diego	5	4-5
Mandinga	7	4-5

The order of priority thus suggests that the sites number 1, 2 and 3 are the ones best fit for the establishment of a industrial waste landfill in the metropolitan region. For these localities a more detailed investigation and data collection, including a conceptual lay-out for a landfill should be established, thus resulting in full EIAs which would be the basis for a final decision on the most suitable location. For more specific recommendations regarding the suggested main topics of the EIAs, please refer to Annex J.3 of this report.

J.3 Initial Environmental Evaluation (IEE) of the Potential Landfill Localities Cerro Carneros and Quilapilún

J.3.1 Introduction

Part of the Industrial Solid Waste Study conducted by the JICA Study Team has been to evaluate comparatively candidate sites for an industrial hazardous waste landfill in the Metropolitan Region of Santiago de Chile.

The Comparative Environmental Evaluation and the recommendation emanating from this CEE is thoroughly described in Annex J.2 of this report.

The three suggested top priority localities in the Metropolitan Region are:

- Cerro de Carneros, in the municipality of Pudahuel, about 22 km west of Santiago and 2 km south of the Santiago - Valparaíso highway.
- Montenegro, in the municipality of Til-Til, about 70 km north of Santiago and 2 km east of the Pan American Highway, east of the village of Montenegro.
- Quilapilún, in the municipality of Colina, about 50 km north of Santiago and 5 km east of the road 57 between Santiago and San Felipe.

The precise location of the three sites and more specific information about them can be found in Annex J.2.2a-c.

For a potential landfill site, intended for long-term or infinite storage of hazardous industrial waste from the entire Metropolitan Region, there is no doubt that an Environmental Impact Assessment (EIA) must be conducted before a final detailed design of the actual landfill can take place. This is evident from the types of waste that are to be disposed of and the risk they may create if not properly handled in the landfill - not to mention potential risks and nuisances from landfills in general.

This Initial Environmental Evaluation therefore is not intended as a discussion of whether an EIA should be conducted on a site before construction of a landfill, but merely as a highlighting of the main topics to be dealt with in this (these) EIA(s). The highlighting of topics will be based on the knowledge gathered with regard to the specific sites as it is presented in Annex J.2.2.

It should be mentioned that the Montenegro site is also the location for a planned landfill for municipal waste. Because of the very advanced state of the preparation process for this municipal waste landfill, an Environmental Impact Assessment study has already been carried out for the location. The EIA covers the area in general and thus also the area south of the planned municipal waste landfill which is potential as industrial (hazardous) waste landfill.

It is generally deemed inappropriate to conduct an IEE and thus make recommendations for an EIA which has already been conducted. Besides, this EIA has been carried out in great detail in agreement with the preliminary regulations for EIAs in Chile and in close contact with COREMA R.M. The IEEs will therefore only cover the potential landfill sites Cerro Carneros and Quilapilún.

The EIA carried out for the Montenegro site should - apart from the suggestions in the

IEEs below - serve as a guideline for EIAs for other sites in the region, simply because following the lay-out and meticulousness of this study will render a comparison with subsequent studies fairer and easier. The evaluation of the EIA for Montenegro site may, on the other hand, benefit from the more general aspects in the below IEEs.

The IEEs are carried out in accordance with JICA's "Environmental Guidelines for Infrastructure Projects VI, Solid Waste Management, September 1992".

J.3.2 Initial Environmental Evaluation of Potential Landfill Site Cerro Carneros

a. Locality and brief potential lay-out description

The potential landfill site is located at the northern slope and at the foot of Cerro Carneros, about 20 km west of Santiago and 2 km south of the Santiago - Valparaíso highway in the municipality of Pudahuel. The area is dry grassland with scattered bushes and trees, presently used for extensive cattle breeding.

The landfill on the site could be an elliptical or egg-shaped cone on the lower slopes of the mountain, extending about 1,100 metres north-south and 600 metres east-west. The average height could be about 40 metres, allowing for a total landfill volume of about 20 million m³.

The localization and potential lay-out of the landfill is shown on figure J.3.2a overleaf.

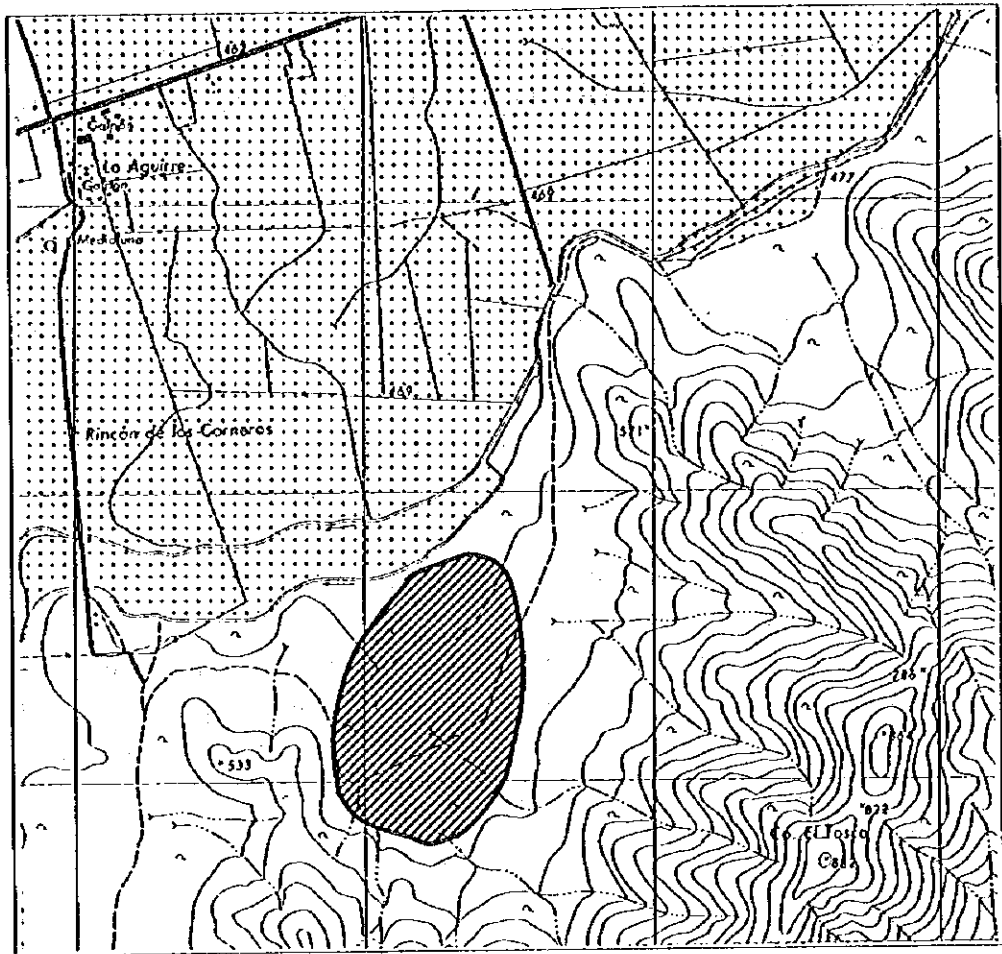


Figure J.3.2a Outline and surrounding of potential landfill Cerro Carneros

b. Resettlement / land acquisition

The area is unpopulated and resettlement is thus out of question as regards housing. The area has one private owner who uses it for extensive cattle breeding. Whether there will still be basis for subsistence for this owner and to what extent the legislation allows for expropriation of land must be carefully investigated in the BJA.

c. Traffic and public facilities

The present access to the area is unsatisfactory, both with regard to the connection to the highway and the local road leading among housing. The EIA must investigate and specify the road access options, especially focusing on the possibility of developing the existing - but fenced-off - road east of the present one as an access road.

Public facilities such as water supply, sewage treatment and power supply have not been identified. It is important that the EIA identifies acceptable options.

d. Cultural property

None known - the matter should be investigated on the basis of historical archives.

e. Water rights / right of common

It is uncertain whether existing rights for water use and ground water abstraction will be at risk (see "Ground Water" and "Water pollution" below).

It is also unclear whether the public has a general access to the area for example for recreational purposes. It is, however, obvious from the planning document that the long-term intentions is to enhance touristic and sports/recreational capabilities in the area, mainly through afforestation.

Both topics should be dealt with in an EIA.

f. Public health conditions

It is unlikely that a well-constructed and operated hazardous waste landfill will generate inconveniences and public health risk, considering the distance of the site from populated areas. It is, however, of importance for the public acceptance of such a landfill that the constructional and operational preconditions be carefully dealt with and assessed in an EIA and that these preconditions also be the basic conditions for the administrative approval of the site.

g. Waste / rodents etc.

The society and public health conditions will generally benefit from hazardous waste being collected and properly treated/disposed of on a site constructed and operated for that special purpose - thus avoiding unconditional disposal elsewhere.

It is, however, important that the need for waste reception control and for opening hours necessary to avoid unconditional waste discharge outside the gates of the site be carefully assessed. Similarly, specific on-site disposal needs for specific waste types

should be assessed and conditions prescribed in the environmental authorization.

Rodents (birds, rats, etc.) are unlikely to appear on a hazardous waste landfill as they will generally go for food which hazardous waste will - normally - not be. The waste types to be disposed of in the landfill should, however, be assessed, and if any biological waste is included which may form the basis for subsistence of rodents, suitable precautions should be prescribed.

h. Ground water

Based on information from SERNAGEOMIN and EMOS it can be assumed that the natural geological protection of ground water resources in the area is good due to low permeability of the upper strata and confined ground water aquifers.

The matter must, however, be carefully investigated as the basis for an EIA and as a basis for the design of construction, and for remediation measures in case of leaks in the bottom liner of the future landfill.

i. Hydrological situation

There are no permanent watercourses crossing the area, but there is some indication that gullies (quebradas) exist and during torrent rain may cause heavy flows through the area. This should be investigated in the EIA and suitable precautions to prevent incidents be suggested and incorporated in the project design.

j. Coastal zone

Not relevant for the site.

k. Flora and fauna

The flora and fauna in the area can be assumed to be typical for a semi-arid area with extensive cattle breeding and little public access.

It should be investigated whether there are specific species in the area which need protection and to what extent this would be an obstacle to the construction and operation of a landfill at the site. The specific issues related to a hazardous waste

landfill (i.e. probably no rodents, odour, air pollution; see relevant sections) should be considered.

l. Landscape

It should be appreciated that the existence of a landfill in operation will not allow for the planned development of the area. It is therefore important that a coordination be established in the EIA between the lifetime of a landfill and the time schedule for the implementation of the planned development of the area.

A cone-shaped, elliptical landfill in the area could be made fit well into the existing landscape, i.e. the hills to the south and the flat land to the north. It is important that the landscape-shaping views be incorporated into the project design for the landfill. It is equally important that conditions be settled for the final coverage of the landfill in order to make allowance for an un-problematic incorporation of the closed landfill in the planned sports/tourist/recreational development (for example for the area to be incorporated in the afforestation of the hills).

m. Air pollution / offensive odours

Air pollution / offensive odours from landfills are most likely to occur from municipal landfills which receive biologically degradable waste. Such waste will generate carbon dioxide (CO_2) and methane (CH_4) during the anaerobic, biological degradation. Besides, foul-smelling gases will be generated.

Emissions from a hazardous waste landfill could generally be assumed to be much smaller and maybe non-existing. This will, however, greatly depend on the types of waste received and the handling of this waste (for example separated disposal in several waste cells). Regarding odour problems, these will also depend on the distance to vulnerable activities, which is here quite large. The need for analysis in the EIA and suggestions for proper handling and avoiding of emissions to be made in the landfill design phase will therefore largely depend on the waste types to be received.

n. Water pollution

The unintended pollution of ground water due to leaking out of landfill leachate and the premeditated discharge of collected landfill leachate are normally considered the most serious problems related to landfilling of waste.

It is therefore of the outmost importance that the total water regime be carefully analyzed (see "Water rights", "Ground water" and "Hydrological situation" above). The geological and hydrogeological conditions must be investigated and the result of unintended leakage of leachate assessed. This assessment should be used both for development of appropriate design parameters (i.e. bottom and top liners; amount of leachate generated, specified on types; leachate collection system), for the design of supervision facilities for the ground water quality / leachate discharge, and for remedial measures in case of incidents.

Less problems could be anticipated in relation to discharge of collected leachate. In the semi-arid area of the landfill site - with average annual precipitation of about 330 mm per year and potential evapotranspiration of about 1,400 mm per year - it may be assumed that the collected leachate can be recycled over the landfill and discharge of leachate thus avoided. The leachate collection and recycling system must, however, be carefully designed in order to avoid operation problems with incompatible types of leachate.

o. Soil contamination

Soil contamination around landfill sites takes place mainly due to poor operation and maintenance procedures which will allow the deposited waste to escape from the fenced landfill area and pollute the surroundings. Besides, discharge of storm water may take place from the landfill site in case of torrent rain if careful site design and preventive measures are not included in project.

The area around the site of Cerro Carneros is not assumed to be especially vulnerable to soil pollution. Besides, hazardous waste will normally be handled with great care within the landfill site. Nevertheless, the risk of soil contamination should be assessed considering the various waste types, and sufficient measures should be prescribed to avoid future problems.

p. Noise and vibrations

Noise and vibrations emanate from traffic to and from and traffic and machinery operation within the landfill site.

The traffic on the Santiago - Valparaíso highway to the landfill can be assumed to be a minor problem as it will contribute only insignificantly to the total traffic on the road.

Problems related to the traffic from the Santiago - Valparaíso highway to the site can be largely remedied if the traffic takes place on a well-constructed road with a paved surface. Although problems could be assumed to be small, the amount of traffic and the generated noise level at the nearest houses should be assessed.

Noise and vibrations from the landfill proper could be assumed not to create problems for neighbours as the nearest houses are about 2 km from the site.

Special noise problems related to the present wildlife in the area should be considered under "Flora and fauna".

q. General issues

Besides the above topics, the following issues should be dealt with and a solution suggested in the EIA and project design phase:

- Programmes for the landfill's self control and the authority control in the operation and post-operation phases of the landfill.
- Reporting to the authorities of the landfill's self-control.
- Authorities' and the landfill's own supervision procedures in the construction and operation phase as well as after the landfill has been closed.

J.3.3 Initial Environmental Evaluation for Potential Landfill Site Quilapilún

a. Locality and brief potential lay-out description

The potential landfill site is located at the northern and eastern slopes and at the foot of the mountain range Loma del Pequén Quillay. The site is about 50 km north of Santiago and 5 km east of the Santiago - San Felipe highway in the municipality of Colina. The area is dry grassland with scattered bushes and trees, presently used for very extensive cattle breeding. Not far from the area, between the site and the highway, there is, however, irrigated farmland and farmhouses.

There are two options for a landfill on the site: It could either be an almost square one at the foot of the hills or a larger, more rectangular and irregular one extending up the

mountain slopes. The former would be about 1,000 metres east-west and 750 metres north-south, have an average height of about 40 metres and contain up to 30 million m^3 . The latter would be extended in the easterly direction to about 1,500 metres of length, the average height would increase to about 80 metres, and the volume thus be up to 90-100 million m^3 .

The localization and potential lay-out of the landfill is shown on figure J.3.3a below.

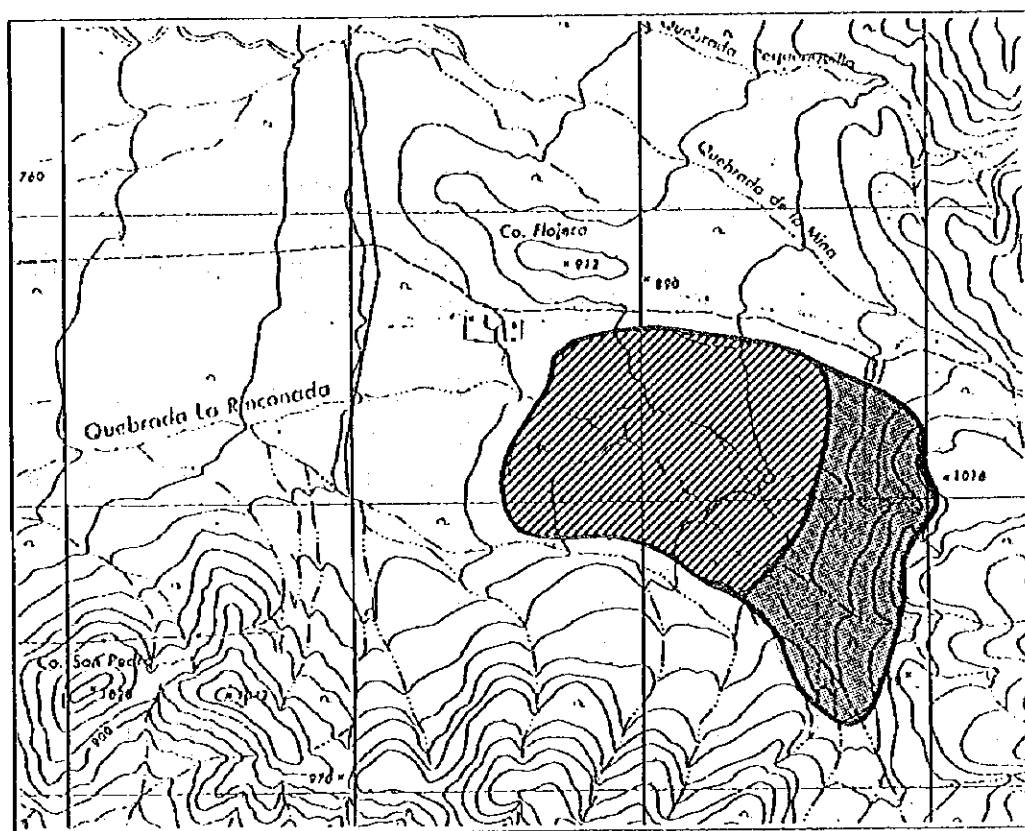


Figure J.3.3a Outline and surrounding of potential landfill Quilapilún

b. Resettlement / land acquisition

There are farmhouses immediately west of the site at the access road. Besides, there is a inhabited shack and an uninhabited one - probably a hunting shack - right northeast of the site. The farmers in the farmhouses cultivate irrigated land west of the houses, between the farm and the highway. The irrigation is done by means of water abstracted from a small watercourse in the mountains. The site in question is used for very extensive cattle breeding.

It seems doubtful that these activities - including the housings - can be maintained in case a landfill is constructed and operated at the site. Except for the landfill occupying part of the farmland - although only cattle breeding area - the farm and the landfill may compete on the access to water, and the general inconvenience of a landfill nearby may be inconceivable for the inhabitants in the houses.

The EIA must consider this carefully and also consider to what extent the legislation allows for expropriation of land and houses.

c. Traffic and public facilities

The present access to the area is unsatisfactory, both with regard to the connection to the highway and the local road leading among housing (the above-mentioned farmhouses). The EIA must investigate and specify the road access options, especially with regard to the destiny of the existing housing.

Public facilities such as sewage treatment and power supply have not been identified. Water supply could presumably be based on the present supply to the farmhouses and for irrigation, but would then compete with these activities. It is important that the EIA identifies acceptable options.

d. Cultural property

None known - the matter should be investigated on the basis of historical archives.

e. Water rights / right of common

It is uncertain whether the existing water abstraction is based on rights to do this. This is a topic for investigation as is the risk of polluting the small watercourse which flows west just north of the northern property-line of the site to the farm and the irrigated land. This must be clarified in the EIA.

It is unlikely that there are rights of common related to the area as it is privately owned and located far from inhabited areas - and the only access being past the owner's premises.

f. Public health conditions

Although a well-constructed and operated hazardous waste landfill will normally not be expected to create inconveniences and public health risk, the short distance to the above-mentioned farmhouses and the risk of contamination of the water supply watercourse may make things look different in this specific case. Therefore this should be carefully considered in the EIA in the light of the overall options for resettlement and expropriation solutions.

g. Waste / rodents etc.

The society and public health conditions will generally benefit from hazardous waste being collected and properly treated/disposed of on a site constructed and operated for that special purpose - thus avoiding unconditional disposal elsewhere.

It is, however, important that the need for waste reception control and for opening hours necessary to avoid unconditional waste discharge outside the gates of the site be carefully assessed. Similarly, specific on-site disposal needs for specific waste types should be assessed and conditions prescribed in the environmental authorization.

Rodents (birds, rats, etc.) are unlikely to appear on a hazardous waste landfill as they will generally go for food which hazardous waste will - normally - not be. The waste types to be disposed of in the landfill should, however, be assessed, and if any biological waste is included which may form the basis for subsistence of rodents, suitable precautions should be prescribed.

h. Ground water

Based on general information from SERNAGEOMIN and EMOS it can be assumed that the natural geological protection of ground water resources in the area is relatively good. This assumption is, however, not certain as it is based on general evidence.

The matter must, therefore, be carefully investigated as the basis for an EIA and as a basis for the design of construction, and for remediation measures in case of leaks in the bottom liner of the future landfill.

i. Hydrological situation

There are no permanent watercourses crossing the area, but there is some indication that gullies (quebradas) exist and during torrent rain may cause heavy flows from the mountain slopes through the area. Besides, the present small watercourse used for farm water supply and irrigation just north of the property-line may be vulnerable to contamination from the site. This should be investigated in the EIA and suitable precautions to prevent incidents be suggested and incorporated in the project design.

It should be mentioned that it will probably be easier to handle the problems related to the quebradas if only the "small" landfill at the foot of the mountains is constructed than if the "big" solution is chosen.

j. Coastal zone

Not relevant for the site.

k. Flora and fauna

The flora and fauna in the area can be assumed to be typical for a semi-arid area with extensive cattle breeding and no public access.

It should be investigated whether there are specific species in the area which need protection and to what extent this would be an obstacle to the construction and operation of a landfill at the site. The specific issues related to a hazardous waste landfill (i.e. probably no rodents, odour, air pollution; see relevant sections) should be considered.

l. Landscape

The landscape development in this area far from general population could be assumed to be of little importance. Besides, it is no doubt possible to shape the landfill to fit well into the landscape.

Although not of major importance, the conditions for the final coverage of the landfill in order to fit into the future landscape should be dealt with in the project design.

m. Air pollution / offensive odours

Air pollution / offensive odours from landfills are most likely to occur from municipal landfills which receive biologically degradable waste. Such waste will generate carbon dioxide (CO_2) and methane (CH_4) during the anaerobic, biological degradation. Besides, foul-smelling gases will be generated.

Emissions from a hazardous waste landfill could generally be assumed to be much smaller and maybe non-existing. This will, however, greatly depend on the types of waste received and the handling of this waste (for example separated disposal in several waste cells). At the actual site the special problems related to odour will also depend on whether the existing housing is kept up or abandoned. This should therefore be analyzed in the EIA. If relevant, suggestions for proper handling and avoiding of emissions should be made for the landfill design phase.

n. Water pollution

The unintended pollution of ground water due to leaking out of landfill leachate and the premeditated discharge of collected landfill leachate are normally considered the most serious problems related to landfilling of waste.

It is therefore of the outmost importance that the total water regime be carefully analyzed (see "Water rights", "Ground water" and "Hydrological situation" above). The geological and hydrogeological conditions must be investigated and the result of unintended leakage of leachate assessed. This assessment should be used both for development of appropriate design parameters (i.e. bottom and top liners; amount of leachate generated, specified on types; leachate collection system), for the design of supervision facilities for the ground water quality / leachate discharge, and for remedial measures in case of incidents.

Less problems could be anticipated in relation to discharge of collected leachate. In the semi-arid area of the landfill site - with average annual precipitation of about 300 mm per year and potential evapotranspiration of about 1,800 mm per year - it may be assumed that the collected leachate can be recycled over the landfill and discharge of leachate thus avoided. The leachate collection and recycling system must, however, be carefully designed in order to avoid operation problems with incompatible types of leachate.

o. Soil contamination

Soil contamination around landfill sites takes place mainly due to poor operation and maintenance procedures which will allow the deposited waste to escape from the fenced landfill area and pollute the surroundings. Besides, discharge of storm water may take place from the landfill site in case of torrent rain if careful site design and preventive measures are not included in project.

As the land use downstream (i.e. west of) the site is quite vulnerable to soil pollution with the present use, this problem should be considered carefully although it can be assumed that hazardous waste will normally be handled with great care within the landfill site. Included in the considerations should be assessment of the various waste types, and sufficient measures should be prescribed to avoid future problems.

p. Noise and vibrations

Noise and vibrations emanate from traffic to and from and traffic and machinery operation within the landfill site.

The traffic on the Santiago - San Felipe highway to the landfill can be assumed to be a minor problem as it will contribute only insignificantly to the total traffic on the road.

Problems related to the traffic from the highway can, however, not be avoided even if a good road with a paved surface is constructed in the present road track as this will take the traffic past - or through - the farmhouses. This should be assessed and alternative solutions may be suggested.

Special noise problems related to the present wildlife in the area should be considered under "Flora and fauna".

q. General issues

It will be seen from the above that many of the considerations in an EIA will depend on an early decision on whether the present land use and especially the present habitation next to the potential landfill site is maintained. It is therefore recommended that this problem be dealt with in depth before a full EIA is launched.

Besides the above topics, the following issues should be dealt with and a solution suggested in the EIA and project design phase:

- Programmes for the landfill's self control and the authority control in the operation and post-operation phases of the landfill.
- Reporting to the authorities of the landfill's self-control.
- Authorities' and the landfill's own supervision procedures in the construction and operation phase as well as after the landfill has been closed.

ANNEX K

EXAMINATION OF AN OPTIMUM TECHNICAL SYSTEM FOR ISWM MASTER PLAN

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