Annex 03

Site Studies

La Vendimia Installation

HYDROLOGICAL-HYDRAULIC ASSESSMENT, PV LA VENDIMIA SOLAR PROJECT, MAULE REGION (CHILE)

Project ID: IG1827115c
Client: Trina Solar
Consultant: GMS Internacional, SL

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1ª	05/11/2021	0	Hydrological assessment	I. Gutiérrez	D. García	JP Singer

HYDROLOGICAL-HYDRAULIC ASSESSMENT, PV LA VENDIMIA SOLAR PROJECT, MAULE REGION (CHILE)

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Re: Hydrological-Hydraulic Assessment, PV La Vendimia Solar Project, Maule Region (Chile).

Project ID: IG1827114c

GMS INTERNACIONAL, SL has completed the hydrological and hydraulic evaluation for the above-referenced project. The services were performed in general accordance with our proposal number "*P21_235_GMS_TRINA SOLAR_Vendimia_GHT_v1_BoQ"* dated 29/07/2021. This report presents the results of the catchment analysis, meteorological analysis, and environmental hydrologic factors research, as a basis for the hydraulic analysis.

Thank you in advance for the opportunity to provide these services to TRINA SOLAR. Please do not hesitate to contact us if you have any questions related to this report. We remain at your disposal to clarify any questions you may have.

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1. INTRODUCTION

1.1. Background

GMS INTERNACIONAL, SL (hereinafter the Consultant) was instructed by TRINA SOLAR (hereinafter the Client) to carry out a hydrological-hydraulic assessment for a projected solar power project in Cauquenes Province, Maule Region, in Chile. Details of the project are included in GMS Internacional, SL proposal reference: *P21_235_GMS_TRINA SOLAR_Vendimia_GHT_v1_BoQ".*

The baseline information that has been provided by the client for performing the present study is shown in **Table 1**.

Table 1. Baseline information for performing the study.

Document/File	Description	Origin	Send date
"LA_VENDIMIA_DIA_Area"	Project boundary	Trina Solar	23/07/21
"Cauquenes - La Vendimia - Septiembre 2021"	Detailed topography the project site	GMS Internacional	02/09/21
"LTM-CL-LaVendimia-STD-DRW-000_00"	Layout of the project	Trina Solar	28/09/21
"IG1827115a_Geotechnical_Site_Investigation_Factual_Report_LaVendimia_Chile_v0"	Geotechnical report	GMS Internacional	12/10/21

1.2. Site location

The study site is located around 3.3 km southeast of Cauquenes commune (**Figure 1**), in the UTM projected coordinates 743932.00 mE and 6013597.00 mS, at 153 meters above sea level (masl). The commune is the capital of the province, which preserve the same name, within the Maule Region.

Cauquenes commune is in the Central Valley, which ends, in the west in low hills belonging to the Coastal Range, while in the east, the valley gives way to the foothills, transitional zone to the Andes Mountains, with wooded hills, caissons and rivers.

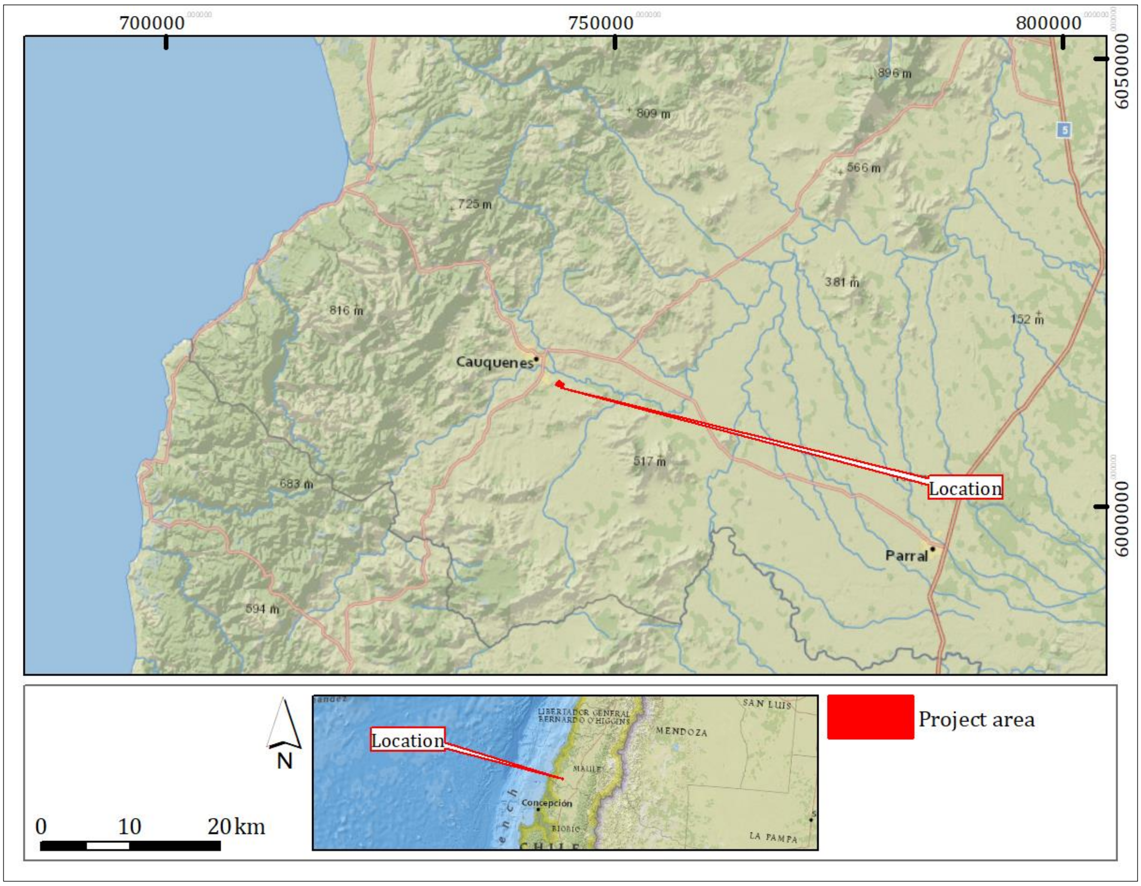

Figure 1. Location of the study site. Coordinates System: WGS84, UTM 18 S.

1.3. General project description

The proposed solar power plant comprises a plot with an area of approximately 25.3 Ha. It will include photovoltaic panels, auxiliary infrastructures (transformers, substations, and associated structures), internal roads for the construction and maintenance activities, and different pipe systems designed to conduct electrical wiring. In **Figure 2** an aerial photography, with the current conditions of the project area is shown.

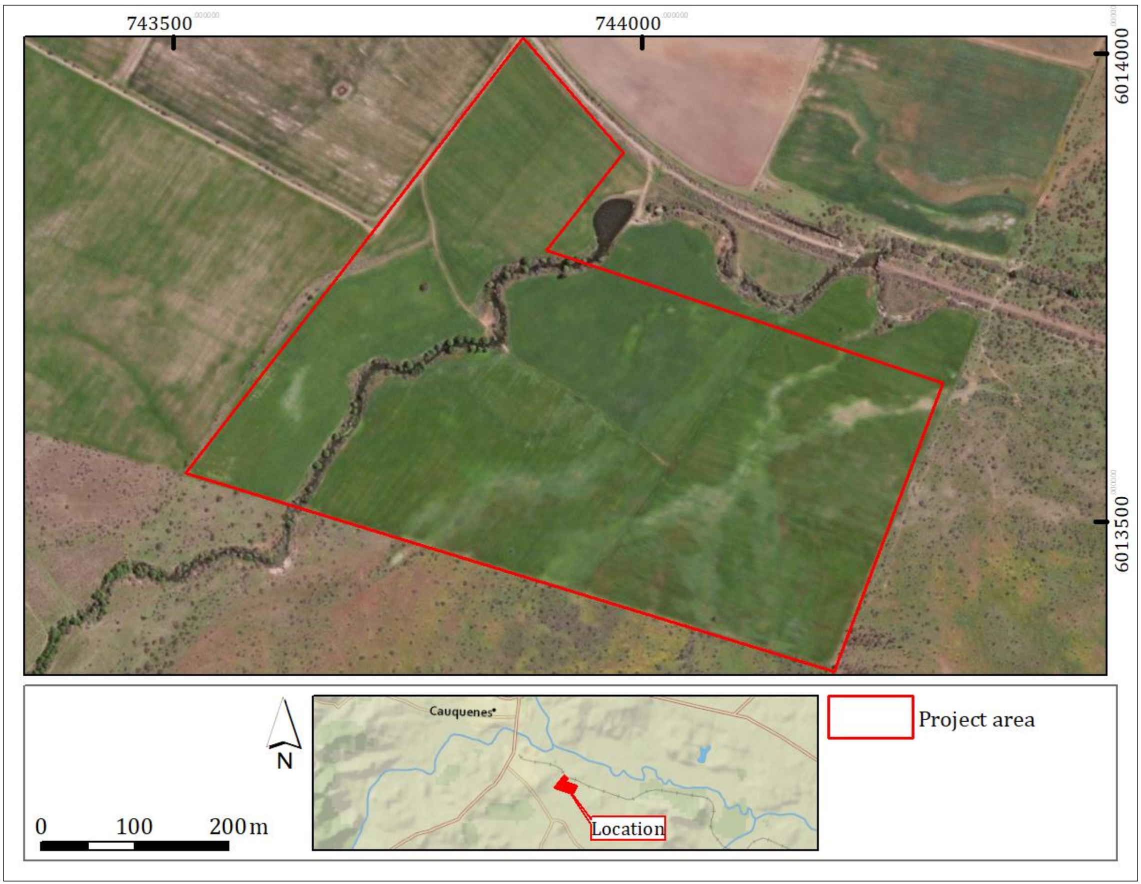

Figure 2. Aerial photo of the project area.

1.4. Main goals

This hydrological-hydraulic assessment aims to shed light, in terms of hydrological processes, on the suitability of the proposed sites to develop and build a solar power plant.

For such general-purpose, the specific objectives of the present hydrological study are:

- To identify the potential runoff contributors to the project area.
- To determine the daily maximum accumulated rain and intensity according to the meteorological data of the nearest stations considering they have trustworthy data.
- To design the hyetographs and convert rainfall to runoff.
- To develop a hydraulic analysis based on hydraulic conceptual and mathematical models.
- To offer general recommendations in order to avoid runoff issues, if any.

Nevertheless, it must be borne in mind that the flooding analysis is a complex issue that may be affected not only by hydrological or climatic factors but also by many other factors, such as territorial, socio-economic or environmental factors. For such reasons, the probabilistic models that are used to corroborate the occurrence of different flood events corresponding to different return periods are subject to a certain level of uncertainty and should be validated with experimental data.

2. METHODOLOGY

2.1. Topographic reference information

Two topographic sources have been used in the present study:

- The first one corresponds to the detailed topographic of the plot, which has been properly surveyed on the field and only contains information of the inner part of the plot (**Table 1**). A DEM (Digital Elevation Model) has been developed from this file that has been used as the main input for the hydraulic modelling (**Figure 3**).
- The second one corresponds to the general topography of the outside part of the plot and is useful to know which are the external contributors to the project site. This last topography has been extracted from ALOS PALSAR MISSION, in a raster format with a 12,5 meters resolution pixel and is available in the ASF website portal (**Figure 3**).

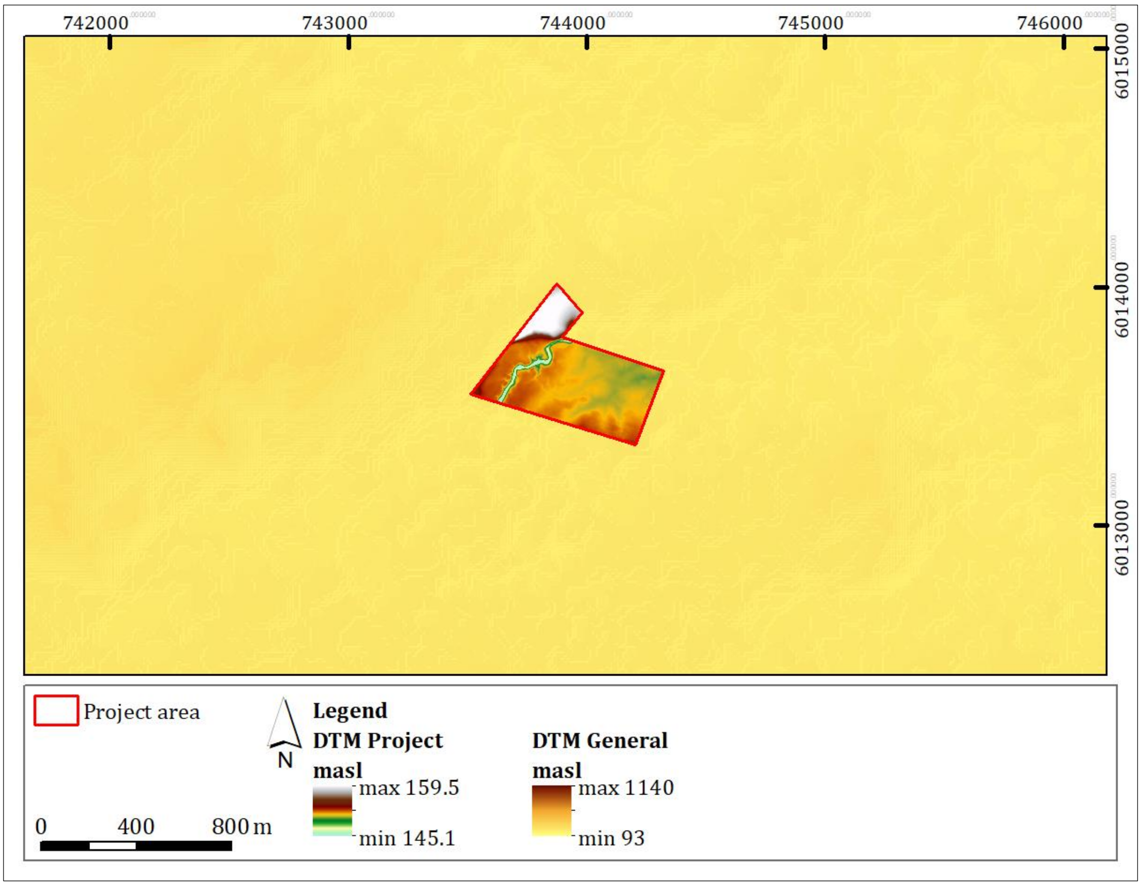

Figure 3. Detailed topography of the inner part of the project site and DTM from ALOS PALSAR MISSION.

2.2. Analysis of the physical characteristics of the study area

For the analysis of the physical characteristics of the study area, a review of bibliographic and historical data is carried out. It is mainly focused on climatology, geomorphology, geology, edaphology and hydrology; all of them are variables that have a great influence on the runoff generation processes.

2.3. Hydrological analysis

The hydrological analysis consists of the statistical examination of past extreme rainfall events to estimate the water streams' peak flow likelihood for different return periods. Hence, research of the closest meteorological stations in the study site is carried out. In case the closest meteorological stations have enough record of precipitation data (25 years or beyond is considered sufficient for the analysis). Once the meteorological stations have been chosen and data have been collected, the time series are adjusted to the most extreme function (i.e. gamma or Gumbel distributions) to eventually obtain the maximum rainfall occurring during events with different occurrence probabilities.

Afterwards, the relationship between rainfall and runoff can be modelled following different methodologies. The response of the runoff in ungauged catchments is best modelled using empirical models (Pechlivanidis et al., 2011), also known as data-driven models. These models use non-linear statistical relationships between inputs and outputs. They are observation-oriented and strongly depend on input accuracy. For simple rainfall-runoff regression models, inputs are rainfall or historical runoff; and the output is runoff measured at a specific location (Sitterson et al., 2017). The general governing equation for empirical models is a function of the inputs, as shown:

$$Q = \mathrm{f}(\mathrm{X}, \mathrm{Y}) \tag{1}$$

Whereas:

Q = runoff output,

X, Y = input datasets of rainfall or historic runoff.

The software HEC-HMS and HEC-GeoHMS (Hydrologic Modelling System) developed by the US Army Corps of Engineers (USDA, 1986) have been used to generate the unit hydrographs for the SCS-CN Method.

3. STUDY AREA MAIN GENERAL FEATURES

3.1. Climatic setting

The weather conditions in Cauquenesis warm and temperate. There is more rainfall in winter than in summer. The Köppen-Geiger climate classification is Csb (Mediterranean). The average temperature is 13.8 °C and the average rainfall is 732 mm.

The driest month is January, with precipitation of 4 mm and the most intense rainfalls in June with an average of 165 mm.

The hottest month of the year, with an average of 20.4 °C, in January and the month of July has the lowest average temperature of the year with 8 °C.

Data from Cauquenes Meteorological Station (Climate-data.org, n.d.). See **Figure 4.**

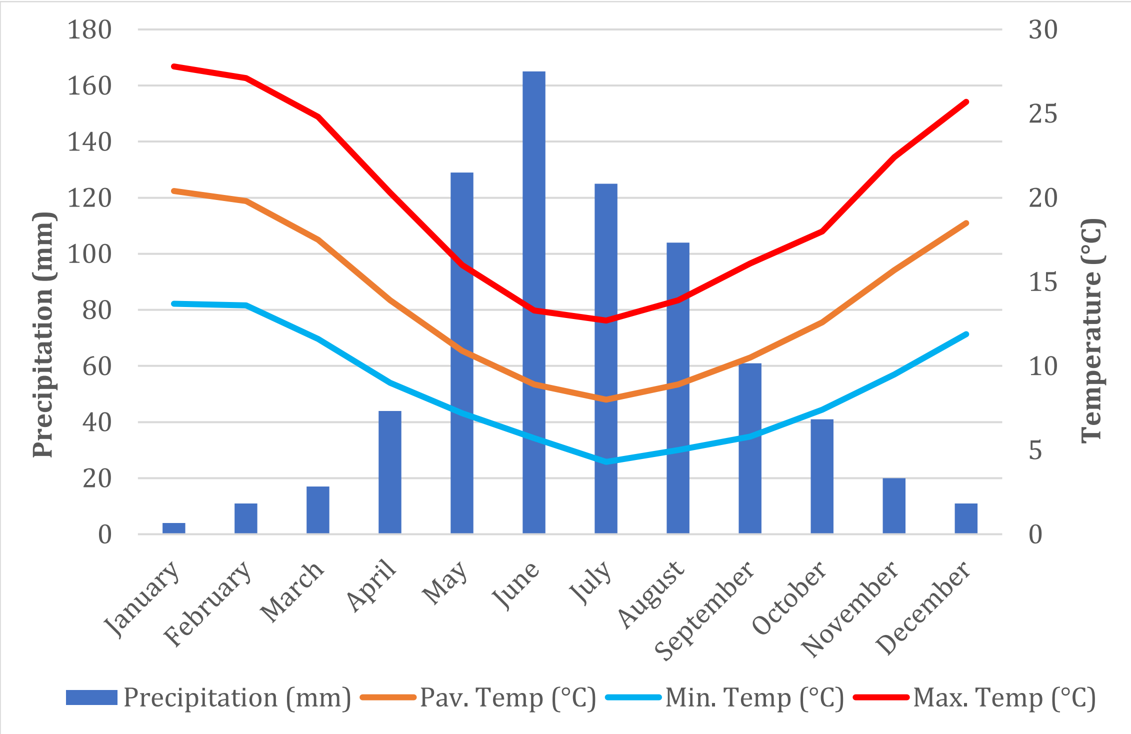

Figure 4. Climograph of Cauquenes. ***Source: climate-data.org.***

3.2. Physiography of the region

The VII Region, where the project site is placed, presents the following relief units; Andes Mountains, Intermediate Depressions; Coastal Range and Coastal Plains (DGA, 2004).

The Andes Mountains is characterized by volcanism that generates average heights that do not exceed 4,000 m.a.s.l, apart from the Peteroa volcano (4090 meters), followed in importance by the Descabezado Grande with 3,830 meters. However, other volcanic cones with lower elevations such as Descabezado Chico and Quizapu are worthy to mention. Furthermore, volcanic activity and glacial action have generated mountain lagoons such as the Teno Lagoon (3991 m.), the Maule Lagoon at 3,000 m.a.s.l, Invernada and Dial Lagoons.

Between the foothills and the Coastal Ridge, there is a longitudinal valley (Intermediate Depression), reaching a width of 40 km in front of Linares and with a length of 170 km. It presents a flat relief only interrupted by the numerous rivers that cross it in an east-west direction. However, towards the central and southern part of the region, it appears between the intermediate depression and the Andes Mountains, a foothill relief of heights between 400 and 1,000 meters above sea level, which is known as "La Montaña".

The Coastal Range is low (between 300 and 700 m) with gentle hills that create basins and valleys. It is divided into two cords, especially between the Maule and Itata rivers (VIII Region), where it gives rise to the Cauquenes (south of the region) and Quirihue basins, which present special microclimatic conditions. The main heights do not exceed 900 meters above sea level, such as the 819m of Guacho hill.

The coastal plains have a wide development with terraces that reach 200 meters with an approximate width of 5 kilometres and are interrupted by rivers that flow into the sea. The beaches are extensive as is the case of "Constitución".

3.3. Geological and Geomorphological Baseline Information

3.3.1. Regional geology and geomorphology

The Maule River region includes the Andes Mountains by the east, the Central Valley and the Coastal Range in the west. The Andes mountains are steep, elevated and showed the effects of glaciation. The slope of rivers and streams is very pronounced. The rocks that make up the Andes Mountains include a wide variety of types and ages. There is a moderate number of granitic rocks from the Cretaceous age, but most of the rocks are volcanic or volcanic sediments, from ages that fluctuate between the Cretaceous and the Quaternary.

The Central Valley is located west of the Andes and its current level is due to the filling of the rivers coming from the Andes Mountains to a lesser extent than the rivers that originate in the Coastal Range, and quaternary volcanic materials, such as deposits ash, mud streams, etc. The central Valley presents a width of about 20 km in the town of Medina, about 60 km in the Parral area, narrowing again to the south of this point. The proportion of quaternary volcanic materials in the valley seems to decrease sharply from north to south; volcanic materials predominate in the north and in the south, alluvial deposits of sand, gravel, silt, and clay.

The northern part of the Central Valley between the Maule River and the Claro River is constituted by an alluvial fan interstratified with volcanic material. The surface of the fan has been dissected by numerous channels resulting in a wavy relief. In the low relief areas, the materials near the surface have been heavily weathered and contain a high percentage of clay.

Towards the south of the Maule River, east of the Panamerican road, the valley is fundamentally a plain formed by the coalescence of the recent alluvial deposits of the rivers Maule, Achibueno, Ancoa, Longaví and Perquilauquén. Most of this area is almost flat and its surface composed of gravel and sand is highly permeable. Locally the area is dissected similarly to the northern part.

A few isolated hills occur in the valley; the same of them appear to be volcanic bodies, while others, particularly those close to the mountain's ranges, are islands hills. Towards the west of the Panamerican road, the sedimentary materials are finer, appearing some volcanic materials.

The Coastal Range, much less steep and elevated than the Andes Mountains, cut by numerous intermountain valleys, is composed of consolidated ancient rocks. Sedimentary rocks, volcanic and strip of granite rocks, are preferably aged cretaceous. This strip extends from north to south in the eastern part; another continues to the west, formed by metamorphic rocks of the Precambrian age.

There are several coastal terraces; the most extensive of them is to the north of the Community of Chanca. 4% of the surface of these terraces is covered by dunes. The bottom material of these "Terrazas" is well classified as sand, apparently marine, with some areas of silt and clay. The depth of the sedimentary fill of the terrace is not known (DGA, 2004).

3.3.2. Local Geology

According to the geological map of Chile (SERNAGOMIN) the study area lies over granites, granodiorites, tonalites and diorites from Carboniferous to Permian (328-235 Ma). **Figure 5.**

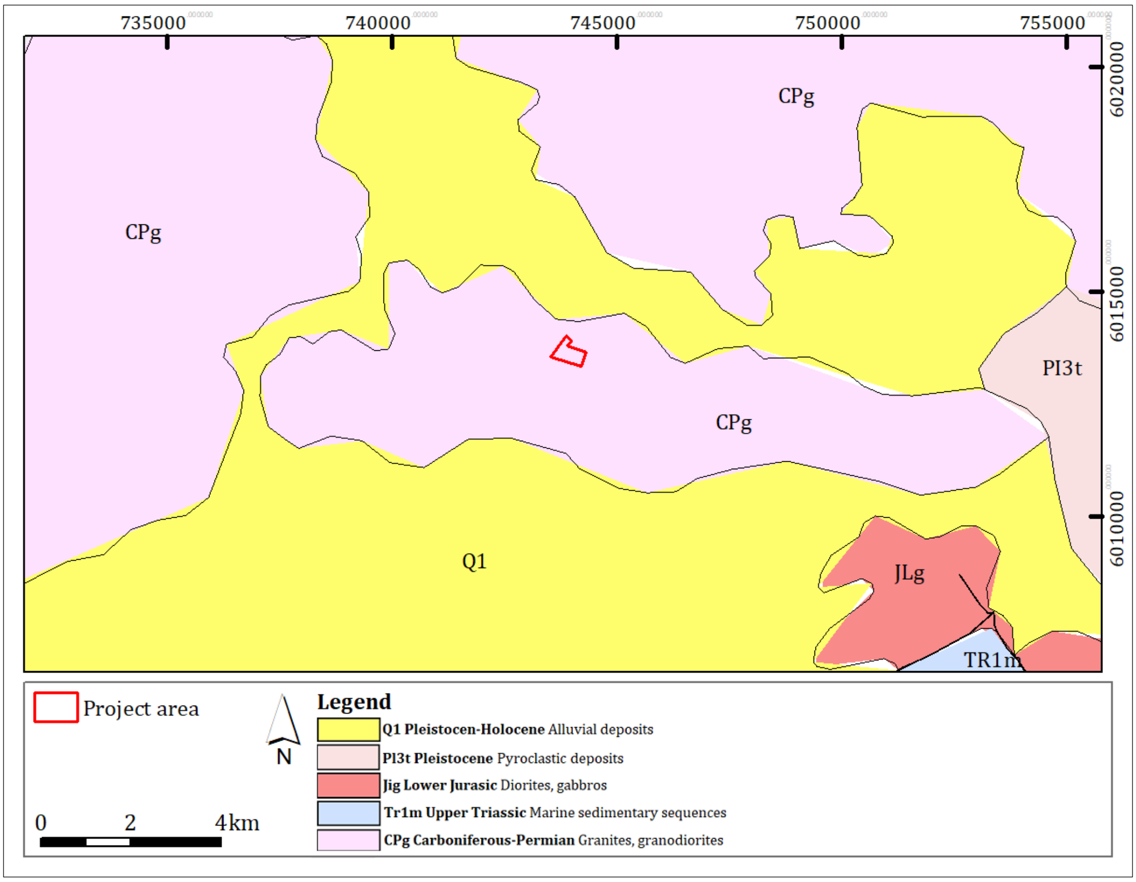

Figure 5. Geology of the project site region.

3.4. Type of soil

According to the "Grandes tipos de suelos en Chile" vectorial layer (from "Red CEDEUS" research portal; credits to *www.rulamahue.cl/*), the predominant soil type in the area are Alfisol and Inceptisol, in USDA soil taxonomy. **Figure 6.**

Alfisol (Luvisols in WRB Soil Resources taxonomy) is defined as soil present in semiarid to humid areas, characterized by a subsoil layer with clays enriched in aluminium- and iron-bearing minerals. Inceptisols are young soils with weak layers differentiation, often found with underlying weather-resistant parent material (USDA, 2014).

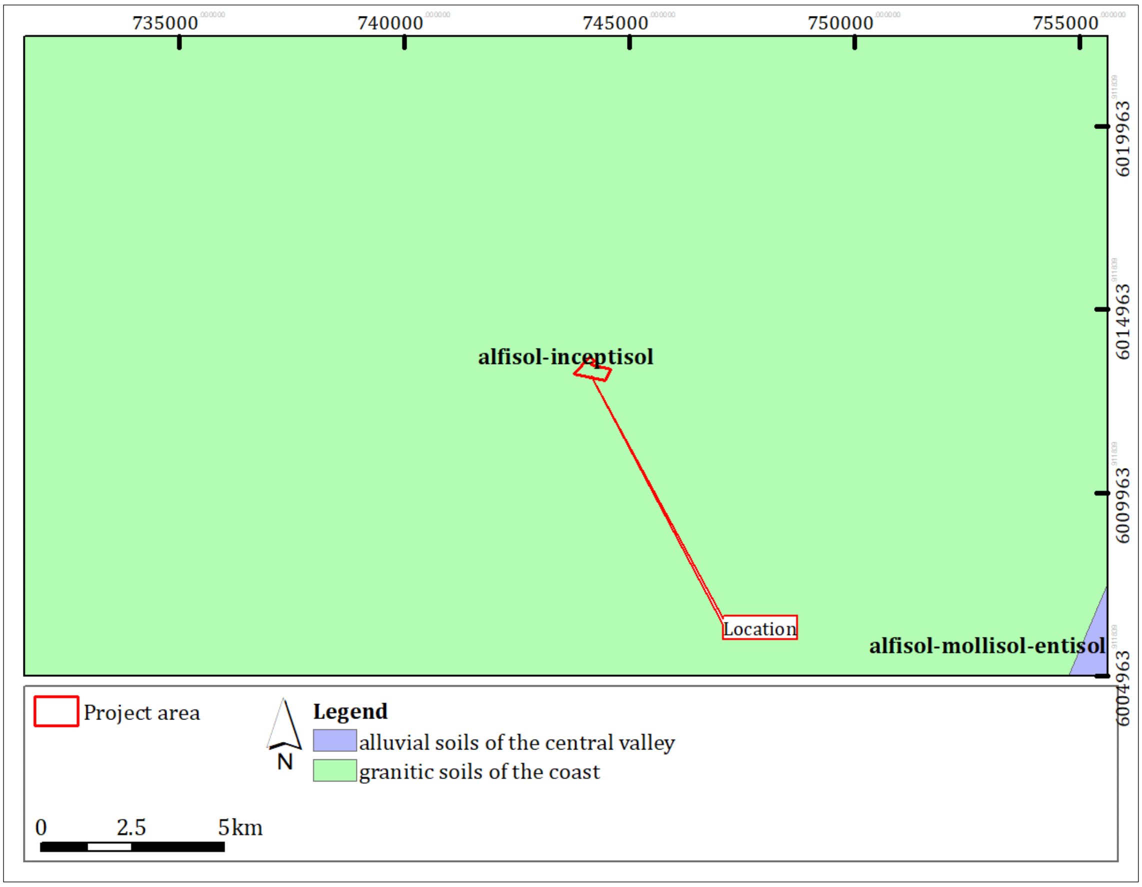

Figure 6. Soil type present in the project area. ***Source: Red CEDEUS.***

3.5. Land uses

According to "Catastros de usos de suelo y vegetación" from Infraestructura de Datos Geoespaciales from Chile (IDE), the land use present in the area where the plot is placed is cropland with minor presence of grassland and shrubland. (**Figure 7**).

Other types of land use in the nearby area are forests and bare lands.

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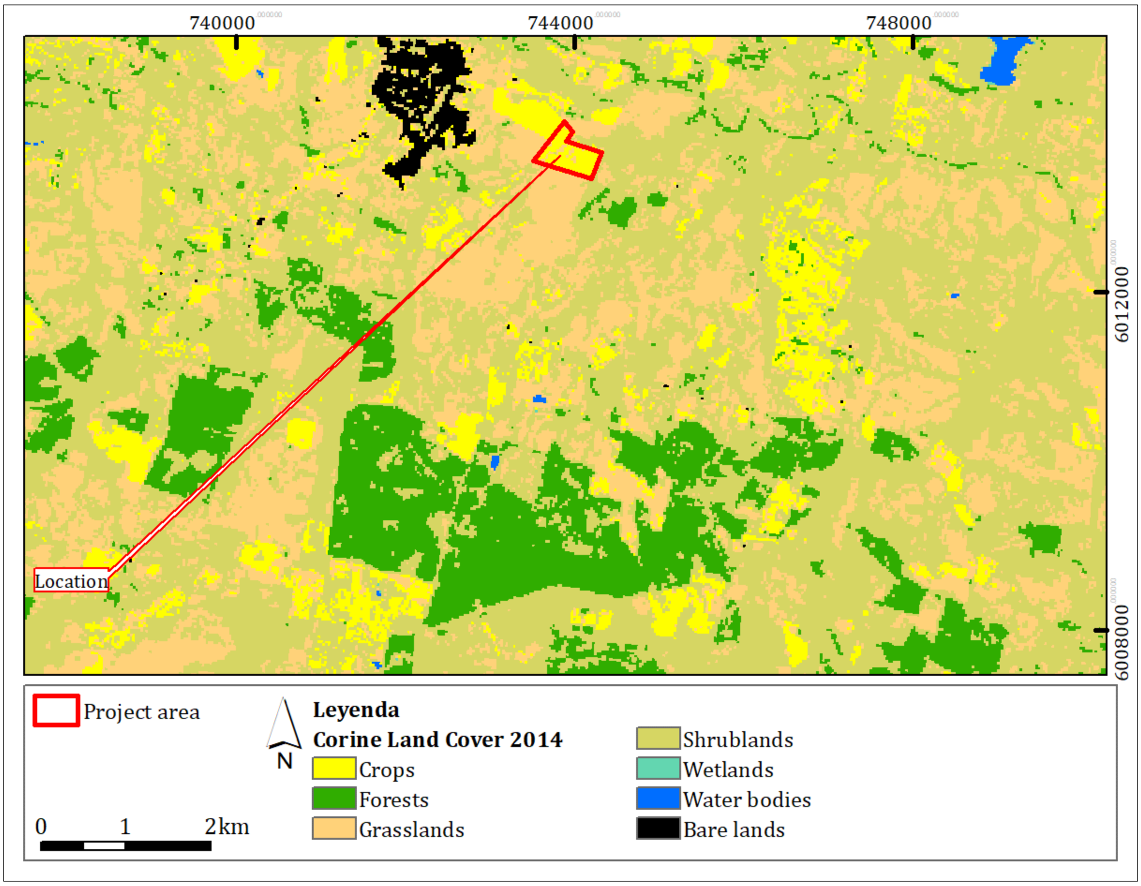


Figure 7. Land uses in the study area. ***Source: IDE***.

3.6. Hydrography

The Maule Region has two hydrography systems: The Mataquito River, to the north, and the Maule River, in the centre.

The Mataquito River has a mixed regime, and its tributaries are the Teno and Lontué rivers. The hydrographic basin of the Malaquito River is around 6200 km² and the average flow is 153 m³/s. It empties into the sea south of Vichuquén lagoon. Its waters are useful to irrigate crops in the valley, covering an irrigated area of 100.000 Ha.

On the other hand, the Maule River is one of the most important watercourses in the country. Its hydrographic basin covers an area of 20,300 km² and has an average flow of 467 m³/s. It is born in the Cordillera de los Andes and has as tributaries in its upper course the rivers Puelche, Los Cipreses, Claro and Melado. In the Longitudinal Valley, it has as tributaries the Loncomilla river, to finally flow into the sea in Constitución with a width of 200 meters.

Concerning the project area, the main hydrological feature is the Cauquenes River that flows from west to east and, in the nearby area, receives the flow of the Tutuven River and the Los Coipos Estuary. One of the branches of the Cauquenes River crosses the project area in a south-southwest to north-east direction.

The Cauquenes River originates in the Coastal Ridge, near Cauquenes and flows into the Perquilauquén River, a tributary of the Loncomilla River.

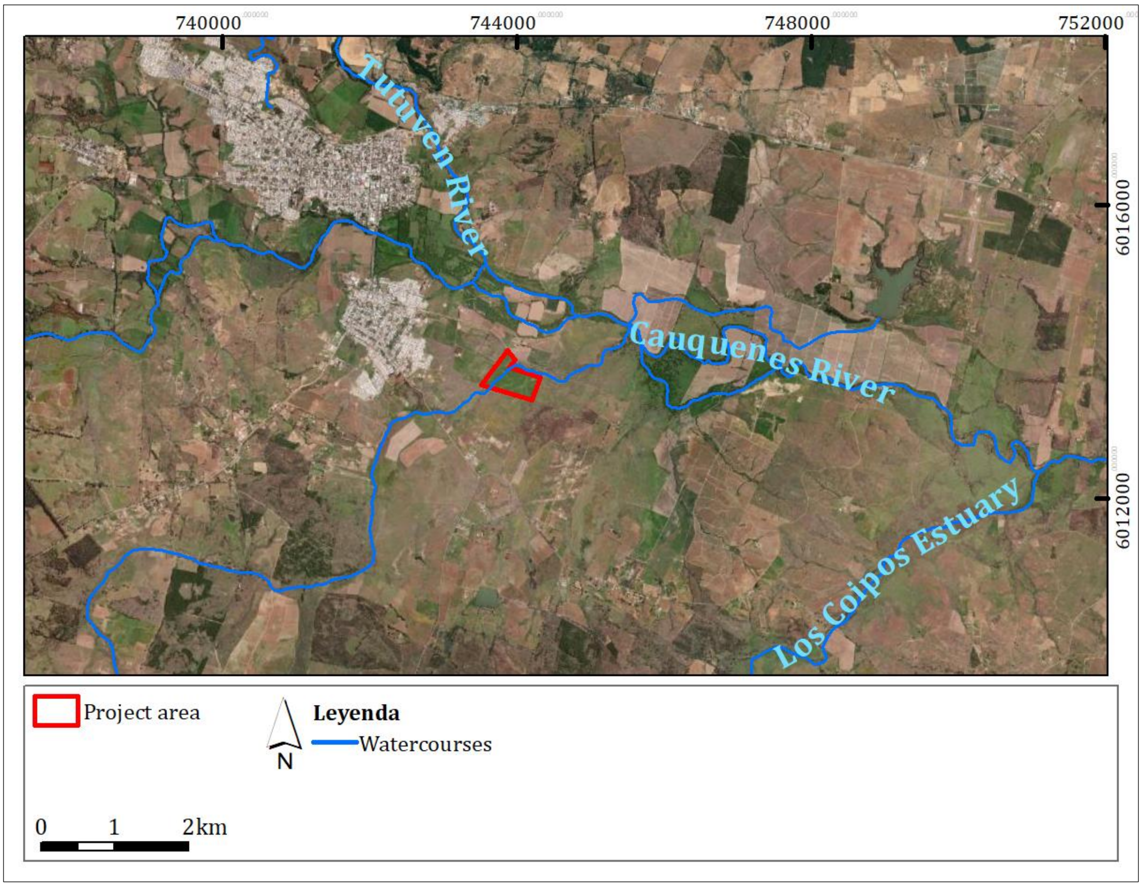


Figure 8. Hydrographic network of the Maule region, detail over the project site area. ***Source: DGA.***

3.7. Topographic Wetness Index

The Topographic Wetness Index (TWI) is a steady-state wetness index. It is related to soil moisture and reflects the tendency of soil to generate runoff. Profiles with higher humidity have additional saturation likelihood, thus, precipitation falling on those profiles may easily turn into runoff. The TWI is a function of both the slope (ß) and the upstream contributing area per unit width orthogonal to the flow direction (af). It is commonly used to quantify the topographic control over hydrological processes (Sørensen et al., 2006), and it is defined as Equation (2):

$$TWI = \ln\left(\frac{af}{\tan ß}\right) \tag{2}$$

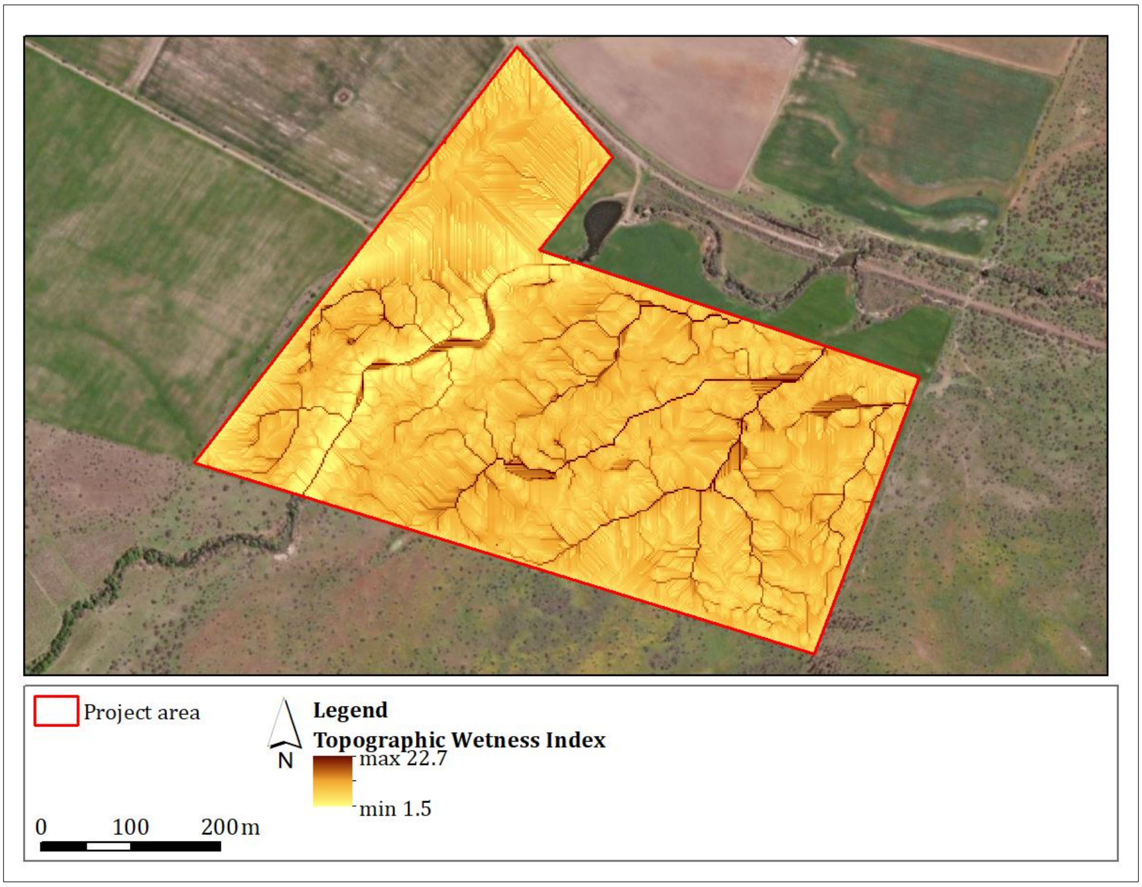


Figure 9. Topographic Wetness Index for the project site.

The TWI expresses the relative volume and the amount of flow movement that will pass through every point across the ground. The greater the drained area, and the lower the slope are, the greater the concentration and water saturation in the soil is. In this way, areas with higher values of TWI are areas of runoff concentration.

As observed in **Figure 9**, there are prone to saturation areas identified as the main watercourses and other intermittent waterways that may affect the area of the project. These prone to saturation areas are especially the darkest zones. As may be observed, water would flow in a south direction and especially, in a southwest to northeast direction, considering the existent slope within the project site.

4. HYDROLOGICAL ANALYSIS

The hydrological analysis examines the hydrometeorological response of the area and investigates the probability of flood occurrence resulting from extreme precipitation events at the catchment for different return periods (T).

The main goals of the hydrological analysis are the following:

- To design the precipitation events that would occur for each return period.
- To obtain the peak flows corresponding to extreme rainfall events for each return period.

4.1. Return periods

A return period is an average time or an estimated average time between events such as storms, floods or river discharge flows to occur. It is a statistical measurement typically based on historic data over an extended time and it is used usually for risk analysis. It assumes that the probability of the event occurring does not vary over time and is independent of past events.

Accordingly, the return period corresponds to the inverse of the average frequency of occurrence. For example, a 10-year flood has a 1/10 = 0.1 or 10% chance of being exceeded in any one year and a 50-year flood has a 0.02 or 2% chance of being exceeded in any one year. In this study, as requested by the client, the following return periods have been considered: 10, 25 and 50. The determination of the maximum daily precipitation corresponding to each return period is obtained from the statistical study of the annual maximum daily precipitation time series measured in the pluviographs located in the basins draining to the site, or close to it.

4.2. Catchment delimitation

A catchment is the area of a surface where collected precipitation drains into a common outlet, such as a river, a bay, or another body of water.

For the study area, through a hydrologic analysis, one catchment has been identified as an external surface water contributor that affects or may affect the site (**Table 2** and **Figure 10**).

Table 2. Catchments parametrization.

Catchment	Area (km^2)	Flow path length (km)	Altitude upstream (masl)	Altitude downstream (masl)	Slope (m/m)
	67	17.61	213	147	0.004

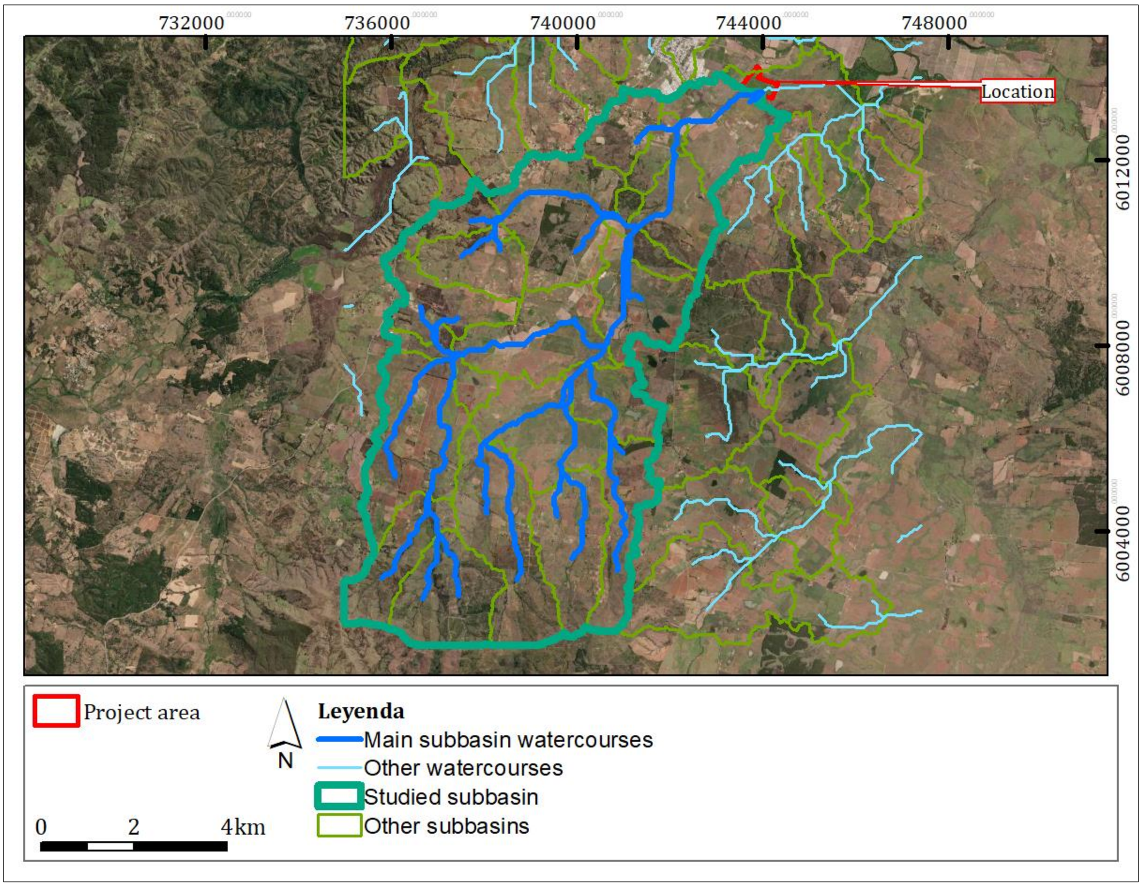


Figure 10. Catchments with influence on the project site.

4.3. Catchment time of concentration

The concentration-time (tc) represents the time required for runoff to travel from the hydraulically most distant point in the catchment to the outlet. It is characteristic of each catchment and depends upon several parameters such as the slope and the length of the flow path. The time of concentration is usually used as the duration of the design storms.

There are several methods available for its calculation and the applicability of each one depends on several factors, among them, the normative and recommendations from the country where the project is located. In this case, the following methods have been used: the Témez Method, the Chow Method and the California Highways and Public Works.

In **Table 3** the time concentration results for every method may be consulted.

4.3.1. Témez Method

$$t_c = 0.3 \cdot \left(\frac{L}{i^{0.25}}\right)^{0.76} \tag{3}$$

Where:

- *tc* = Time of concentration (h).
- *L* = Longitude of the main flow path (km).
- *i* = Average slope of the main course (m/m).

4.3.2. Chow Method

$$t_c = 0.273 \cdot \left(\frac{L}{S^{0.5}}\right)^{0.64} \tag{4}$$

Where:

- *tc* = Time of concentration (min).
- *L* = Longitude of the main flow path (km).
- *S* = Average slope of the main course (m/m).

4.3.3. California Highways and Public Works from USA

$$t_c = 0.95 \cdot \left(\frac{L^3}{H}\right)^{0.385} \tag{5}$$

Where:

- *tc* = Time of concentration (h).
- *L* = Longitude of the main flow path (km).
- *H* = Height difference between the highest point and the lowest point in the basin, (m/m).

Table 3. Area (A), slope (J), time of concentration (Tc) for each of the identified catchments.

Catchment	A (km²)	Longitude of the stream (m)	J (%)	Difference height (m.)	Temez Tc (h)	California Tc (h)	Chow Tc (h)
	67	17608.5	0.378	67	**7.66**	5.2	10.2

In Chile, the document "Manual de Carreteras de la Dirección de Vialidad del Ministerio de Obras Publicas" use the equations from the California Culverts Practice Method (1932), the Spanish Method (Témez) and Giandotti Method. The first one is used in small mountain catchments, but the studied subbasin is categorized as medium to large size with a flat slope (<1%). The Témez method applicability criteria are for 1 to 3000 km² and 15 min to 24 hours of tc values.

Considering the above information, the Témez method result is selected.

4.4. Rainfall data

To obtain the maximum annual daily precipitation, the database from which the meteorological data has been obtained is "Explorador Climático de Chile". This explorer uses the databases compiled by the "Centro del Ciencia del Clima y Resiliencia (CR)2", which since its creation has worked to compile and consolidate an extensive, complete and updated database of climatological observations available for Chile. To identify the influence of the nearest station on the study area and, on the basins draining to the site, Thiessen polygons were created (**Figure 11**). This methodology shows that the meteorological station with influence on the project area is the "Tutuven Embalse" station. **Table 4**.

Table 4. Tutuven Embalse meteorological station general data.

Name	Province	Region	Easting (m)	Northing (m)	Altitude (masl)	Distance to the site (km)
Tutuven Embalse	Cauquenes	Maule	736458	6024380	173	12.7

Complete meteorological data for the Tutuven Embalse station may be found in **ANNEX I.**

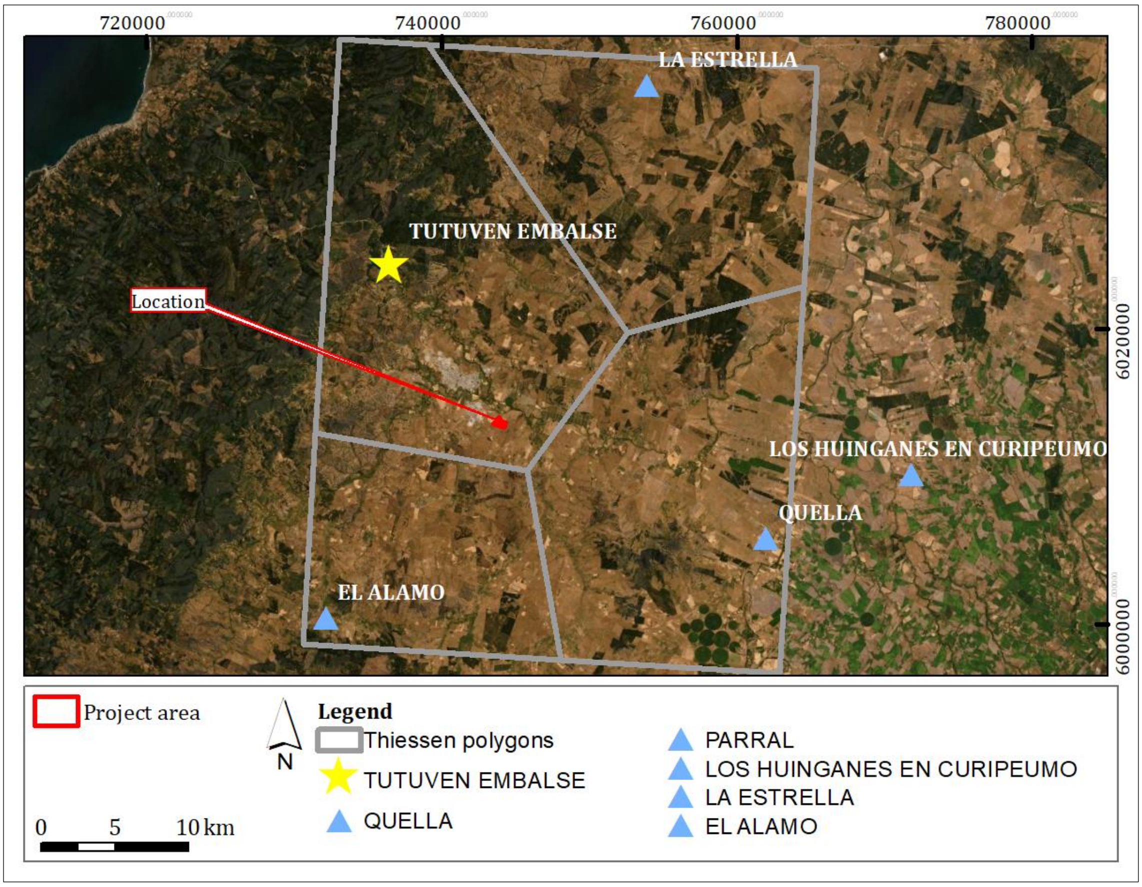


Figure 11. Thiessen polygons from meteorological stations nearby the site.

4.5. Probability distribution functions

In order to predict the maximum rainfall for each return period, statistical methods are applied. The time-series of maximum annual precipitation in 24 hours were adjusted to different probability functions: Gumbel and Gamma of two parameters. (**Table 4**). The distribution with a better fit for the different stations was Gumbel **(ANNEX I)** since is the distribution with lower quadratic error.

In **Table 5** the maximum precipitation in 24 hours for every return period is shown.

To verify values from maximum daily precipitation data, 10-years return period maximum daily precipitation data isohyets have been consulted from DGA (1991). **ANNEX I**.

Table 5. Maximum daily probable rainfall according to Gumbel distribution (mm).

TR	Maximum daily rainfall (mm)
5	95.16
10	109.92
25	128.56
50	142.40
100	156.13
200	169.81
500	187.86

4.6. Intensity-Duration-Frequency curves

The Intensity-Duration-Frequency curves (IDF) are built up to know the variation of the intensity and the duration of the precipitation with its frequency of incidence. They are represented by a mathematical relationship between the intensity of precipitation, its duration and the frequency of occurrence (Pizarro et al., 2005).

The mathematical representation of the IDF curves is as follows:

$$\mathrm{I} = \frac{\mathrm{a} \cdot \mathrm{T}^{b}}{\mathrm{t}^{c}} \tag{6}$$

Where:

- I = Intensity (mm/hr)
- t = Rainfall duration (min)
- T = Return period (y)
- a, b, c = Adjustment parameters (non-dimensional)

According to the coefficients for the 24-hours rainfall relationships (Campos-Aranda, 2009), the maximum precipitation for different duration times may be calculated (**Table 6**).

Table 6. Maximum rainfall for different duration times.

Duration (h)	Quotient	Maximum daily rainfall (mm)					
		T= 5	T= 10	T= 25	T= 50	T= 100	T= 200
24	X24	95.16	109.92	128.56	142.40	156.13	169.81
18	X18 = 91%	86.59	100.02	116.99	129.58	142.08	154.53
12	X12 = 80%	76.13	87.93	102.85	113.92	124.90	135.85
8	X8 = 68%	64.71	74.74	87.42	96.83	106.17	115.47
6	X6 = 61%	58.05	67.05	78.42	86.86	95.24	103.59
5	X5 = 57%	54.24	62.65	73.28	81.17	88.99	96.79
4	X4 = 52%	49.48	57.16	66.85	74.05	81.19	88.30
3	X3 = 46%	43.77	50.56	59.14	65.50	71.82	78.11
2	X2 = 39%	37.11	42.87	50.14	55.54	60.89	66.23
1	X1 = 30%	28.55	32.97	38.57	42.72	46.84	50.94

Based on previous results (**Table 6**), and duration times, the equivalent intensity is calculated by dividing the precipitation by the duration (**Table 7**).

Table 7. Maximum rainfall intensity for different duration times.

Duration (h)	Duration (min)	Maximum daily rainfall intensity (mm/h)					
		T= 5	T= 10	T= 25	T= 50	T= 100	T= 500
24	1440	3.96	4.58	5.36	5.93	6.51	7.08
18	1080	4.81	5.56	6.50	7.20	7.89	8.58
12	720	6.34	7.33	8.57	9.49	10.41	11.32
8	480	8.09	9.34	10.93	12.10	13.27	14.43
6	360	9.67	11.17	13.07	14.48	15.87	17.26
5	300	10.85	12.53	14.66	16.23	17.80	19.36
4	240	12.37	14.29	16.71	18.51	20.30	22.08
3	180	14.59	16.85	19.71	21.83	23.94	26.04
2	120	18.56	21.43	25.07	27.77	30.45	33.11
1	60	28.55	32.97	38.57	42.72	46.84	50.94

Through the performance of the mathematical calculations based on change of variables and applying potential regressions, the values of the adjustment parameters a, b, and c are obtained, resulting in the following equation:

$$I = \frac{287.5177 \cdot T^{0.155976}}{t^{0.61639}} \tag{7}$$

From this equation, the IDF curves are obtained for each return period (**Figure 12**).

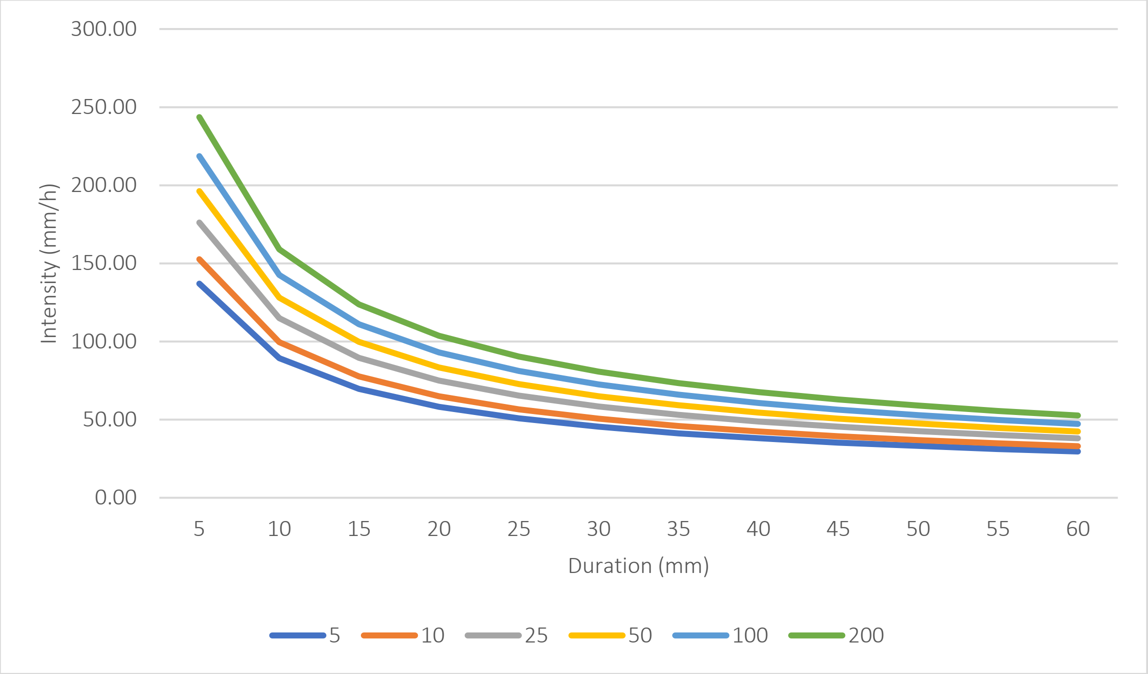
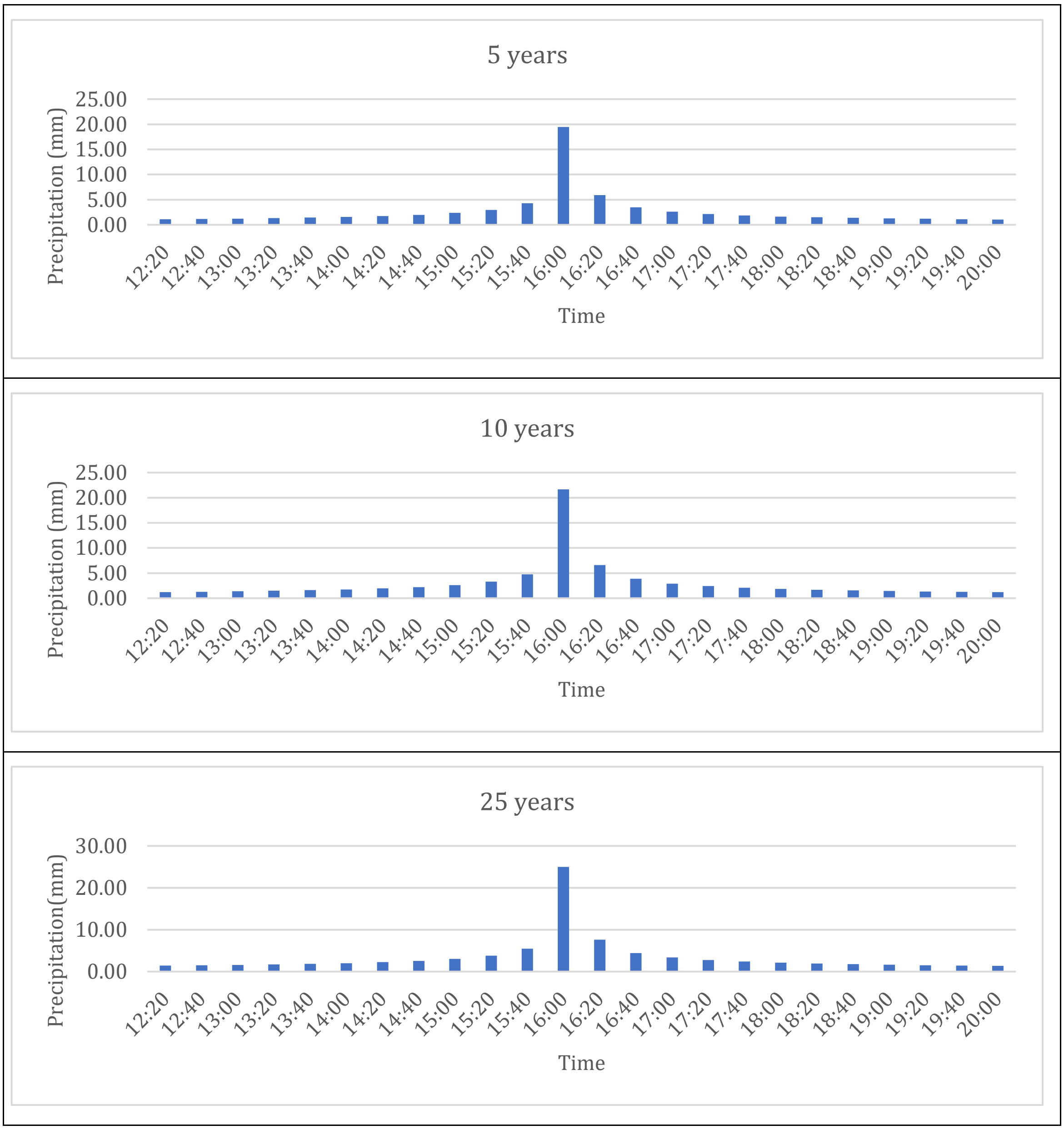


Figure 12. IDF curves for Linares station.

4.7. Hyetographs

The design rainfall events (hyetographs) are created using the IDF curves and the alternating block method (Chow et al., 1994). These hyetographs reflect the distribution of rainfall produced during the duration of the event for each return period.

8-hours hyetographs have been generated. Furthermore, 20-minutes intervals for each hyetograph have been applied. Here below, in **Figure 13**, the design hyetographs for the studied catchment area are shown.



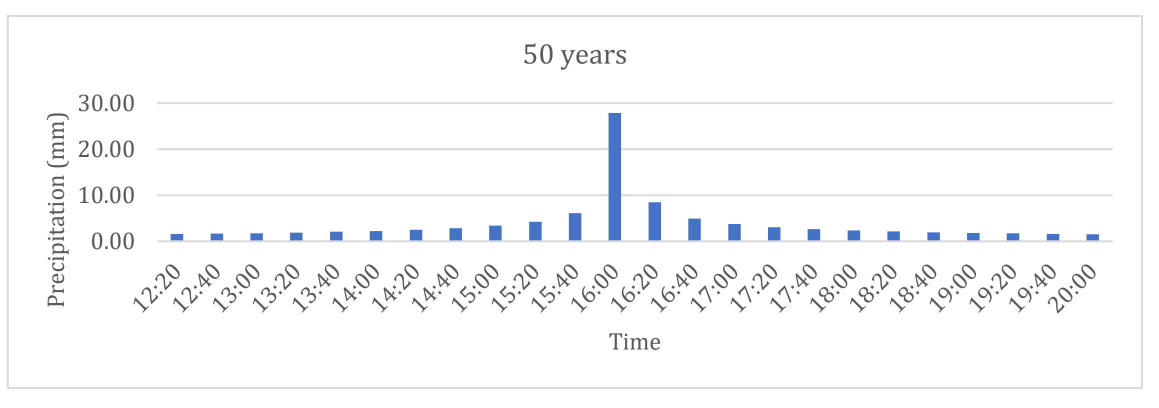


Figure 13. Hyetographs for T = 5, 10, 25, 50 years for Catchment 1.

4.8. Rainfall-runoff model

In the present study, the Soil Conservation Service rainfall-runoff model (SCS-CN) has been the method used to calculate the flows reaching the plot.

4.8.1. Soil Conservation Service Curve Number Method (SCS-CN) overview

The Soil Conservation Service Runoff Curve Number Method (SCS-CN) was developed in 1972 by the U.S Soil Conservation Service and is based on an empirical model to obtain the surface water runoff from a specific hyetograph. The method is based on rainfall abstractions according to the potential for soil to absorb a certain amount of moisture. This potential storage (S) is related to a "curve number" (CN) which is a characteristic of each soil type, land use and the initial degree of saturation commonly known as the antecedent moisture condition. Typical values for the SCS Curve Number CN as a function of soil type, land use and degree of saturation can be found in the "Technical Release 55" (USDA, 1986).

The SCS runoff equation is:

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S} \qquad (8)$$

Whereas:

- Q = runoff (mm).
- P = rainfall (mm).
- S = potential maximum retention after runoff begins (mm).
- Ia = initial abstraction (mm).

The Initial abstraction (I_a) corresponds to the losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration. I_a is highly variable but generally is correlated with soil and cover parameters. Through studies of many small catchments, I_a was found to be approximated by the following empirical equation:

$$I_a = 0.2S \qquad (9)$$

By removing I_a as an independent parameter, this approximation allows the use of a combination of S and P to produce a unique runoff amount. Substituting equation (9) into equation (8) gives:

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)} \qquad (10)$$

Finally, potential retention (S) is related to the soil and cover conditions of the catchment through the Curve Number (CN).

$$S = \frac{25400}{CN} - 254 \qquad (11)$$

4.8.2. Curve Number

In order to obtain the effective precipitation height, it is necessary to know the curve number (CN) for every single basin draining the sites. It is an empirical parameter that is based on the hydrological group of the soil, the land use and the hydrological condition. The curve number can take a value from 0 to 100 depending on its ability to generate surface runoff. Values close to 0 represent very high permeability conditions, while values close to 100 represent impermeability conditions. Typical values for the curve number can be found in technical document No. 55 (USDA, 1986). In this way, an average value for each basin has been calculated.

There are four soil hydrological groups, these range from A to D, representing group A with a minimum runoff potential and D with a high runoff potential. To assign a particular group to the soil, its composition, texture and infiltration must be considered.

The curve number applied in the study area has considered the lithology and land uses in each interest area. According to the information contained in the geotechnical report, developed by the Consultant (indicating the presence of a soft and brownish Silty CLAY underlying the topsoil), soils might be classified hydrologically as **type C** within the site. In areas where "in situ" data has not been possible to be collected (especially outside of the project plot), vectorial layers from official institutions have been obtained. To take conservative values, **C-type soil** has been selected both for the project site and for the identified catchments.

Once the hydrological group has been selected, the land use of the drainage basins is considered and weighted for every basin to have a final curve number (**Table 8**).

Table 8. Curve number obtained through areas weighted for the studied subbasin.

Land cover	CN	Area (km^2)	Weighted CN
Croplands	89	3.06	4.06
Shrublands	70	34.47	36.01
Grasslands	79	23.32	27.50
Forests	73	6.11	6.65
Bare lands	25	0.02	0.01
Wetlands	96	0.00	0.01
Water bodies	100	0.04	0.05
		Final CN	**74.29**

4.8.3. Catchment parameters

The input information for obtaining the flow through the Curve Number Method for the catchment identified in the present study and the project area, through HEC-HMS software, is the following:

Table 9. Input parameters for the identified basins.

	A (km²)	J (m/m)	CN	tc (min)	Lag (min)**
Subbasin	67	0.0038	74.29	459.47	275.68
Project area	0.253	-	89	-	-

**Lag time is defined as the time between the centroid of effective rainfall and the peak discharge of the resultant direct runoff hydrograph. This time can be approximated to the time of concentration as T_c*0.6.

4.9. Excess rainfall and hydrographs

With the HEC-HMS software, excess rainfall and complete hydrographs for the duration of the designed storms (hyetographs) have been obtained for each of the catchments and return periods.

The excess rainfall corresponds to the volume of rain available to generate direct surface runoff. This is equal to the total amount of rainfall minus all abstractions, including interception, storage, and infiltration (**Table 10**). It is calculated from the curve number of the project area (**Table 9**).

Table 10. Rainfall and excess rainfall for each design storm and identified catchment.

	Project area	
Design storm for:	**Rainfall (mm)**	**Excess rainfall (mm)**
T = 5 years	65.79	38.96
T = 10 years	73.28	45.62
T = 25 years	84.56	55.87
T = 50 years	94.22	64.81

Hydrographs are graphical representations of the stream discharge or rate of flow at a time. The rising limb of the hydrograph represents the rapid increase of flow resulting from rainfall causing surface runoff and then later throughflow. Peak discharge occurs when the river reaches its highest level. The time difference between the peak of the rainfall event and the peak discharge is known as the lag time. The recession limb is when discharge decreases, and the river's level falls. It has a gentler gradient than the rising limb as the most overland flow has been discharged and it is mainly throughflow that is making up the river water.

ANNEX II includes the design hyetographs for the studied subbasin. Peak flow results for the studied river reach can be consulted in **Table 11**.

Table 11. Peak flows results.

Design storm for:	Peak flow (m^3/s)
T = 5 years	43.52
T = 10 years	55.11
T = 25 years	73.96
T = 50 years	91.17

5. HYDRAULIC ANALYSIS

5.1. Conceptual model

Floods are temporary overflows of land which is usually not covered by water. It includes floods caused by rivers, mountain torrents or intermittent water streams. These may have a fluvial origin, caused by the channel overflow, or pluvial, caused by *in situ* rainfall. The hydraulic model is developed over the Digital Elevation Model of the detailed topography of the study site (**see section 2.1**).

Excess rainfall, hydrographs for the subbasin with influence on the project area are the hydrologic conditions input, while the output condiction is defined by a normal depth.

The resulting hydraulic model will highlight areas that are susceptible to flooding and erosion due to the storm event. Models have been built up with the hydrological software HEC-RAS 5.0.7 developed by the Hydrologic Engineering Centre of the US Army Corps of Engineers (**ANNEX III**), allowing to obtain:

- The maximum extension of the water sheet.
- The maximum depth of the water sheet.
- The maximum velocity of the flow.

5.2. Depth and velocity for a 10-years return period

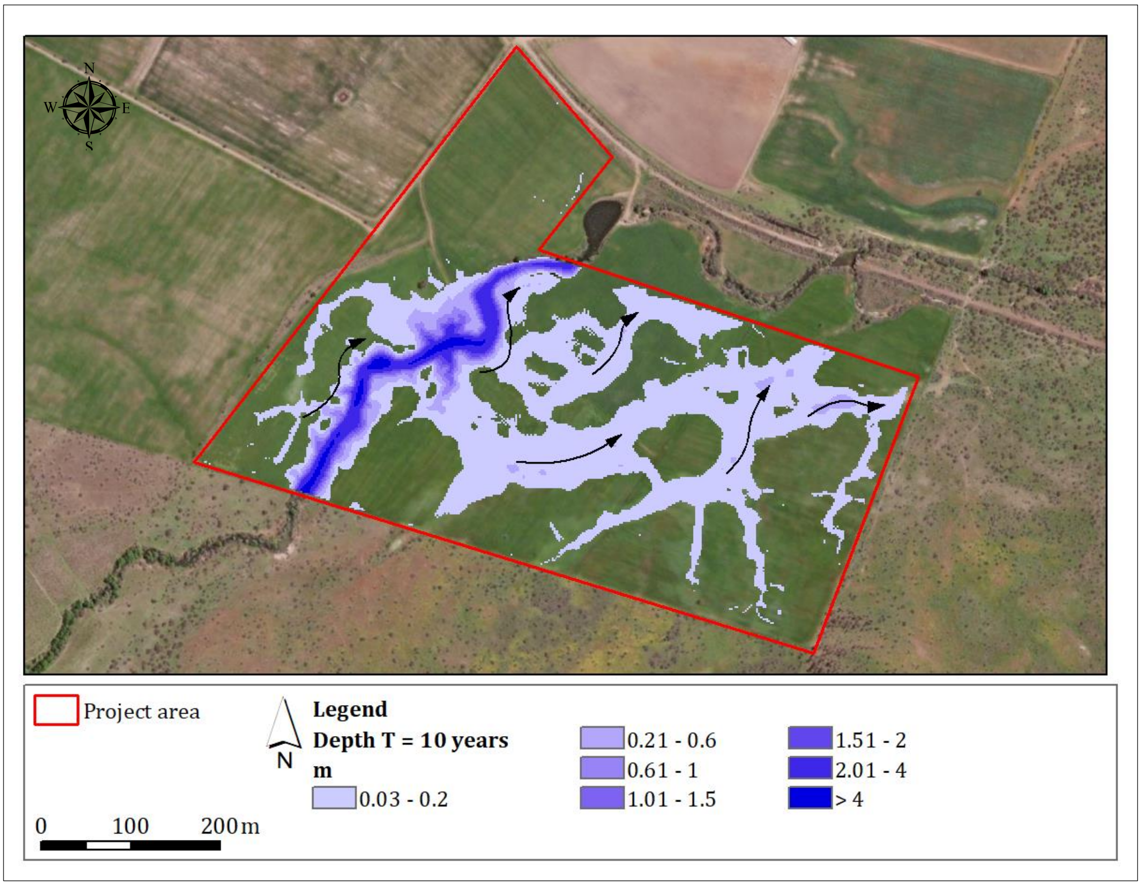


Figure 14. Extension and depth of surface water for T=10 years.

Results from 10-years hydraulic simulation show that water runoff coming from a rainfall event will naturally flow in a southwest-northeast direction. Runoff water concentrates alongside the river reach while in the adjacent flood plains the water depth is mainly very low (<0.2 m).

Water depths vary, for a 10-years return period in the interest areas, from a few centimetres to a maximum value of 4.1 meters. The runoff velocity ranges from less than 0.1 up to 2.3 m/s on the main riverbed.

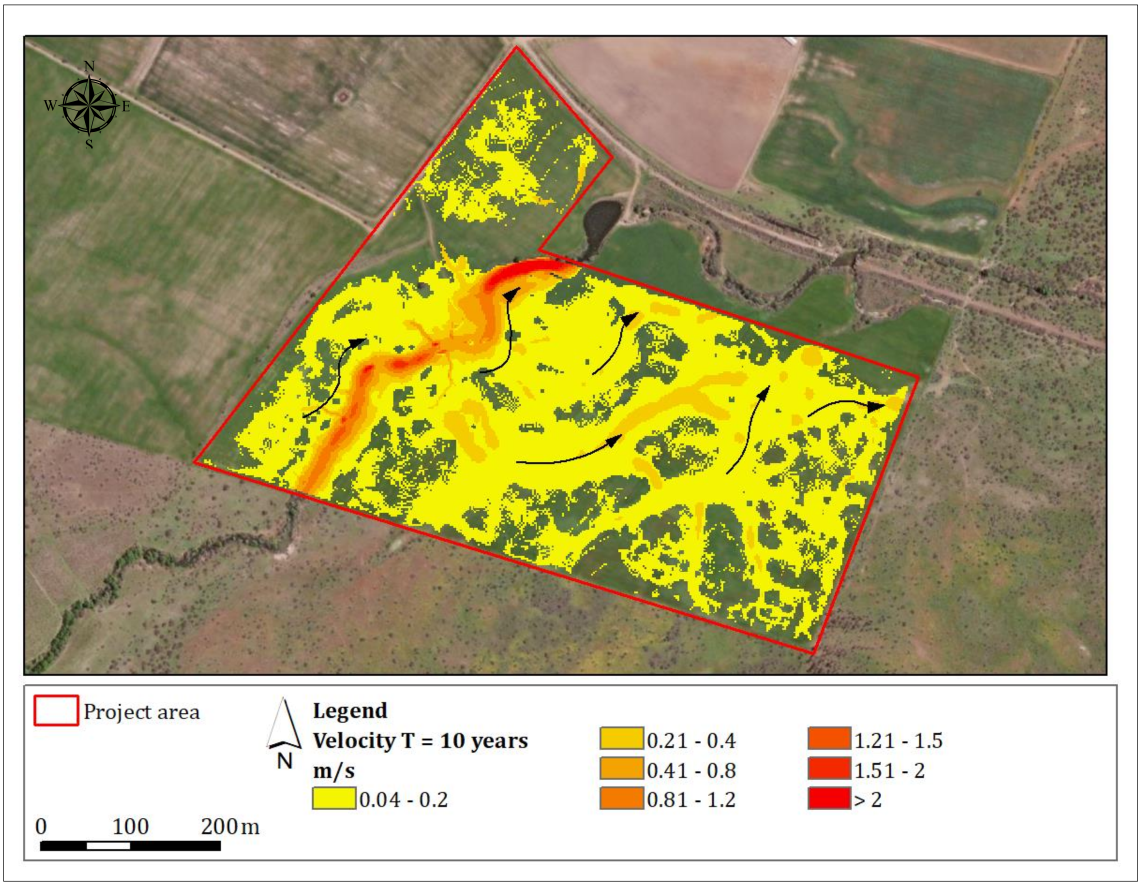


Figure 15. Runoff velocity for T=10 years.

5.3. Depth and velocity for a 25-years return period

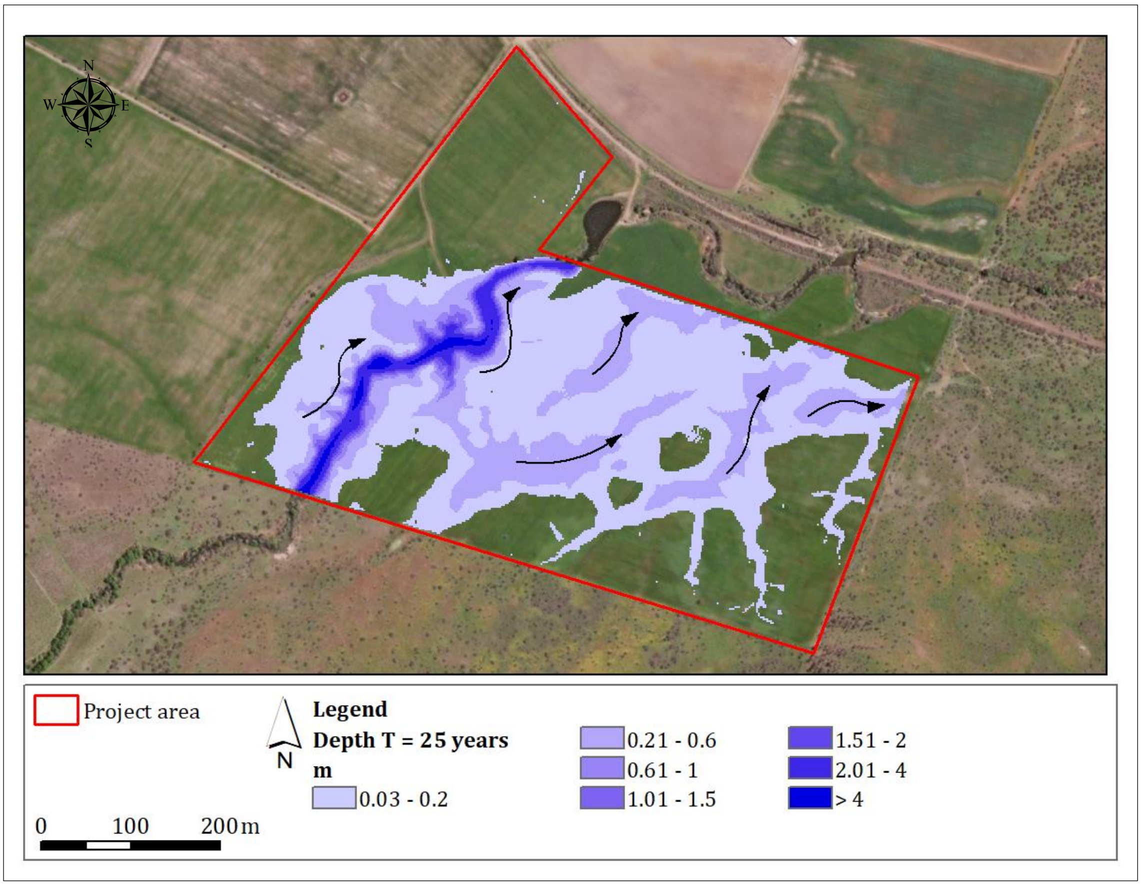


Figure 16. Extension and depth of surface water for T=25 years.

Results from 25-years hydraulic simulation show that water runoff coming from a rainfall event will naturally flow in a southwest-northeast direction. Runoff water concentrates alongside the river reach.

Water depths vary, for a 25-years return period, from a few centimetres to a maximum value of 4.5 meters. The runoff velocity ranges from less than 0.1 up to 2.8 m/s on the main riverbed.

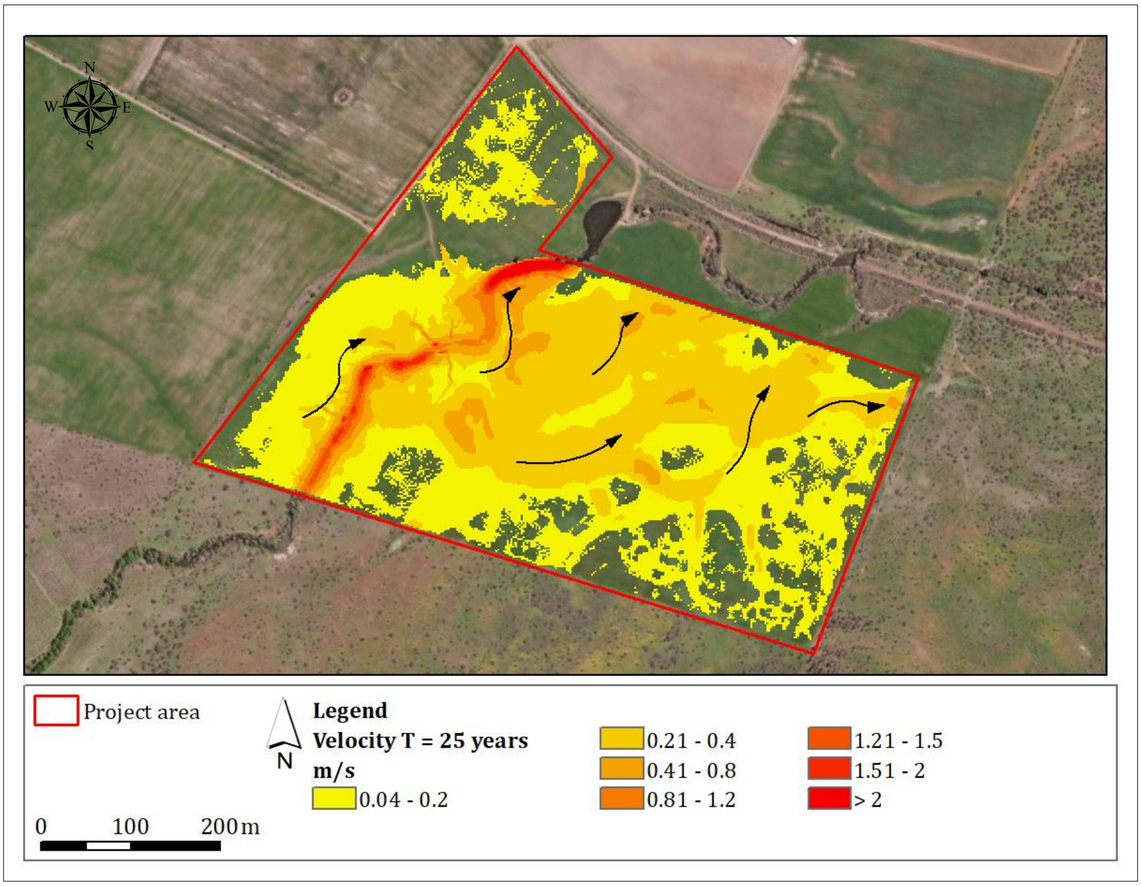


Figure 17. Runoff velocity for T=25 years.

5.4. Depth and velocity for a 50-years return period

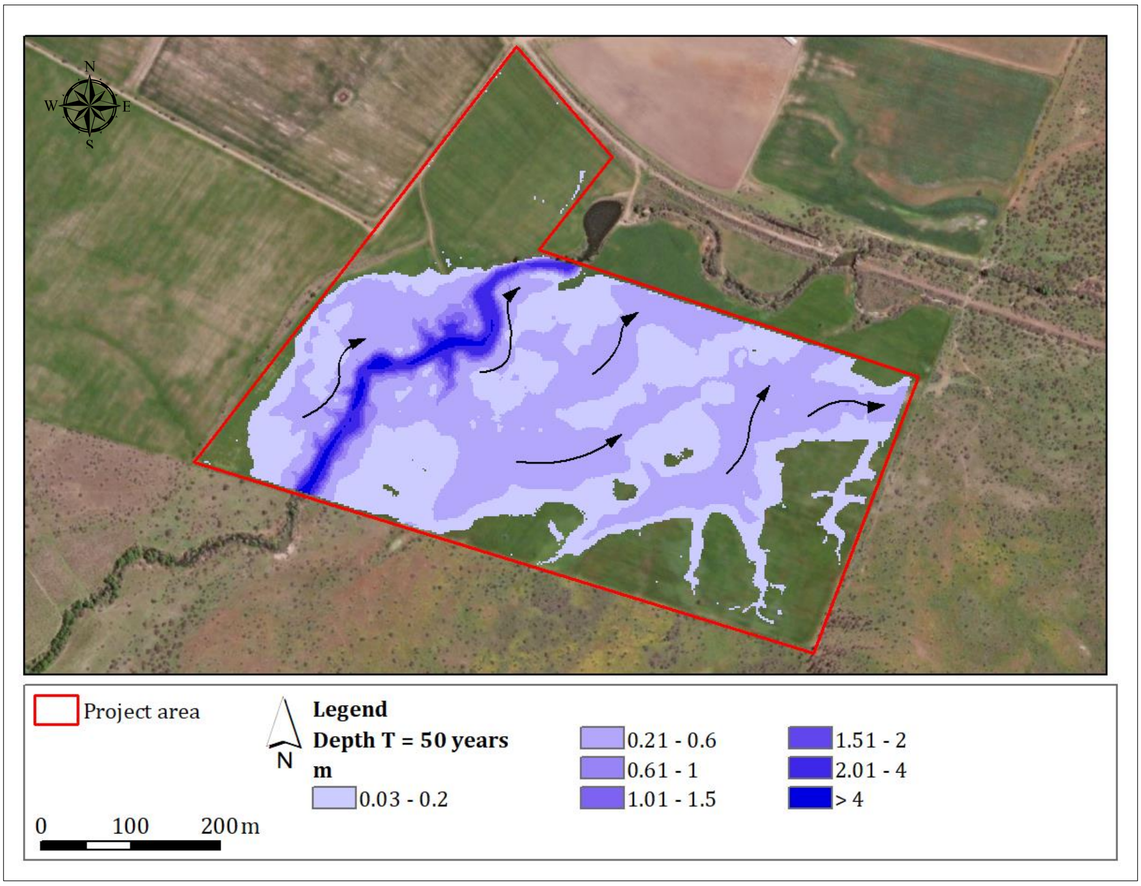


Figure 18. Extension and depth of surface water for T=50 years.

Results from 50-years hydraulic simulation show that water runoff coming from a rainfall event will naturally flow in a southwest-northeast direction. Runoff water concentrates alongside the river reach.

Water depths vary, for a 50-years return period, from a few centimetres to maximum values of 4.9 meters. The runoff velocity ranges from less than 0.1 up to 2.8 m/s on the main riverbed.

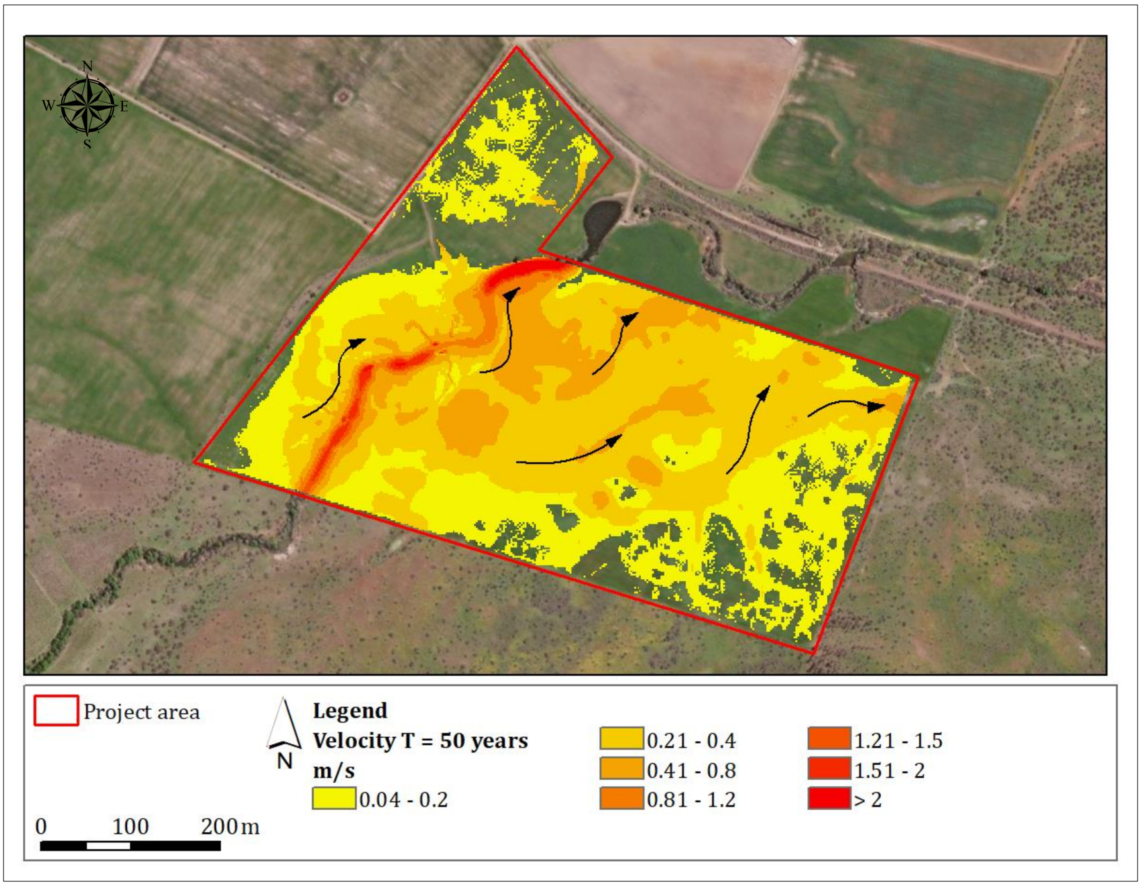


Figure 19. Runoff velocity for T=50 years.

5.5. Erosion prone areas

From the laboratory results of the samples collected in the geotechnical survey the predominant soil type within the project site is silty CLAY. According to FAO's maximum admissible runoff velocities, this type of soil would have an admissible velocity of around 1 m/s (**Table 12**). This analysis of erosion-prone areas is based on the runoff velocity results for a 25-years return period, which in turn, is the lifespan of a solar plant.

Table 12. FAO's maximum admissible runoff velocity. In grey, the soil type and velocity for the project area.

Type of soil or coating	Maximum admissible average velocity (m/s)
UNCOATED CHANNELS	
Soft or very small clay	0.2
Very light and fine sand	0.3
Very light loose sand or mud	0.4
Coarse sand or light sandy soil	0.5
Medium sandy soil and silt of good quality	0.7
Sandy silt, small gravel	0.8
Medium silt or alluvial soil	0.9
Consistent silt, clayey silt	1
Consistent gravel or clay	1.1
Hard clay soil, common gravel soil, or clay and gravel	1.4
Crushed stone and clay	1.5
Coarse gravel, pebbles, shale	1.8
Conglomerates, cemented gravel	2
Soft rock, layers of stones, hard layer	2.4
Hard rock	4
COATED CHANNELS	
Concrete cement moulded on-site	2.5
Precast cement concrete	2
Stones	1.6-1.8
Concrete blocks	1.6
Bricks	1.4-1.6
Submerged plastic membrane	0.6-0.9

According to this consideration, no erosion-prone areas have been identified in the flood plain.

It is important to recognise that the river channel (the studied branch of the Cauquenes River that flows through the project area) is a natural channel that is constantly developing; however, it could be considered as a mature river, so the process of erosion and deposition is naturally balanced. Taking this into account should advise the need to intervene as little as possible in the river channel and the adjacent floodplain. The recommended non-intervention zone is 20 m from the centre of the channel for both the right and left banks.

6. CONCLUSIONS AND RECOMMENDATIONS

The projected solar plant comprises an area of 25.3 Ha and is located around 3.3 km southeast of Cauquenes commune, at the UTM projected coordinates 743932.00 mE and 6013597.00 mS, at 153 meters above sea level (masl).

The climate in the project area according to Köppen-Geiger is "Mediterranean", with the rainfall season in winter. The annual average rainfall is 732 mm.

According to the geotechnical information provided, silty clays may be found within the project site, while predominant land uses are croplands.

The site area is intercepted by one watercourse, identified in the study as a branch of the Cauquenes River.

The project site is also affected by "in situ" generated runoff water from a rainfall event. In general, runoff water flows in a southwest-northeast direction, following the natural slope and without causing water accumulation or retention issues. Thus, water concentrates in the main river channel.

Bearing in mind the velocity values obtained through the hydraulic simulations, considering the existing soil within the project site and consulting FAO's criteria of maximum admissible average velocities, no erosion issues might be expected on the floodplain, in most parts of the project area.

However, some water control and risk mitigation actions are recommended:

- To even the ground in those areas where sinks/hollows are present.
- To designate a 20-metre buffer zone from the centre of the channel to both banks of the river.

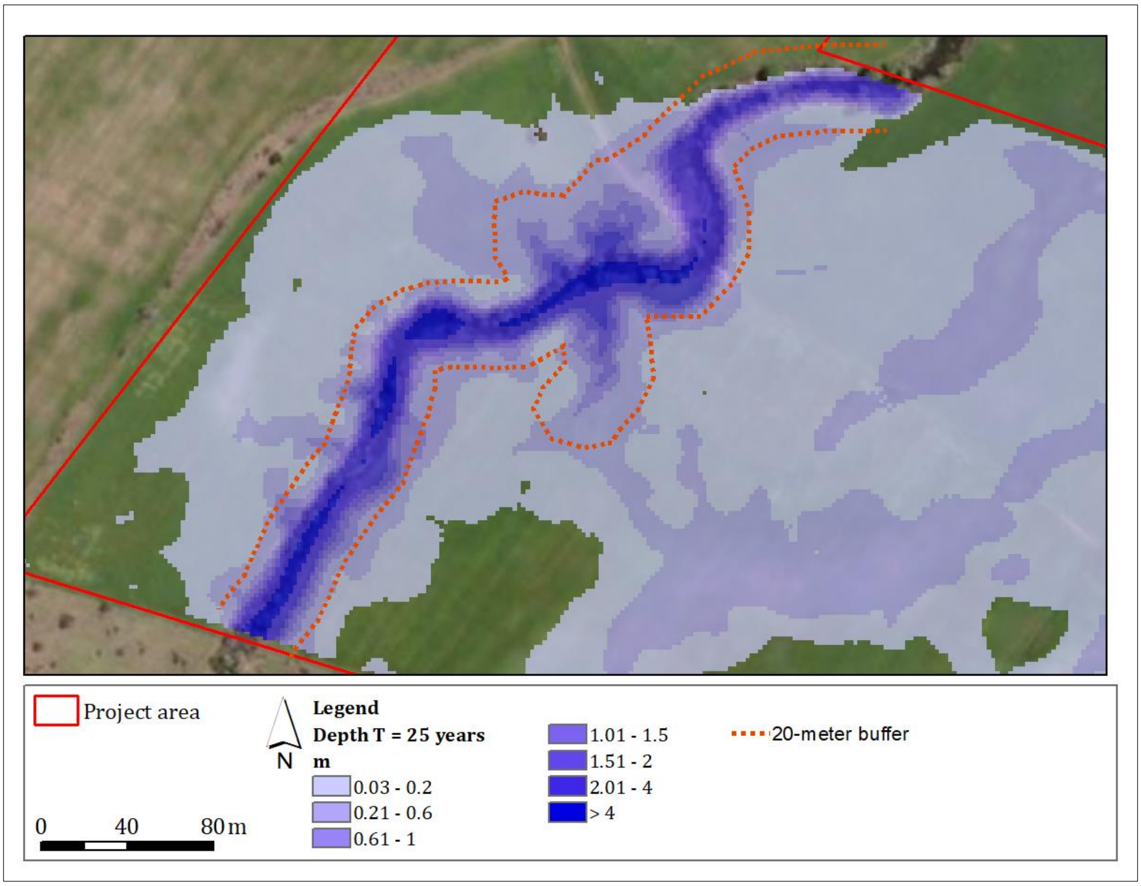


Figure 20. Recommended 20-meters buffer.

7. Final notes

The conclusions and recommendations reached in this report consider currently existing conditions (available topography, land uses, soil type, soil morphology, etc.) as provided by the Client. Any changes in the topography and layout conditions, as well as in the land use, or any changes in any miscellaneous factor affecting this study, may yield substantial changes in the conclusions and recommendations herein.

8. ADDITIONAL NOTES

I. This hydrological report has been prepared by GMS Internacional, SL for the exclusive use of Trina Solar and their design team for specific application to the proposed project;

II. The work on the project has been carried out in accordance with reasonable and acceptable engineering practices. No other warranty, either written or implied, is applicable to this project.

III. The results, conclusions and recommendations in this report are based solely on the information available at the time this report was prepared.

IV. In the event that the location or design of the structures is altered, the conclusions and recommendations presented herein should not be considered valid unless GMS Internacional, SL has been given the opportunity to review the changes.

V. It is strongly recommended that GMS Internacional, SL is provided with a topographic survey in order to carry out a detailed flood risk investigation. If GMS Internacional, SL is not accorded the privilege of making this review, we can assume no responsibility for misinterpretation of our recommendations;

VI. In the event that a third-party company performs additional investigation, GMS Internacional can assume no responsibility in the outcome nor in the use of such results by the client;

VII. The use of information contained in this report should be done at the client's option and risk.

VIII. This report including its conclusions, recommendations and findings should be related to the terms and conditions and the scope of works agreed between the Consultant and the Client. Words PRELIMINARY or DRAFT written on any page throughout the report means that the information contained thereof shall NOT be considered for construction design.

IX. Conclusions and Recommendations sections of this report should not be specifically relied upon out of the content of the whole report and particularly of the context and the development, if any, proposed.

X. Any special conditions appertaining to the site which have not been revealed by the abovementioned investigation may therefore have not been considered in the report. The assessment may be subject to amendment in the light of additional information becoming available. Any amendments shall be issued after the Client has accepted the initial version. This Consultant will inform the Client about any version released after the initial report has been accepted.

XI. Any recommendations and interpretations contained in this report represent the consultant's opinion only. This opinion has been arrived at in accordance with currently accepted hydrological and hydraulic best practices at the time of reporting and based on current legislation in force at that time.

XII. Where the data available from previous site investigation reports, supplied by the Client, have been used, it has been assumed that the information is correct. No responsibility can be accepted by the Consultant for inaccuracies within the data supplied.

XIII. Comments on groundwater conditions are based on observations made at the time of the investigation unless otherwise stated. It must be born in mind that groundwater levels vary due to seasonal or other effects.

XIV. The copyright in this report and other plans and documents prepared by the Consultant is owned by him and no such report, plan or document may be reproduced, published or adapted without his written consent. Complete copies of this report may, however, be made and distributed by the Client as an expedient in dealing with matters related to its commission.

XV. Editable versions of these document (i.e. .doc format) would not have legal validity.

XVI. This report is prepared and written in the context of the proposals stated in the introduction to this report and should not be used in a different context. Furthermore, new information, improved practices and legislation may necessitate an alteration to the report in whole or in part after its submission. Therefore, with any change in circumstances or after the expiry of one year from the date of the report, the report should be referred to the Consultant for re-assessment and, if necessary, re-appraisal.

9. REFERENCES

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HYDROLOGICAL-HYDRAULIC ASSESSMENT, PV LA VENDIMIA SOLAR PROJECT, MAULE REGION (CHILE)

ANNEX I: PRECIPITATION DATA AND TIME SERIES ANALYSIS

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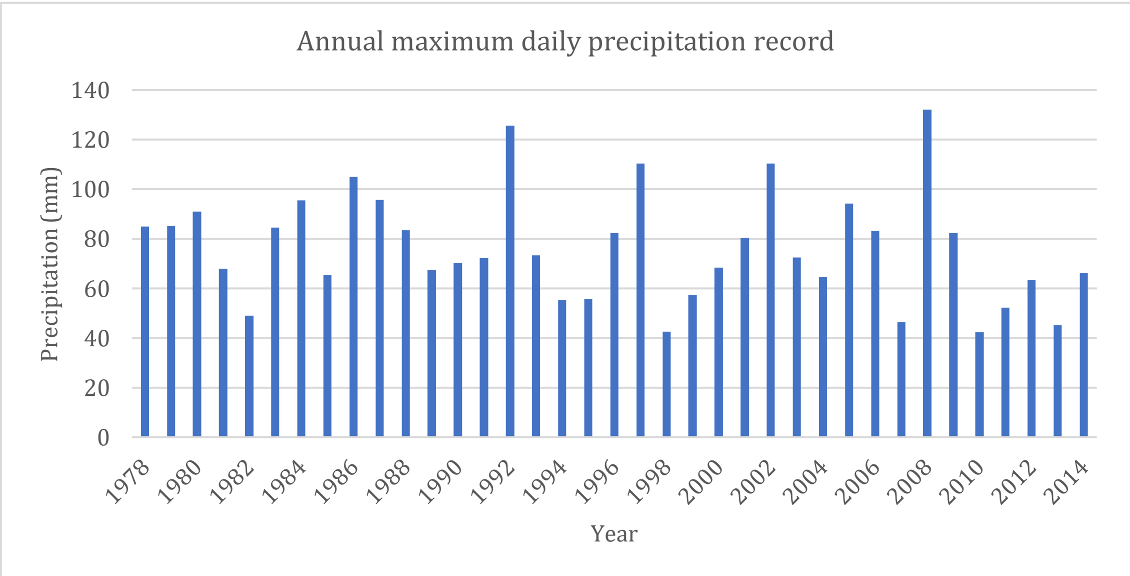
1. METEOROLOGICAL STATIONS NEARBY

Name	Province	Region	Easting (m)	Northing (m)	Altitude (masl)	Distance to the site (km)
Tutuven Embalse	Cauquenes	Maule	736458	6024380	173	12.7

2. PRECIPITATION DATA

Tutuven Embalse meteorological station record

Year	Precipitation (mm)		
1978	85	**1997**	110.4
1979	85.2	**1998**	42.5
1980	90.9	**1999**	57.3
1981	68	**2000**	68.3
1982	49	**2001**	80.4
1983	84.5	**2002**	110.4
1984	95.4	**2003**	72.4
1985	65.3	**2004**	64.5
1986	105	**2005**	94.3
1987	95.6	**2006**	83.2
1988	83.4	**2007**	46.4
1989	67.5	**2008**	132
1990	70.4	**2009**	82.4
1991	72.3	**2010**	42.3
1992	125.6	**2011**	52.3
1993	73.4	**2012**	63.4
1994	55.3	**2013**	45
1995	55.6	**2014**	66.2
1996	82.4		



3. RAINFALL ADJUSTMENT THROUGH PROBABILISTIC FUNCTIONS

One of the most important aspects of rainfall-runoff models is the obtention of a design storm representative of future probabilistic events associated with a certain rainfall record from the past. This procedure is known as frequency analysis.

Many processes in Hydrology must be analyzed and explained based on probabilistic science, due to its inherent randomness. Therefore, it is not possible to predict an avenue or precipitation based solely on a determinative basis. Fortunately, statistical methods allow presenting, organizing and reducing data to facilitate its interpretation and evaluation.

This part of the work presents the maximum annual flows quantified and presented with continuous probability distributions. The historical records of the rainfall stations have been adjusted with three existing probability distributions:

Exponential distribution with two parameters.

Two parameters gamma distribution.

Extreme Values General Distribution (Gumbel).

It must be remembered that a random variable is the one that cannot be predicted with certainty when performing an experiment and its behavior is described by its law of probabilities, which is specified by its probability density function f (x), or by its accumulated density function F (x) that represents the area under the curve of the density function, representing the probability of occurrence of the event.

a) Exponential distribution with two parameters

The exponential distribution function is defined as:

$$F(x) = \int_0^x (1 - e^{-\beta x}) dx$$

And the probability density function is:

$$f(x) = \beta e^{-\beta x}$$

Where β is known as scale parameter.

The estimation of the scale parameter through the moment's method will be done through the following equation:

$$\beta = \frac{1}{\hat{x}}$$

Where x is the sample average, that will be calculated through the following expression:

$$\hat{x}=\sum_{i=1}^{n}\frac{x_i}{n}$$

The equation to determine the calculated flows through the sample with the Exponential is:

$$Qcalc.=\frac{Ln\left(\frac{1}{T}\right)}{-\beta}$$

Where T is the return period in years and Q_{calc} is the given calculated peak flow.

b) Extreme Values General Distribution (Gumbel)

Suppose we have N samples, each of which contains n events. If the maximum x of the n events of each sample is selected, it is possible to show that, as n increases, the probability distribution function of x tends to:

$$F(x)=\int_{0}^{x}e^{-e^{-\alpha(x-\beta)}}dx$$

The probability density function is then:

$$f(x)=\alpha e\left[-\alpha(x-\beta)-e^{-\alpha(x-\beta)}\right]$$

Where *y* are the parameters of scale *y* form of the function and are estimated by the method of moments like = 0.78 and = -0.5772, where *x* represents the average of the sample and *s* is the standard deviation that will be calculated with the following equation:

$$s=\sqrt{\frac{\sum_{i=1}^{n}(x_i-\hat{x})}{n-1}}$$

The equation to determine the flows through the Gumbel Distribution is:

$$x=Qcalc=\beta-\alpha\left[\ln\left(\ln\frac{T}{T-1}\right)\right]$$

c) Two Parameters Gamma Distribution

The probability distribution function is:

$$F(x) = \int_0^x \left[\frac{x^{\beta-1} e^{\left(\frac{-x}{a}\right)}}{\alpha^{\beta}\Gamma(\beta)} \right] dx$$

The Two Parameters Gamma Probability density function is defined as:

$$f(x) = \frac{x^{(\beta-1)} e^{\left(\frac{-x}{a}\right)}}{\alpha^{\beta}\Gamma(\beta)}$$

Where β y α are the scale and shape parameters of the function and $\Gamma(\beta)$ is the Gamma function. The parameters β and α are evaluated by the moment criteria through the next equations:

$$\alpha = \frac{s^2}{\hat{x}}$$

$$\beta = \left(\frac{\hat{x}}{s} \right)^2$$

Where x and s are the average and standard deviation of the data.

To obtain the design events for different return periods, the Gamma distribution can be obtained in an approximate way using the standardized variable z of the normal distribution through the following approximation equation:

$$Qcalc = (\alpha)(\beta)\left[1 - \frac{1}{9\beta} + z\sqrt{\frac{1}{9\beta}}\right]^3$$

d) Minimum Squared Error Method

It consists in calculating the squared error for each distribution function, such as:

$$E = \left[\sum_{i=1}^{n} (Qci - Qmi)^2 \right]^{\frac{1}{2}}$$

Where Q_{ci} is the i-th slot data calculated with the probability distribution Q_{mi} is the i-th slot data of the hydrometric record in question and E is the minimum squared error.

The function of probability of greater adjustment to the hydrometric record will then be that which meets an E value close to zero. The calculation procedure to correlate a sample to a probability distribution is the one that follows below:

- Get the values of the sample.
- Sort the expenses of the sample from highest to lowest (Since the objective is to determine maximum expenses).
- Calculate the return periods for each year of registration through the equation.
- Calculate the maximum expense according to the distribution of probabilities chosen.
- Determine squared errors, based on the differences between calculated and measured expense.
- Finally, evaluate the sum of squared errors.

3.1. TUTUVEN EMBALSE STATION

3.1.1. Gumbel distribution function

Years	Maximum Daily Precipitation (mm.)	Maximum Daily Precip. Sorted (mm.)	Sort Nº	T	(xi-x)^2	Maximum Daily Precip. Calculated (mm.)	Error
1978	85.0	132.0	1	38.0	3101.29	136.94	24.38
1979	85.2	125.6	2	19.0	2429.42	123.04	6.57
1980	90.9	110.4	3	12.7	1162.07	114.79	19.26
1981	68.0	110.4	4	9.5	1162.07	108.85	2.40
1982	49.0	105.0	5	7.6	823.07	104.17	0.68
1983	84.5	95.6	6	6.3	372.07	100.29	22.03
1984	95.4	95.4	7	5.4	364.40	96.96	2.43
1985	65.3	94.3	8	4.8	323.61	94.02	0.08
1986	105.0	90.9	9	4.2	212.84	91.39	0.24
1987	95.6	85.2	10	3.8	79.02	88.99	14.33
1988	83.4	85.0	11	3.5	75.50	86.77	3.14
1989	67.5	84.5	12	3.2	67.06	84.71	0.05
1990	70.4	83.4	13	2.9	50.26	82.78	0.39
1991	72.3	83.2	14	2.7	47.46	80.95	5.07
1992	125.6	82.4	15	2.5	37.08	79.21	10.20
1993	73.4	82.4	16	2.4	37.08	77.54	23.64
1994	55.3	80.4	17	2.2	16.72	75.93	19.97
1995	55.6	73.4	18	2.1	8.47	74.38	0.95
1996	82.4	72.4	19	2.0	15.29	72.86	0.22
1997	110.4	72.3	20	1.9	16.09	71.39	0.83
1998	42.5	70.4	21	1.8	34.94	69.94	0.21
1999	57.3	68.3	22	1.7	64.17	68.51	0.04
2000	68.3	68.0	23	1.7	69.07	67.09	0.82
2001	80.4	67.5	24	1.6	77.63	65.69	3.29
2002	110.4	66.2	25	1.5	102.23	64.28	3.70
2003	72.4	65.3	26	1.5	121.24	62.86	5.95
2004	64.5	64.5	27	1.4	139.50	61.43	9.42
2005	94.3	63.4	28	1.4	166.69	59.97	11.74
2006	83.2	57.3	29	1.3	361.41	58.48	1.39
2007	46.4	55.6	30	1.3	428.94	56.93	1.78
2008	132.0	55.3	31	1.2	441.45	55.32	0.00
2009	82.4	52.3	32	1.2	576.52	53.60	1.69
2010	42.3	49.0	33	1.2	745.88	51.75	7.56
2011	52.3	46.4	34	1.1	894.66	49.70	10.86
2012	63.4	45.0	35	1.1	980.37	47.33	5.43
2013	45.0	42.5	36	1.1	1143.17	44.42	3.67
2014	66.2	42.3	37	1.0	1156.74	40.26	4.17
				Sum	**17905.48**	**Average error**	**6.18**
	Average pp. (mm.)	76.31					
	Beta	65.66		**T**	**1/T**	**Max. daily pp. (mm.)**	
	Av. Error	6.18		5	0.2	95.16	
				10	0.1	109.92	
				25	0.04	128.56	
				50	0.02	142.40	
				100	0.01	156.13	
				200	0.005	169.81	
				500	0.002	187.86	

3.1.2. Gamma 2P distribution function

Years	**Maximum Daily Precipitation (mm)**	**Maximum Daily Precipitation sorted (mm)**	**Sort Nº**	**(xi - x)^2**	**T**	**F(Precip.)**	**w**	**z**	**Maximum Daily Precipitation calculated (mm)**	**Error**
1978	85.0	132.0	1	3101.29	38.00	0.95	2.70	1.94	125.17	46.64
1979	85.2	125.6	2	2429.42	19.00	0.93	2.43	1.62	115.56	100.82
1980	90.9	110.4	3	1162.07	12.67	0.87	2.25	1.41	109.56	0.71
1981	68.0	110.4	4	1162.07	9.50	0.87	2.12	1.25	105.07	28.38
1982	49.0	105.0	5	823.07	7.60	0.84	2.01	1.12	101.44	12.69
1983	84.5	95.6	6	372.07	6.33	0.77	1.92	1.00	98.34	7.53
1984	95.4	95.4	7	364.40	5.43	0.76	1.84	0.90	95.63	0.05
1985	65.3	94.3	8	323.61	4.75	0.75	1.77	0.80	93.19	1.23
1986	105.0	90.9	9	212.84	4.22	0.72	1.70	0.72	90.96	0.00
1987	95.6	85.2	10	79.02	3.80	0.66	1.63	0.63	88.90	13.67
1988	83.4	85.0	11	75.50	3.45	0.66	1.57	0.55	86.97	3.87
1989	67.5	84.5	12	67.06	3.17	0.65	1.52	0.48	85.14	0.41
1990	70.4	83.4	13	50.26	2.92	0.64	1.46	0.41	83.41	0.00
1991	72.3	83.2	14	47.46	2.71	0.64	1.41	0.34	81.75	2.11
1992	125.6	82.4	15	37.08	2.53	0.63	1.36	0.27	80.15	5.08
1993	73.4	82.4	16	37.08	2.38	0.63	1.32	0.20	78.59	14.48
1994	55.3	80.4	17	16.72	2.24	0.60	1.27	0.13	77.09	10.99
1995	55.6	73.4	18	8.47	2.11	0.51	1.22	0.07	75.61	4.88
1996	82.4	72.4	19	15.29	2.00	0.50	1.18	0.00	74.16	3.09
1997	110.4	72.3	20	16.09	1.90	0.50	1.13	-0.07	72.73	0.18
1998	42.5	70.4	21	34.94	1.81	0.47	1.09	-0.13	71.31	0.83
1999	57.3	68.3	22	64.17	1.73	0.44	1.05	-0.20	69.90	2.57
2000	68.3	68.0	23	69.07	1.65	0.44	1.00	-0.27	68.50	0.25
2001	80.4	67.5	24	77.63	1.58	0.43	0.96	-0.33	67.09	0.17
2002	110.4	66.2	25	102.23	1.52	0.41	0.92	-0.40	65.67	0.28
2003	72.4	65.3	26	121.24	1.46	0.40	0.87	-0.48	64.23	1.15
2004	64.5	64.5	27	139.50	1.41	0.39	0.83	-0.55	62.77	3.00
2005	94.3	63.4	28	166.69	1.36	0.37	0.78	-0.63	61.27	4.54
2006	83.2	57.3	29	361.41	1.31	0.29	0.74	-0.71	59.73	5.89
2007	46.4	55.6	30	428.94	1.27	0.26	0.69	-0.79	58.12	6.37
2008	132.0	55.3	31	441.45	1.23	0.26	0.64	-0.88	56.45	1.31
2009	82.4	52.3	32	576.52	1.19	0.22	0.59	-0.98	54.66	5.59
2010	42.3	49.0	33	745.88	1.15	0.18	0.53	-1.09	52.75	14.03
2011	52.3	46.4	34	894.66	1.12	0.15	0.47	-1.21	50.64	17.94
2012	63.4	45.0	35	980.37	1.09	0.13	0.41	-1.36	48.24	10.51
2013	45.0	42.5	36	1143.17	1.06	0.11	0.33	-1.54	45.38	8.31
2014	66.2	42.3	37	1156.74	1.03	0.11	0.23	-1.78	41.58	0.52
			Sum	17905.48					**Average error**	**9.19**
						T	**w**	**z**	**Max. daily pp. (mm.)**	
	Average (mm.)	76.31				5	1.7941	0.8415	94.14	
	Beta	11.71				10	2.1460	1.2817	105.89	
	Av. error	9.19				25	2.5373	1.7511	119.45	
						50	2.7971	2.0542	128.80	
						100	3.0349	2.3268	137.61	
						200	3.2552	2.5762	146.02	
						500	3.5255	2.8785	156.66	

4. DISTRIBUTION FUNCTIONS SUMMARY PER STATIONS

4.1. Linares station

TR (years)	Gamma	Gumbel	Maximum accumulated precipitations in 1 day (DGA)
5	94.14	95.16	-
10	105.89	109.92	>100.00
25	119.45	128.56	-
50	128.80	142.40	-
100	137.61	156.13	-
200	146.02	169.81	-
500	156.66	187.86	-
Error	9.19	6.18	-
Adjustment (%)	99.5%	99.9%	-

HYDROLOGICAL-HYDRAULIC ASSESSMENT, PV LA VENDIMIA SOLAR PROJECT, MAULE REGION (CHILE)

ANNEX II: DESIGN HYETOGRAPHS AND HYDROGRAPHS FOR THE SOIL CONSERVATION SERVICE-CURVE NUMBER METHOD (SCS-CN)

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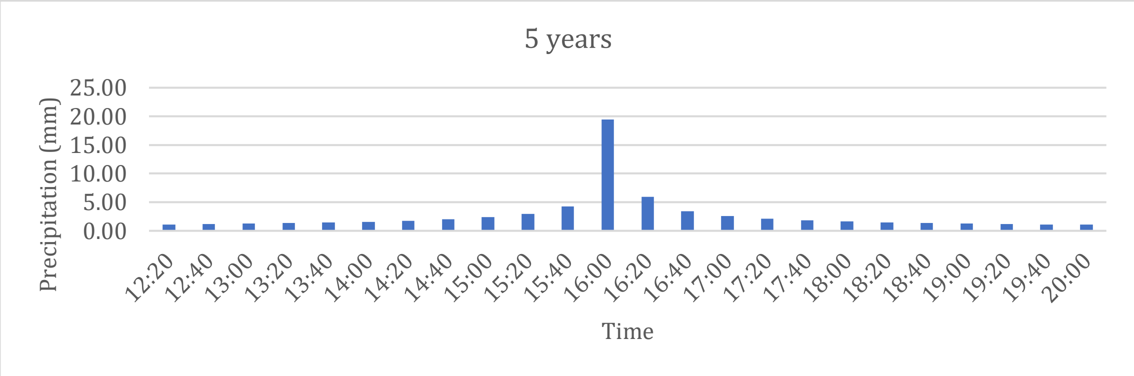
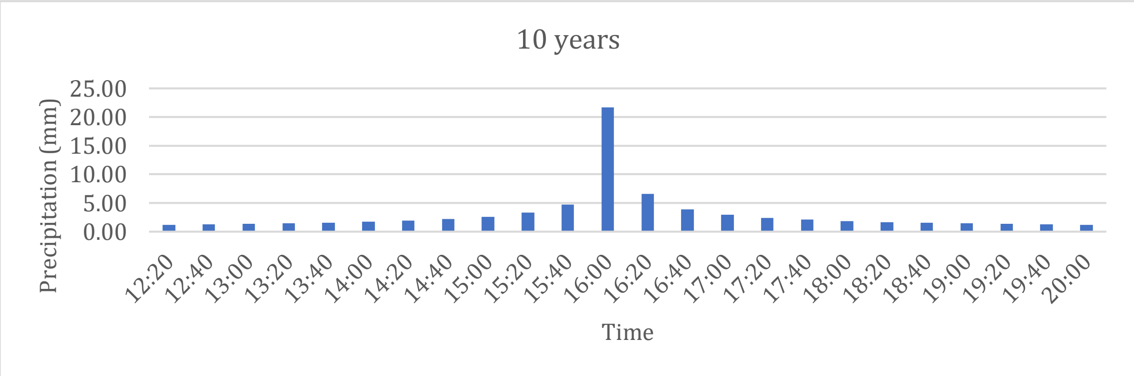
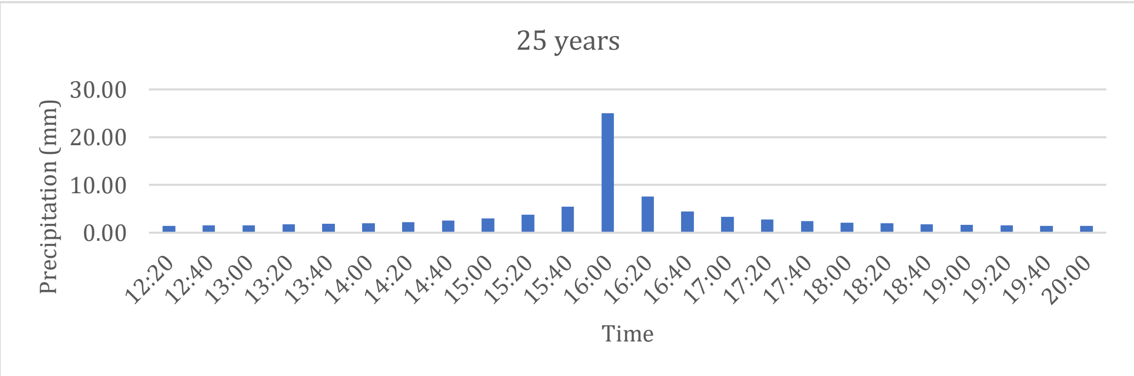
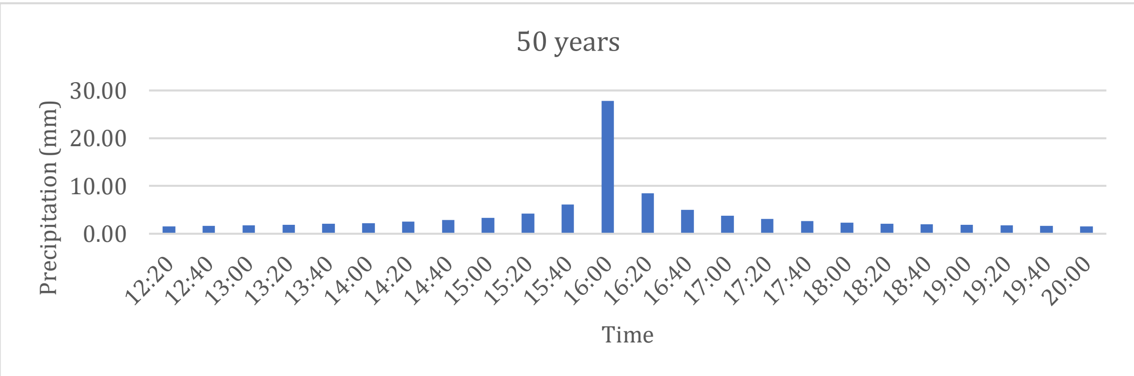
1. HYETOGRAPHS AND EXCESS RAINFALL FOR LINARES STATION

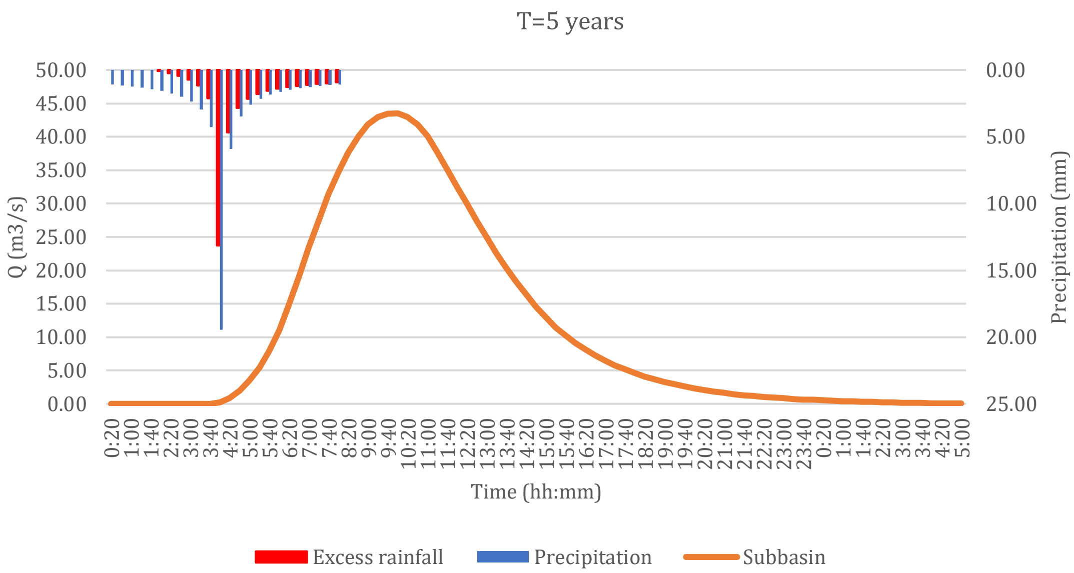


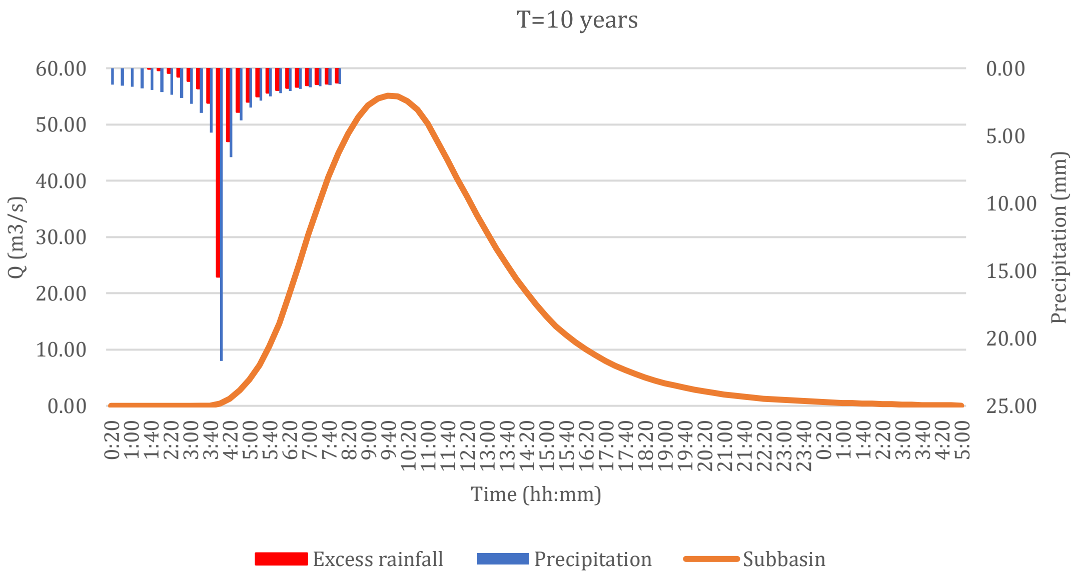


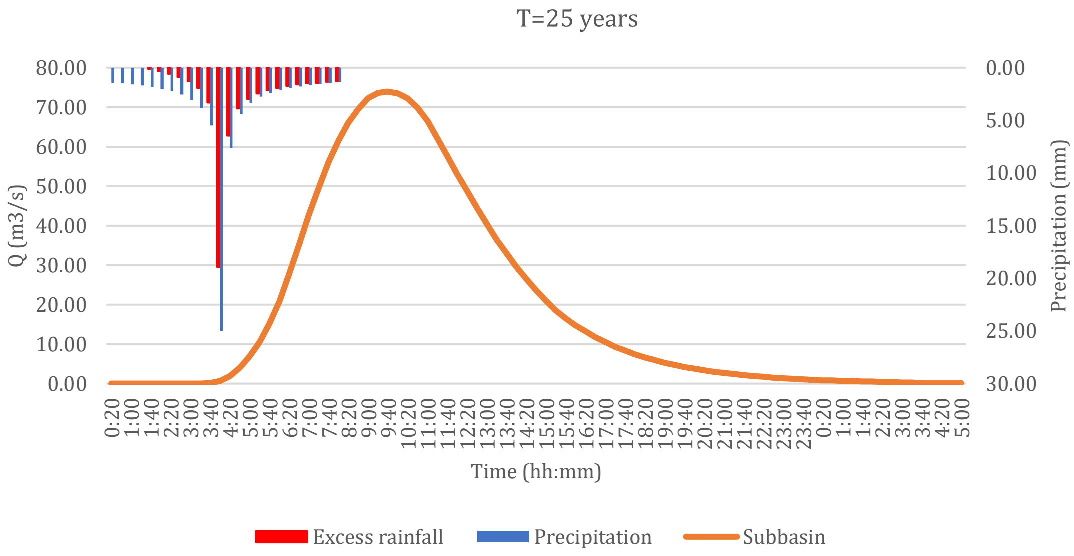


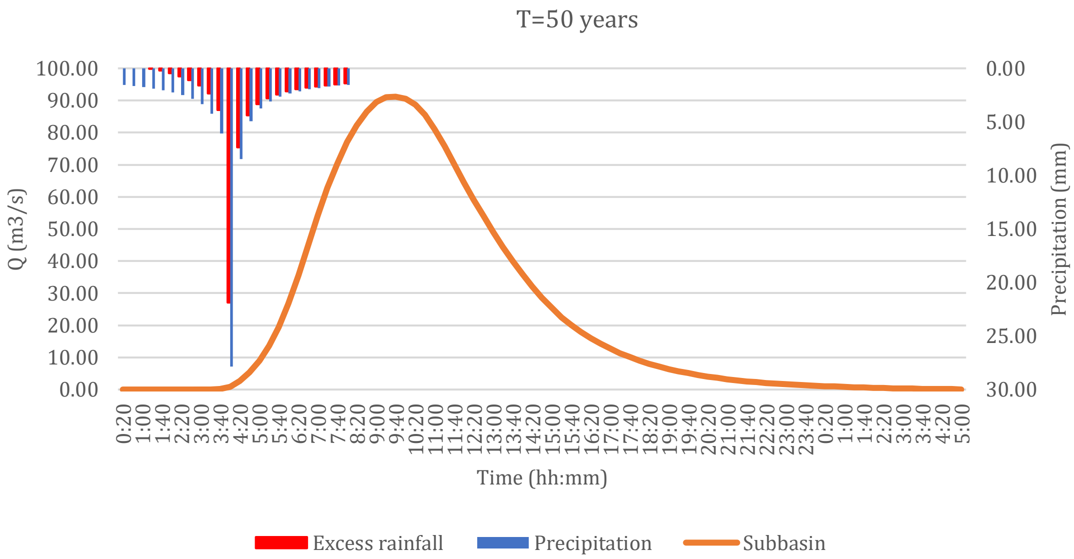


2. HYDROGRAPHS






T=25 years
Q (m3/s)
Precipitation (mm)
Time (hh:mm)
Excess rainfall
Precipitation
Subbasin


T=50 years
Q (m3/s)
Precipitation (mm)
Time (hh:mm)
Excess rainfall
Precipitation
Subbasin

HYDROLOGICAL-HYDRAULIC ASSESSMENT, PV LA VENDIMIA SOLAR PROJECT, MAULE REGION (CHILE)

ANNEX III: HEC-RAS 2D SOFTWARE METHODOLOGY

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Trinasolar

1. 2D FLOW MODELLING WITH HEC-RAS

HEC-RAS in its version 5.0 can perform not only 1D modelling but also 2D modelling and a combination 1D – 2D. These capabilities are described below:

a) 1D, 2D modelling:

The ability to run combined models allows the user to work in wide river systems, for example, you can use the 1D model on the riverbed and the 2D model on the areas adjacent to it, where greater detail hydraulic results are needed.

b) Saint-Venant and Wave Diffuse in 2D.

The program allows to choose between the equations of Saint-Venant or Diffuse Wave in 2D to carry out the modelling. In general, the Diffuse Wave equations in 2D allow software to process information quickly and has greater properties of stability.

c) Numeric scheme used: Implicit Finite Volume.

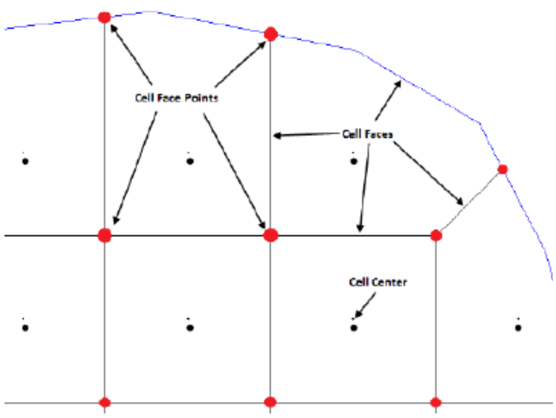
The finite volume method improves the stability and robustness on the techniques of finite differences and finite elements; it allows to perform realistic flow situations in Subcritical, Supercritical and Mixed regimes.

d) Solution algorithm for the coupling of 1D and 2D models.

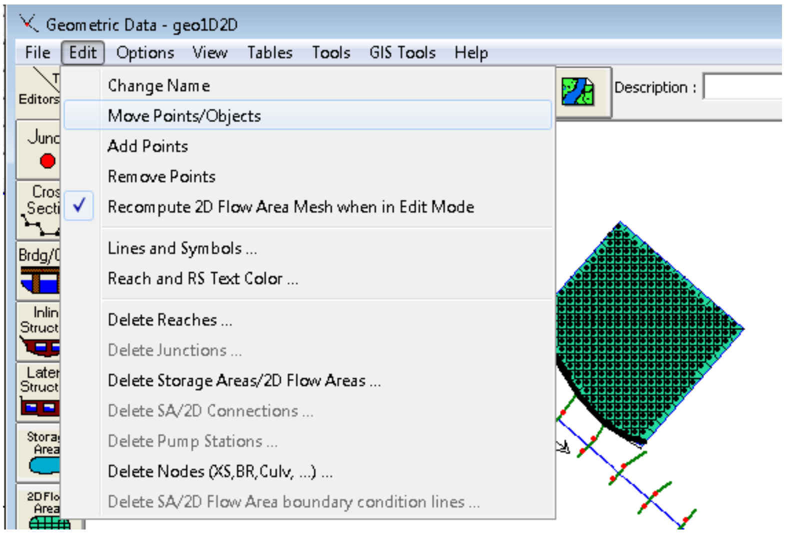
This algorithm allows direct feedback at each step of time between the 1D and 2D flow elements. For example, the case of the river modelled in 1D connects to any area (modelled in 2D) by some dam (lateral structure). If we consider that the flow moves above the dam, or because of the rupture of the dam, from model 1D to 2D, then the program uses the landfill equation to solve the computation of the flow. For each step of time, the landfill equation uses the results of the 1D and 2D models allowing the exact counting of the submerged landfill.

e) Structured and unstructured computational meshes.

HEC-RAS 5.0 was designed to work with unstructured meshes, but also can work with structured meshes. The computational cells of a certain mesh can be triangles, squares, rectangles or polygons up to 8 sides at most. The computational mesh does not need to be orthogonal, however if it were the numerical discretization is more simplified and efficient. The cell that makes up a computational mesh has the following properties: Cell Center, Cell Faces, and Cell Face Points



The generated mesh can be manipulated easily with tools offered by the software. This edition allows to move, add and remove points from the cells that are generate. When doing this, neighbouring cells will change automatically. This action is taken when there is the need to have more detail in certain areas.



HEC-RAS performs the computational meshing process following the Triangulation of Delaunay and then constructs a Voronoi diagram. The process is analogous to when the Thiessen polygon is constructed to attribute a basin area to a specific rain gauge.

Choosing mesh size is one of the important steps to consider. In general, a mesh that fits the terrain should be chosen and will control the movement of the flow. Changes in mesh size should be made gradually so as to improve the calculation accuracy.

f) Detailed table of hydraulic properties for cells and cell faces 2D computations

Each cell and cell face is pre-processed in order to obtain tables of hydraulic properties based on the underlying terrain used in the modelling. Basically, the pre-process calculates a detailed Elevation-Volume relationship for each cell; And for each cell face it calculates the Wet Elevation-Perimeter, Elevation-Area, Elevation-Roughness, and other hydraulic properties.

These relationships created by the program allow the user to create large computational cells preserving the details of the terrain; which is advantageous because it makes the calculation times faster, since it generates greater hydraulic details at the level of each cell. The choice of cell size is based on the level of detail you want to obtain.

g) Detailed flood maps and animations.

HEC-RAS, through its RAS Mapper tool, offers the possibility to visualize maps of flooded areas, as well as the animation of the water flow when the flood occurs. This process is based on the underlying ground and not on the computational cell size of the mesh generated.

h) Solution of the numerical scheme based on multiprocessors.

The solution obtained from the modelling, has been programmed to take advantage of the processors that the computer has, which allows it to run faster if we only used one.

i) 64-bit and 32-bit processors

HEC-RAS can now work on computers that have 32-bit and 64-bit processors, it being known that a 64-Bit processor will run faster than 32-Bit and can handle large amounts of data.

j) Limitations of 2D Modelling with HEC-RAS

- It provides little flexibility to add hydraulic structures within a 2D area
- It cannot run sediment transport simulation due to erosion or deposition within a 2D area.
- It is not possible to run water quality simulation within a 2D area.
- - Pumping stations cannot be connected within a 2D area.
- - The HEC-RAS bridging modelling capabilities cannot be used within a 2D area. Sewers, landfills, and ruptures can be modelled but using the SA/2D Area Conn tool.

k) The computational time step in 2D flow modeling with HEC-RAS

There is a need to choose a suitable computational time step that works well with the mesh. HEC-RAS 2D, refers to two ways to choose the value of this parameter. These are based on the Courant Number and will be applied as the Saint Venant equation or Diffuse Wave is used to solve the model, as shown in the following formulation.

l) Saint Venant equation:

$$C = \frac{V * \Delta T}{\Delta X} \leq 1.0$$

Maximum value of C =3.0

Where:

C = Courant Number

V = Flow velocity

ΔT = Computational time step

ΔX = Average Cell size

m) Diffuse Wave equation:

$$C = \frac{V * \Delta T}{\Delta X} \leq 2.0$$

Maximum value of C =5.0

The basic tasks, prior to modelling, that are developed in the RAS Mapper environment are:

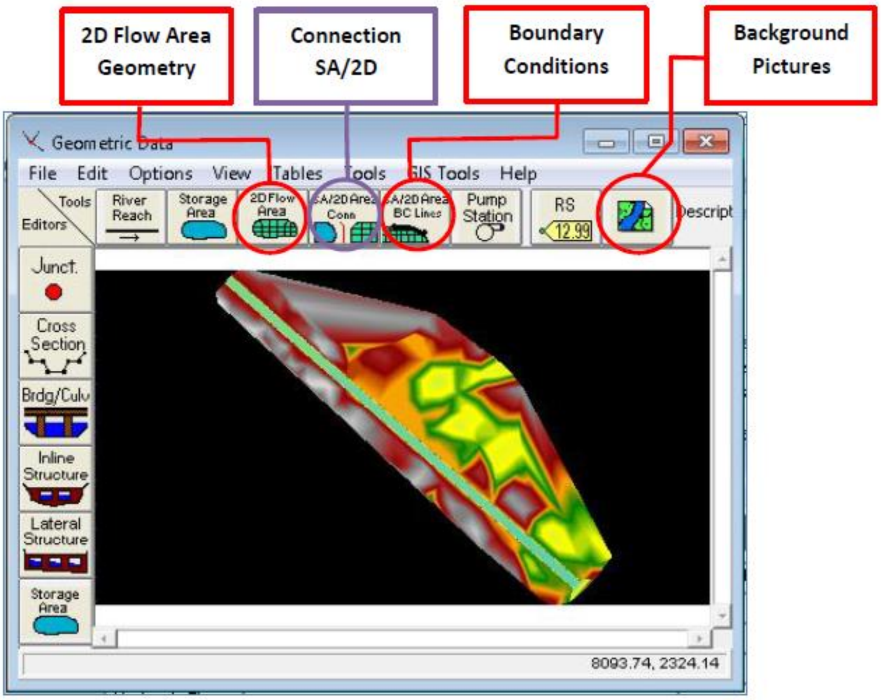
1. Define the work space reference system: The first task to start the two-dimensional modelling is the Georeferencing the model to work. This task is achieved in RAS Mapper, through of the Set Projection for Project tool. HEC-RAS 5.0, allows georeferencing the model, using extension files ".prj" (ESRI projection file), linked to the database containing the ArcGIS software as of version 10.0. You should enter the ArcGIS program files and choose the appropriate reference system.
2. Generate the digital terrain model: The formats recognized by the program are: Floating Grid Point (* .flt), GeoTIFF (* .tif), ESRI grid files, and others as USGS DEM file. Any of the formats chosen for modelling, will finally be converted into GeoTIFF format (* .tif), which will be compressed to allow less storage space and faster speed of computation when generating maps of flood. To achieve this purpose, you must choose the New Terrain option and then choose the file (* .tif) that contains the terrain digital model. One of the important things to know is that from the generated terrain, the program allows us to generate an image, which will be used as a background when we want to define the boundaries of the 2D zone, when entering the geometric data.
3. Generate polygons with land uses. Finally, to load information on land use, the New Land Classification tool must be used, this process is done by importing ShapeFile files created in ArcGIS. If you do not use this option, the program will default to the value that appears when generating the 2D mesh and will apply it over the entire surface of the terrain contained in the 2D mesh.

n) 2D geometry generation

The numerical scheme used in HEC-RAS 2D allows to generate a geometry of structured and unstructured meshes whose sides vary from 3 to 8 sides per mesh. The creation of the mesh is done from the tool Geometric Data, as it is designed to do for models in 1D. Briefly, the process consists of drawing a polygon enclosing the area to be evaluated, indicating the mesh size to be used in the modelling and finally drawing the edge where the boundary conditions will be imposed. The steps to generate the 2D geometry are explained below.

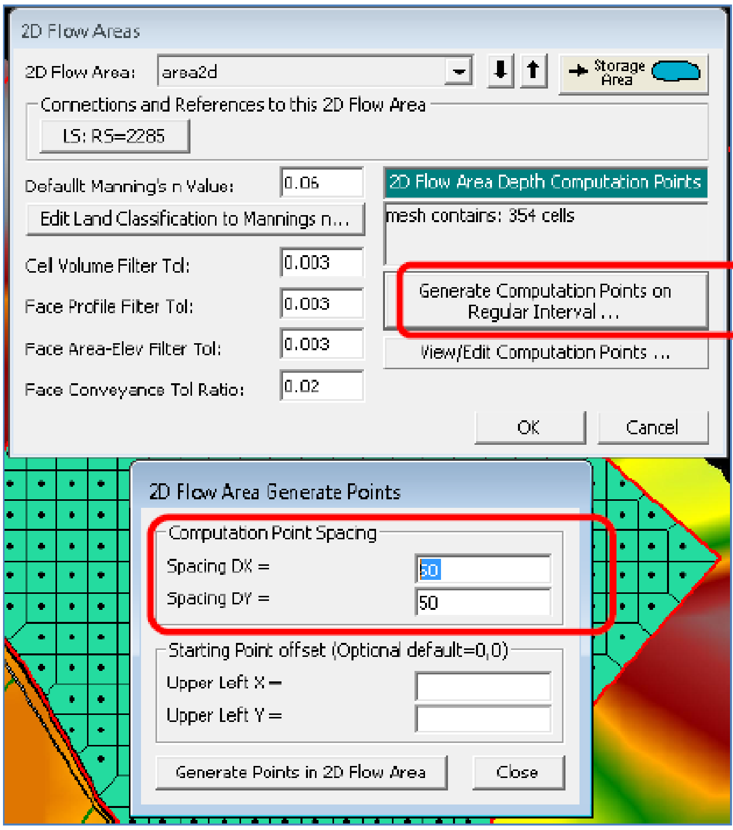
Inside the Geometric Data window, we must initially recognize three basic tools to generate the model in 2D.

- The first thing to do is to load the background image created in RAS Mapper; which as previously said will help us to delimit the area to be evaluated. This action is performed with the Background Pictures tool, which loads the figure Georeferenced, and therefore avoids generating inconsistencies when relating the 2D geometry to the digital terrain model.

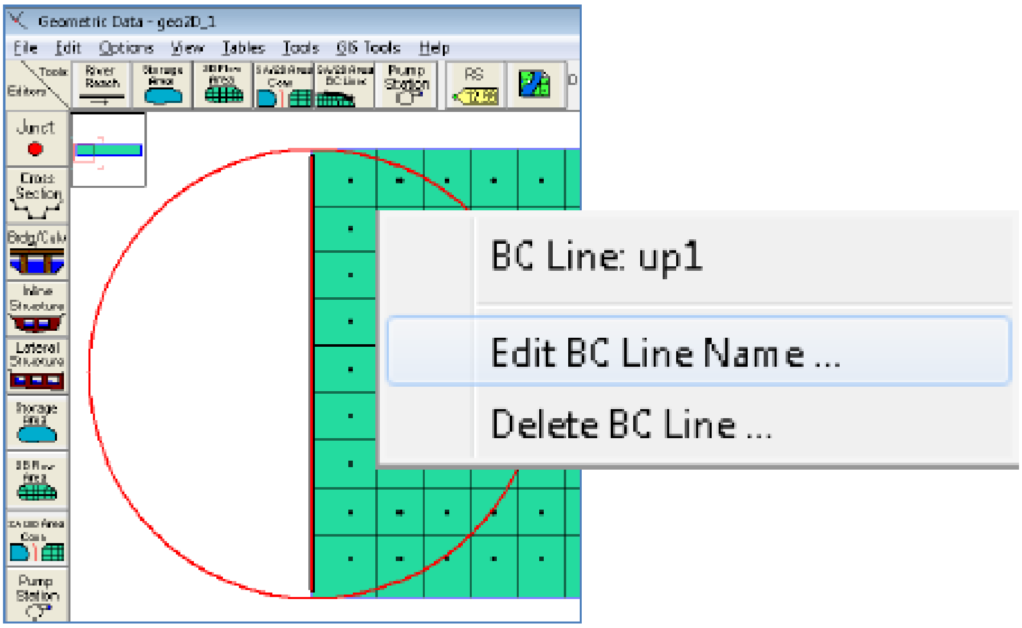


- The second step is to delimit the 2D area to be analyzed, using the 2D Flow Area Geometry tool when activated, the default pointer in the Windows environment becomes shape, indicating that you can start with the drawing of the polygon. At the end of the drawing, the created polygon will appear on the screen, which, when selected, displays a series of options, from which you have to choose Edit 2D Flow Area to set some tolerances for generating the 2D mesh, place a manning value that will assume the default program and specify the size of the mesh.

- HEC-RAS 2D, as we can see, begins the meshing process with structured meshes, which can be modified with the intention of adapting to the morphology of the terrain.



- The final step in the 2D meshing process is to indicate the location of the boundary conditions, which can be performed using the Boundary Conditions tool. In this stage, when selecting the option Edit BC Line Name, it will only ask for the name with which we want to designate the boundary condition; Since the way of entering the hydraulic data in the modelling, continues being the same one that uses HEC-RAS in its previous versions.



As we have seen the creation of 2D geometry turns out to be quite simple. However, it must be taken into account that in the process of generating and editing the mesh, problems can arise such as: cells that lack a center, cells containing more than one center, cells with two sides that coincide with the perimeter of the mesh, or that there are cells with more than 8 sides. These problems must be solved by adding or removing points that generate or subtract cells.

o) Execution of the 2D model

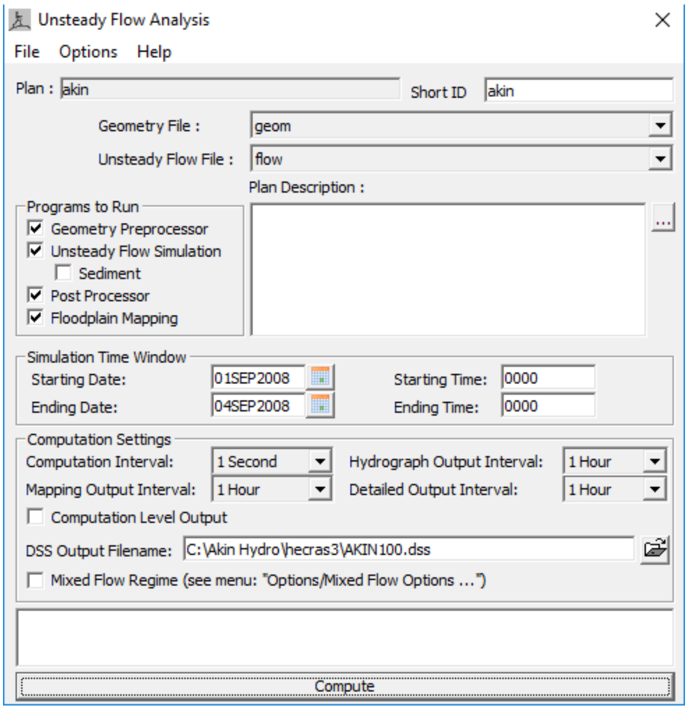
The execution of the 2D model requires a series of previous configurations, involving the establishment of calculation tolerances to obtain consistent results. Two of the most important parameters to configure are: the mesh size and the time step of calculation.

The mesh size (Δx) will allow the model to be appropriately adapted to the terrain and so that it can include all the obstructions present.

The time step of computation (Δt), is related to the Courant Number, which is obtained from the relation between space, velocity, and time; being known that mentioned relationship must be less than the unit.

The close relationship between the two parameters makes one appropriate time interval for it to work well with the elaborate mesh. It is thus that the user must test with different cell sizes (Δx) and also with different steps of calculation time (Δt) to be able to have good numerical precision and to minimize the calculation time. In the next chapter we can see the results obtained when modelling cases by varying these parameters.

Once the above recommendations have been made, the flow in non-permanent condition must be carried out. As in previous versions, a window appears from where we can create a processing plan, choose the geometry to process, and as the non-permanent flow data to be used in modelling. Version 5.0 of HEC-RAS, now includes the Floodplain Mapping option, whose purpose is to automate the process of calculating a flood map and to use them in other applications such as HEC-WAT. By default, this option is disabled. Then shows an image of the analysis window to define the flow processing in Non-permanent conditions.



p) Viewing Results

As a final part of the 2D flow analysis process, it is important to show the results obtained from the modelling, which can be visualized within the RAS Mapper environment.

In the graphical environment of RAS Mapper, we can see the results tab, from which the plans generated (if there were several of them), and for each plan we can see the type of results offered by the software, such as: Draft, Speed and Elevation.

For each of them, the program offers configuration options to customize your presentation, as well as the possibility of exporting the water stain as a shapefile for use in other software.

GEOTECHNICAL FINAL REPORT
LA VENDIMIA PV SOLAR PROJECT
CHILE

Project ID: IG1827115a
Client: Trina Solar
Consultant: GMS Internacional, SL

Edition	Date	Version	Revision Purpose	Written	Reviewed	Approved
1ª	08/12/2021	0	First version of the report	R. Rayo	JP Singer	JP Singer

GEOTECHNICAL FINAL REPORT

LA VENDIMIA PV SOLAR PROJECT, CHILE

Prepared by:

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December 08th, 2021

Trina Solar Holding

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Attn: Ms Julie Baudry

Email: julie.baudry@trinasolar.com

Re: Geotechnical Final Report, La Vendimia, Chile

GMS Internacional SL. has completed the Geotechnical Final Report of PV La Vendimia, Chile, for the project referenced above.

These services were performed in general accordance with the scope defined with the client and established in the document *P21_235_GMS_TRINA SOLAR_Vendimia_GHT_v1_BoQ'.*

This report presents the scope and results of the surface and subsurface exploration, presents results for shallow foundations design and general recommendations with regards to the foreseen civil engineering works to be performed on site.

We would like to express our gratitude in advance for the opportunity to be of service to Trina Solar on this project.

Please do not hesitate to contact us should you have any further questions regarding this report, or if we may be of further assistance.

GMS Internacional, SL

EXECUTIVE SUMMARY		
Chapter	***Summary***	***Section***
Site Address	The PV Project is located to approximately 4 km southeast from Cauquenes city, in the Maule Region, located in the central zone of Chile.	2
Site Setting and History	The project is about 25 Ha and it is located. The site is characterized by a relatively flat topography for agricultural use.	2
Geological Framework	The survey area presents Paleozoic and Cenozoic age rocks and Quaternary deposits. The project is located at Pleistocene-Holocene age deposits, which are basically alluvial, colluvial and mass removal deposits intercalated with volcanic deposits	3.3
Geomorphology	The site is situated within the central depression, which is characterized by a uniform topography from Andes Chain to Coastal Range. Its main lithological materials are alluvial, colluvial and fluvio-glacial deposits, intercalated with recent volcanic materials from the Quaternary period. The project site is located over and elongated depression with an average elevation of 135 masl. The potential hydrological risks are recommended to be evaluated in a Hydrological Report.	3.2
Seismic Conditions and liquefaction	According to official Chilean standard (NCh 433 Of.1996 modified in 2009), the peak ground acceleration for the site is 0.40·g m/s^2 for a return period of 475 years. These values are expected to produce seismically induced dynamic loads that may be critical. In addition, soil liquefaction is not expected to occur during a seismic event.	3.5
Field works undertaken	15 Trial Pits 15 Variable energy Dynamic Cone Penetrometer (Panda2) 5 Vertical Electrical Sounding (VES) 5 CBR testing in situ (Panda 2) 5 In situ Thermal resistivity tests (TR) 5Modified Proctor and CBR 15 Laboratory soil samples.	4

Ground Conditions Encountered	Four Geotechnical Units have been characterized: GU-01, GU-02, GU-03, GU-04. **GU-01**: TOPSOIL (Clayey SILT), unit weight 17 kN/m^3, N_{SPT} 5, internal friction angle 10°, undrain shear strength of 28 kN/m^2, effective cohesion of 25 kN/m^2 and elastic modulus of 8000 kN/m^2. **GU-02**: CLAY, unit weight 18 kN/m^3, N_{SPT} 8, internal friction angle 15°, undrain shear strength of 48 kN/m^2, effective cohesion of 40 kN/m^2 and elastic modulus of 8000 kN/m^2. **GU-03**: Sandy GRAVEL, unit weight 20 kN/m^3, N_{SPT} 18, internal friction angle 32°, undrain shear strength of 0 kN/m^2, effective cohesion of 0 kN/m^2 and elastic modulus of 39500 kN/m^2. **GU-04**: Silty SAND, unit weight 22 kN/m^3, N_{SPT} 26, internal friction angle 34°, undrain shear strength of 0 kN/m^2, effective cohesion of 0 kN/m^2 and elastic modulus of 48000 kN/m^2.	5.2
Geophysical tests	A total of 5 Vertical Electrical Soundings were performed across the site using the Wenner method. The resistivity results are rather disparate across the plot with values within the 0.84-329 Ohm·m range. Two main families may be distinguished, with slight differences in electrical resistivity mainly in the shallow layers, in addition to the depths at which the layers meet according to each data set. In general, the first behaviour is characterized by low electrical resistivity values from 8 to 68 Ohmm within the first meter, these values indicate the presence of clay materials in the upper part, while the second behaviour is characterized by having higher electrical resistivity values within the upper part, with values up to 329 Ohm · m corresponding to fine materials and gravels with low humidity. In terms of corrosion, low resistivity values produce high corrosivity grade.	4.4
Geotechnical Appraisal	<u>Shallow foundations:</u> The shallow foundation analysis was performed. Based on the present analysis the **soil may have sufficient capacity to support the loads assumed herein** as long as the recommendations are followed. With regards to the construction of the shallow foundations, the following recommendations were drawn:	5

	- Construct the shallow foundation below the topsoil level and removal of topsoil layer (GU-01) before the foundation installation as it may have a high-water content and low compactness. - Levelling and removal of all debris prior to the foundation installation, to ensure eccentric loads are not acting in the foundation. - It is not recommended to build the substation and / or additional buildings in the GZ-B, due to the larger thickness of the GU-02 clay layer. - Compact a coarse well-graded gravel bed and/or install a geotextile below the foundation to prevent pore pressure build-up and reduce the possible settlement effects. <u>Pile rammability analysis:</u> The rammability analysis of the site was performed based on the geotechnical data gathered on site. After a detailed analysis of the data, it is concluded that **the direct ramming of piles may be expected to be feasible at 1.5m depth across the site** and therefore, **predrilling may not be required. Due to the presence of gravels at shallow depth, shallow depth refusals might be possible**, mainly in the northern zone, where the presence of gravel layers is more frequent. **Due to that variability, it is highly recommended to carry out a pull-out test campaign** to fully characterize pile behaviour across the site. <u>Slope stability:</u> A general slope stability assessment of the site was carried out. The analysis included the assessment of 3 different slope heights using the limit equilibrium method. Stable slopes were calculated to be from **1H/5V** to **4H/5V** for temporary conditions, and from **1H/5V** to **4H/3V** for long-term conditions, for slopes from 1m to 3m.	
Road materials	The study area has a laboratory **CBR value ranging from 12% to 14.87%** for CBR Zone 1. CBR Zone 2 it shows values of **25.13%.** The topsoil layer must be removed. The subgrade surface modulus of the soil was estimated based on the measured CBR laboratory value. According to international guidelines (Highways England, 2009), the estimated subgrade surface modulus (E) of the soil for CBR values of 12% and 25% are E= 70MPa, 103MPa respectively.	6

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Soil Corrosivity Assessment	Aggressivity to concrete Based on the results of the Baumann-Gully test, as well as sulphate (SO_4) tests for this project, we concluded that **no soil may not be aggressive against concrete structures.** Aggressivity to metal piles In general, according to NACE- RP-5002 and AWWA C-105 standards soil corrosion ranges from **low to very corrosive.** It is therefore recommended to conduct a wider soil corrosion survey in accordance with DIN 50929 standard, which uses a broader set of chemical tests to determine the degree of soil corrosion more accurately.	7
This summary should be read in conjunction with the following final report		

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CONTENTS

FIGURES

TABLES

ANNEXES

1. INTRODUCTION

1.1. *Project background*

GMS Internacional, SL (hereinafter referred to as the Consultant) has been appointed by Trina Solar (hereinafter referred to as the Client) to carry out a Geotechnical survey for the La Vendimia PV Project.

The location tests were performed according to the plot accessibility and the Trina Solar Staff indications.

The survey area location is shown in **Figure 1**.

Following this, the study goals and features of the project and site were identified and shown, and the field tests were then described. Based on these field tests, a final report was published, listing the results obtained in relation to the 'La Vendimia' project.

1.2. *Goals of the geotechnical investigation*

The objective of the fieldwork activities is the geotechnical characterization of the subsoil conditions encountered on the La Vendimia PV solar project, in order to provide the information for the geotechnical design of the foundations needed for the different structures required by the project.

1.3. *Scope of works*

The geotechnical survey and all of the performed tests have resulted in a final report, which contains the following information:

a) Description of the geological and geomorphological features as well as the natural risks for the site.

b) 15 trial pits (TP) to 3.0 m maximum depth or refusal. The trial pits have been logged by the site's workers, including a photographic record.

c) 15 Variable energy Dynamic Cone Penetrometer (Panda2) tests to a 3.0 m maximum depth or refusal, for the purpose of collecting geotechnical information of the soil strength below the site upon which the foundations will be laid, and also recognizing any variation with respect to the soil strength in the project area.

d) 5 Vertical Electrical Soundings (VES) for the purpose of supporting in the underground electrical wiring design.

e) 5 California Bearing Ratio tests in situ (CBR).

f) 5 Thermal resistivity tests in situ (TR).

g) 5 Modified Proctor and CBR.

h) 15 samples to carry out physical and chemical characterization tests.

i) A final geotechnical report including field data analysis, geotechnical assessment on PV foundations and recommendations and rammability assessment.

1.4. *Alterations*

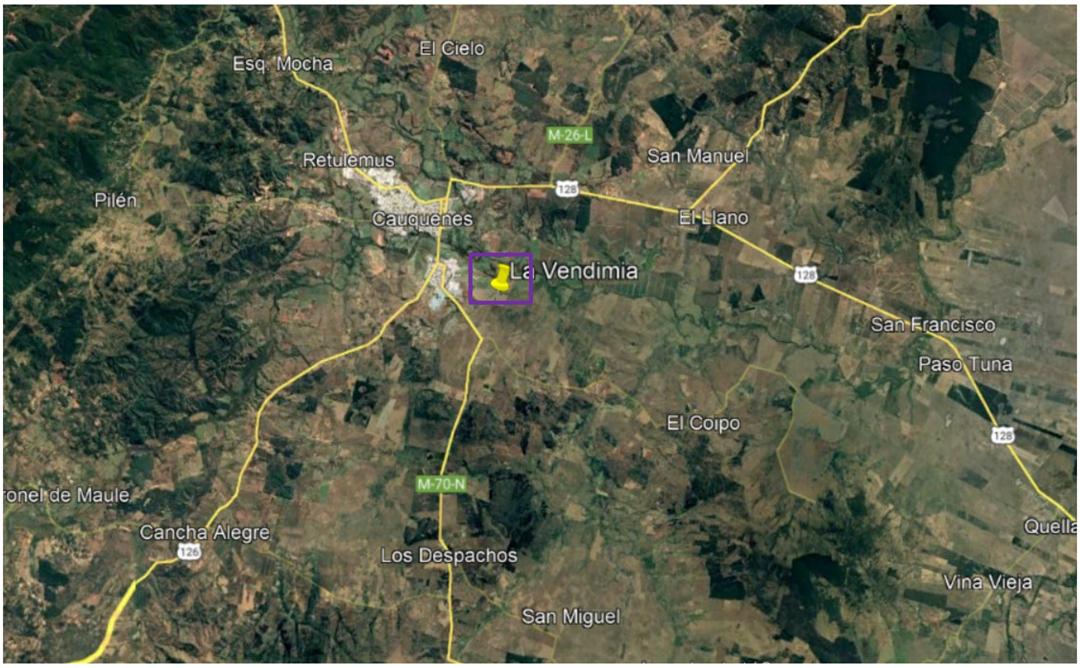
The fieldworks, laboratory and geotechnical analysis satisfied the initial specifications established in the scope agreed with Trina Solar in '*P21_235_GMS_TRINA SOLAR_Vendimia_GHT_v1_BoQ'* file.

It should be noted that the field test locations were carried out based on the accessibility for every point and the indications by the technical staff of Trina Solar.

2. LOCATION AND SITE DESCRIPTION

The survey site is located to the southeast of Cauquenes city, in the Maule Region, located in the central zone of Chile. The site location can be found in Annex 1 at the end of this report.

The project area is located at an average of 135 m above sea level (asl).



GMS INTERNACIONAL	**Site Location:**	**Project:** IG1827115a **Date:** 03/12/2021	**Figure 1:** Site Location	Trinasolar

The solar PV project area is about 25 Ha and is located approximately 4 km from the city of Cauquenes. The site is characterized by a relatively flat topography for agricultural use.

3. CLIMATIC SETTING, PHYSIOGRAPHY, GEOLOGY, HYDROLOGY AND SEISMICITY

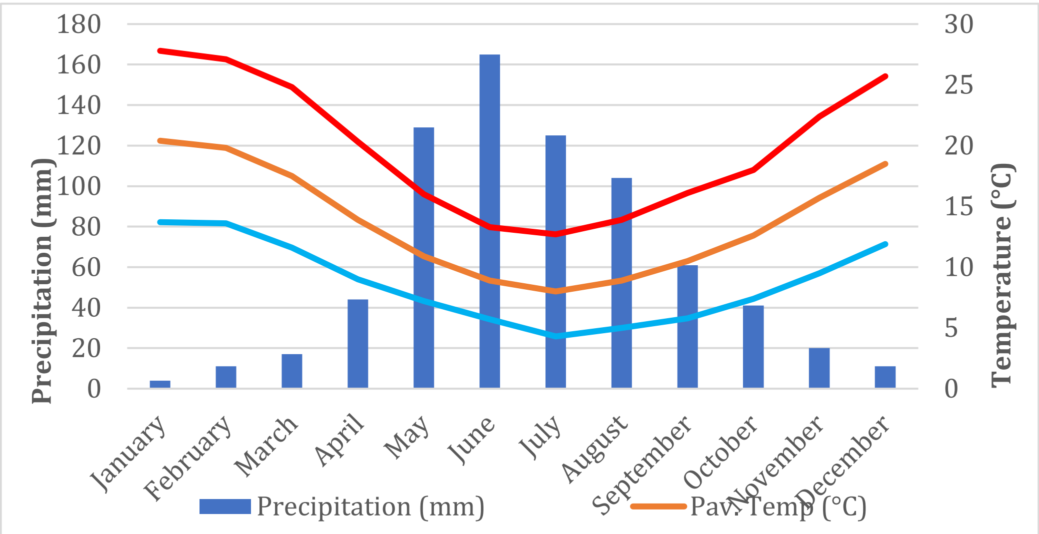
3.1. *Climatic setting*

The weather conditions in Cauquenes, which is the closest meteorological station to the project area, are warm and temperate. There is more rainfall in winter than in summer. The Köppen-Geiger climate classification is Csb (Mediterranean). The average temperature is 13.8 °C and the average rainfall is 732 mm.

The driest month is January, with a precipitation of 4 mm and the most intense rainfalls in June with an average of 165 mm.

The hottest month of the year, with an average of 20.4 °C, is January and the month of July has the lowest average temperature of the year with 8 °C.

*Data from Cauquenes Meteorological Station (Climate-data.org, n.d.).



GMS INTERNACIONAL	**Project:** IG1827115a **Date:** 03/12/2021	**Figure 2:** Climatic setting of the region	Trinasolar

3.2. *Physiography*

Cauquenes region physiography is characterized by the four of Chilean traditional relief: Coastal Plain, Costal Range, Central Depression and the Andes Chain.

This region is situated within the central depression, which is characterized by a uniform topography from Andes Chain to Coastal Range. Its main lithological materials are alluvial, colluvial and fluvio-glacial deposits, intercalated with recent volcanic materials from the Quaternary period.

The project site is located over and elongated depression with an average elevation of 135 masl. See **Figure 3**.

	Site Location:	**Project:** IG1827115a **Date:** 03/12/2021	**Figure 3:** Physiography of the area	

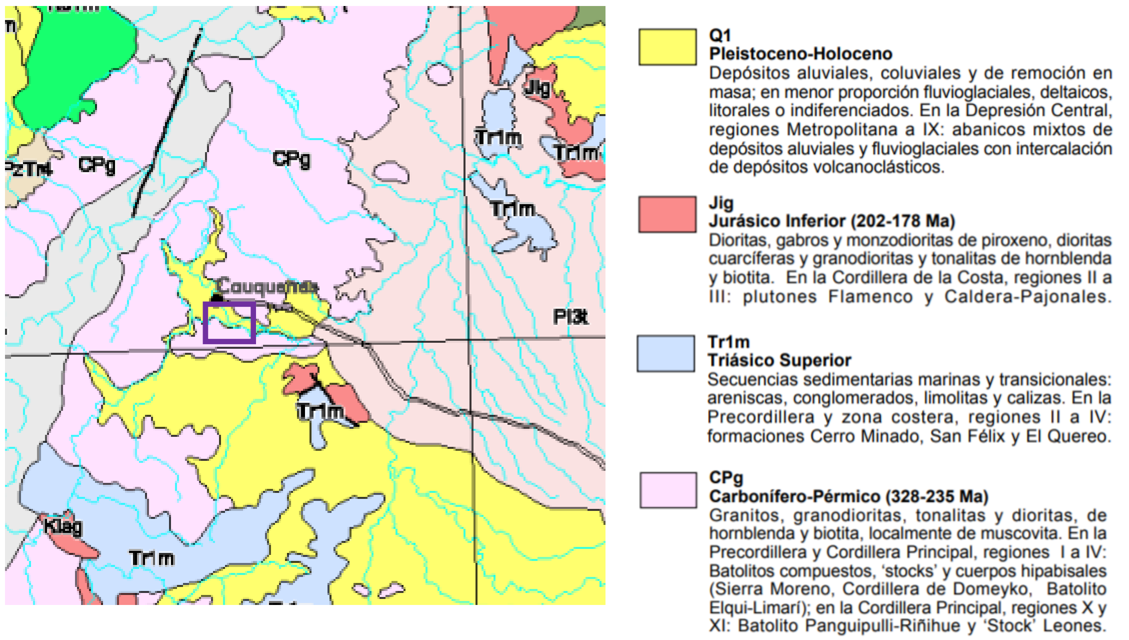
3.3. *Geological Baseline Information*

3.3.1. Regional geology

The Maule River region includes the Andes Mountains by the east, the Central Valley and the Cordillera de la Costa to the west. The Mountains of the Cordillera de los Andes are steep, high and show the effects of glaciation. The slope of the rivers and streams is very steep. The rocks that make up the Andes Mountains include a great variety of types and ages. There is a moderate number of granitic rocks from the Cretaceous age, but most of the rocks are volcanic or volcanic sediments, of ages that fluctuate between the Cretaceous and the Quaternary.

3.3.2. Local Geology

The survey area presents Paleozoic and Cenozoic age rocks and Quaternary deposits. The project is located at Pleistocene-Holocene age deposits, which are basically alluvial, colluvial and mass removal deposits intercalated with volcanic deposits. The Jurassic correspond to intrusive rocks composed mainly of diorites, gabros and monzodiorites. The Triassic rocks are marine and transitional sedimentary sequences corresponding to sandstones, conglomerates, siltstones, and limestone. The Carboniferous-Permian intrusive rocks are composed of granites, granodiorites, tonalites and diorites.See **Figure 4**.



GMS INTERNACIONAL	**Site Location:**	**Project:** IG1827115a **Date:** 03/12/2021	**Figure 4:** Geology of the area	Trinasolar

3.3.3. *Economic Geology*

There are no significant mining works within the zone. The main ground use is for agriculture.

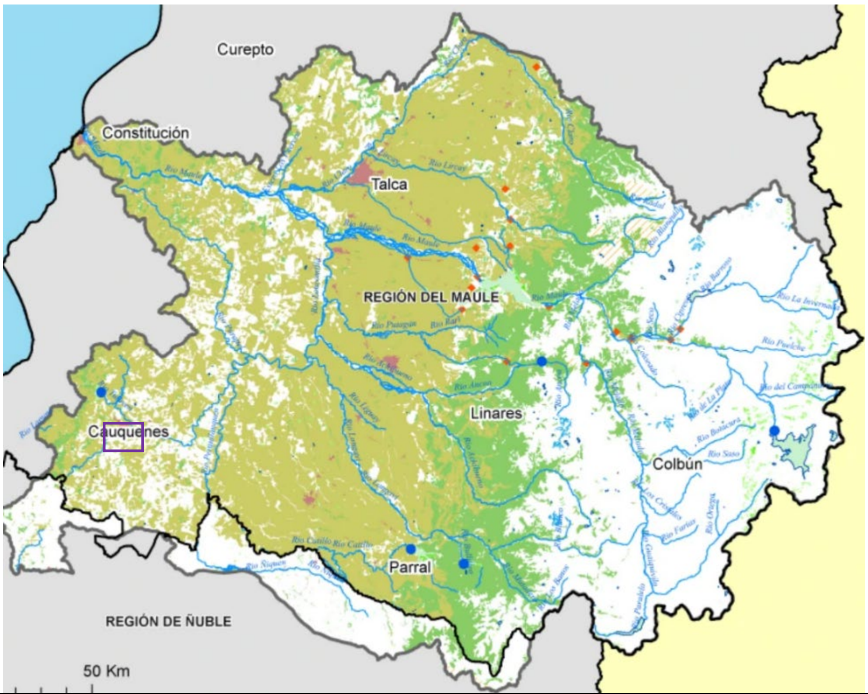
3.4. *Hydrology*

The hydrological system is distinguished by presenting a plot of drains that are born on the eastern front of the Cordillera de la Costa, characterized by micro-basins of the interior dry land.

The most important water courses correspond to rivers Perquilauquén, Cauquenes, Tutuvén, Rosales, Purapel, Cuyarranquil, Ñinquén, being tributary rivers of Maule River, which is one of the most important rivers in Chile. The hydrographic basin of the Maule River covers an area of 21.000 km^2 and it has a length of 240 km.

As shown in **Figure 5**, Cauquenes river flows near the area of investigation.

The limits of possible flooding area, results and recommendations will be shown in the Hydrological Report performed by GMS Internacional.



GMS INTERNACIONAL	**Site Location:**	**Project:** IG1827115a **Date:** 03/12/2021	**Figure 5:** Streams and water bodies in Cauquenes	Trinasolar

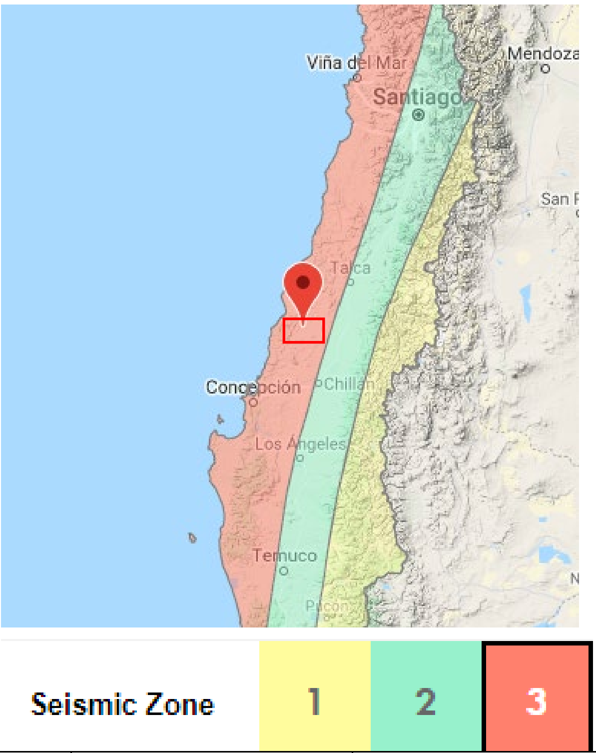
3.5. *Seismicity and liquefaction*

The analysis is based on the available seismic coefficients also summarized in Figure 6, as well as the data collected during the field works campaign.

According to official Chilean standard ("NCh2369," 2015), the peak ground acceleration for the site is 0.4·g m/s^2, and it lays in the '3 Type' seismic zone. These values are expected to produce seismically induced dynamic loads that may be critical.

Additionally, the potential for soil liquefaction is associated with the presence of groundwater, as well as with the grain size distribution during a seismic event with soil accelerations over 0.4·g m/s^2.

Partial runoff of groundwater was found through the pores of the walls in one trial pit only, however, at the time of the study (October) the precipitation conditions are moderately low; therefore, it is expected that in the months of highest rainfall intensity, the water table may raise to shallower depths. Despite these conditions, granular materials within the site present rather high compactness and the cohesive nature of some layers make **soil liquefaction unlikely during a seismic event.**



	Site Location:	**Project:** IG1827115a **Date:** 03/12/2021	**Figure 6:** Seismic map	

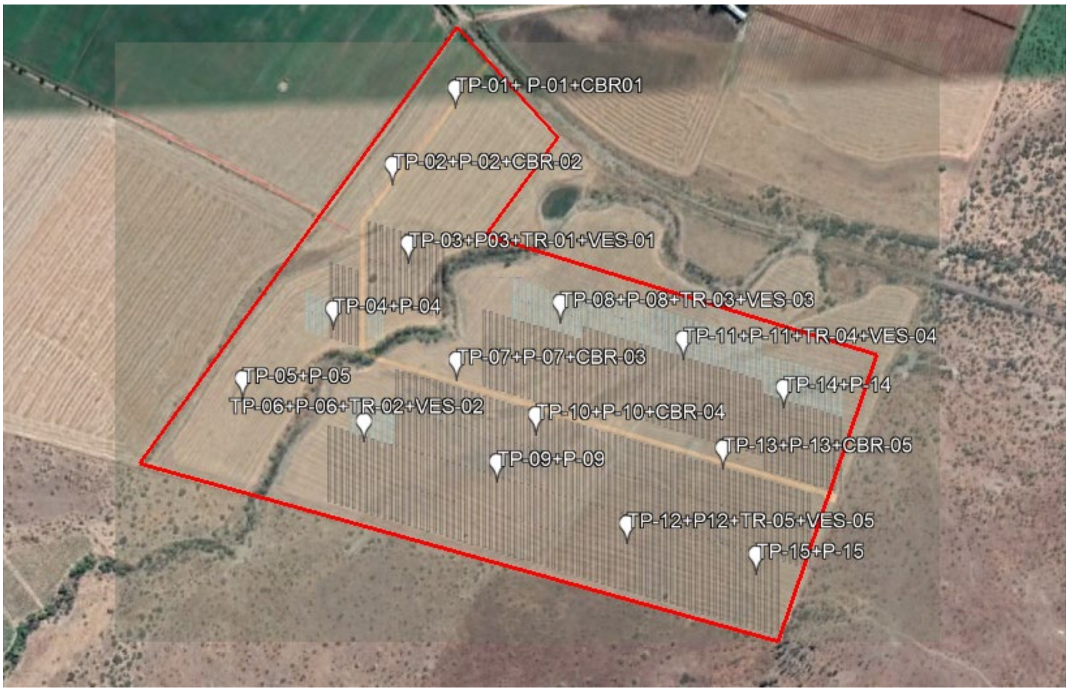
4. GEOTECHNICAL GROUND INVESTIGATION

4.1. *Field works description*

The field works were carried out during the period from 06th of October to 15th of October.

The scope of this survey was based on the proposal ref. 'P21_235_GMS_TRINA SOLAR_Vendimia_GHT_v1_BoQ' and according to Trina Solar's indications.

The following figure shows the tests location. Individual maps with the final location for every field work group are shown in the correspondent annexes.



GMS INTERNACIONAL	**Project:** IG1827113a **Date:** 16/03/2021	**Figure 7:** Fieldworks' location	Trinasolar

4.2. *Trial pits*

A total of 15 mechanical excavated trial pits (TP) were performed up to a maximum depth of 3.20m or refusal. The trial pit walls were logged and photographed to determine the geomorphological features of the area such as local geology, lithology, and geological surface processes. In all trial pits bulk samples were collected for laboratory testing. Completed trial pits depths varied from 3.00 to 3.20 m depth.

The excavation of trial pits was carried out using a JBC backhoe excavator.

Only in TP-15 partial runoff of groundwater was found at 1.10m depth through the pores of the walls, however, at the time of the study, (October) the precipitation conditions were moderately low; therefore, it is expected that during the months of highest rainfall intensity, the water table may raise to shallower depths.

The trial pits' locations, logs and pictures are shown in **Annex 2.**

The following table shows the individual depths, location, and excavation date of trial pits.

Table 1: Geographical coordinates of trial pits

TP	Date	Depth (m)	X (m W)	Y (m S)
TP-01	14/10/2021	3.10	743869	6013928
TP-02	14/10/2021	3.00	743798	6013847
TP-03	14/10/2021	3.00	743813	6013761
TP-04	14/10/2021	3.00	743729	6013692
TP-05	14/10/2021	3.00	743628	6013619
TP-06	13/10/2021	3.00	743759	6013569
TP-07	13/10/2021	3.00	743862	6013633
TP-08	13/10/2021	3.00	743977	6013692
TP-09	13/10/2021	3.00	743903	6013521
TP-10	13/10/2021	3.00	743947	6013571
TP-11	13/10/2021	3.00	744110	6013649
TP-12	13/10/2021	3.00	744043	6013450
TP-13	13/10/2021	3.00	744150	6013529
TP-14	13/10/2021	3.00	744218	6013593
TP-15	13/10/2021	3.20	744183	6013413

A description of shallow stratigraphy according to the limited excavations indicates a rather uniform layered deposit across the site, with some variations of the layer depths, thickness, and/or lithological composition.

The upper superficial layer in the entire site area was characterized by a soft and brownish clayey SILT, often with the presence of roots. It presents a thickness from 0.30m to 0.40m.

Under TOPSOIL, a soft dark brown CLAY appears throughout the plot, its thickness can vary between 0.40m and 2.20m reaching the 3m depth in the central area of the plot where fine materials predominate.

Below CLAY two different layers may be found. In the northern zone, there is a rather dense light brown sandy GRAVEL layer, which may be at 0.70m and reach 3.00m depth, being its thickness more than 0.80m.

On the other hand, in the southern part of plot a brown silty SAND of high compactness shows below a clayey layer. This sandy layer starts below 1.00m depth and reaches 3m depth overall, while in the eastern side of the plot GRAVEL lens-shaped layers may show between 0.80m a 1.70m depths.

The water table was observed in TP-15 only at 1.10m depth running off the pores of the walls thereof.

Four different geological units were differentiated:

- **TOPSOIL:** soft and brownish clayey SILT
- **CLAY**: soft dark brown CLAY, slightly moist.
- **Sandy GRAVELS:** dense light brown sandy GRAVELS
- **Silty SAND:** brown silty SAND of high compactness.

4.3. *Variable energy Dynamic Cone Penetrometer Tests (Panda2)*

Aiming to assess the in-situ soil mechanical behavior in the site, 15 Variable energy Dynamic Cone Penetrometer (VDCP) tests were performed across the site up to a maximum depth of 3.0 m or refusal, according to the UNE-EN ISO 22476:2008 international standard, to aid in the classification of the soil type as well as in the design of the pile foundations.

The penetration tests were performed close to the location of the trial pits to allow for the identification of soil layers and enable the direct strength correlation with the different lithological layers.

The individual cone penetrometer data is shown in **Annex 3.**

The following table shows the individual location, refusal depth and performance date of the dynamic cone penetrometer tests.

Table 2: Geographical coordinates of penetrometer tests

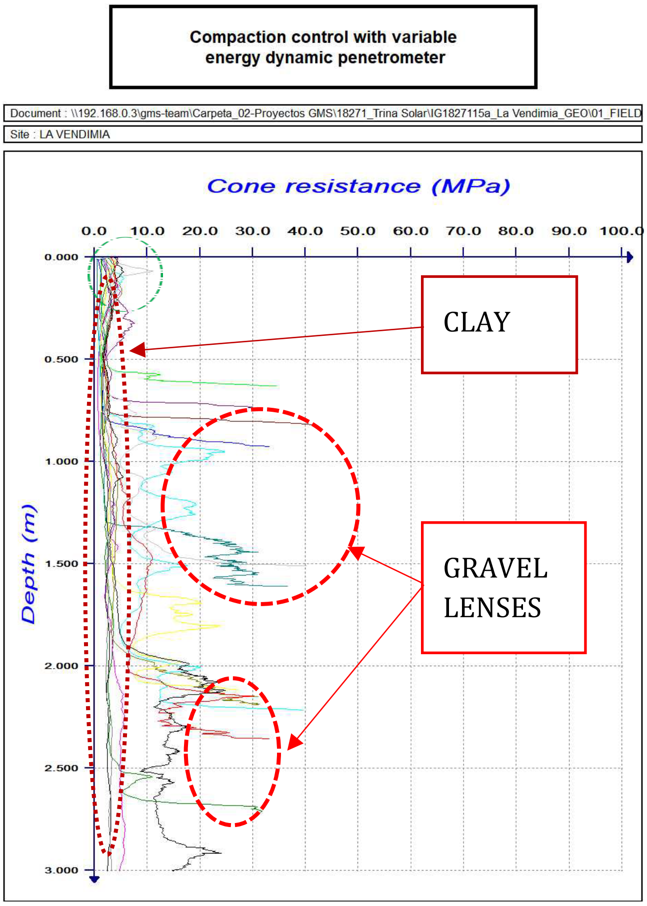
Penetrometer test ID.	Date	Depth (m)	X (m W)	Y (m S)
P-01	06/10/2021	1.50	743869	6013928
P-02	06/10/2021	2.2	743798	6013847
P-03	06/10/2021	2.1	743813	6013761
P-04	07/10/2021	3.00	743729	6013692
P-05	07/10/2021	3.00	743628	6013619
P-06	07/10/2021	3.00	743759	6013569
P-07	07/10/2021	2.35	743862	6013633
P-08	06/10/2021	2.71	743977	6013692
P-09	06/10/2021	0.82	743903	6013521
P-10	06/10/2021	2.18	743947	6013571
P-11	06/10/2021	3.00	744110	6013649
P-12	06/10/2021	0.63	744043	6013450
P-13	06/10/2021	0.73	744150	6013529
P-14	06/10/2021	1.60	744218	6013593
P-15	06/10/2021	0.92	744183	6013413

The Variable energy Dynamic Cone Penetrometer chart shows a minimum refusal depth of 0.63 m at P-12 and deepest depth reached at 3.0m at P-04, P-05, P-06 and P-11.

Refusal at shallow depths may be due to the presence of shallow GRAVELS layer and dense compactness of SAND layers, as described above.

Regarding soil penetration resistance, three different behaviors have been observed, the first one is for CLAY layer which presents a low resistance up to 5MPa, this behavior is presented across the site from 0.40m till 3.00m depth in some cases (P-04, P-05, P-11). The second behavior belongs to the sandy layer with values ranging between 10 – 20 MPa till reaching higher refusal figures of 30 – 40 MPa in the peak density areas (P-06, P-09, P-10). Finally, the third behavior belongs to tests performed within gravelly areas, those presented refusal at 0.80m depth with values of around 45 MPa (P-01, P-02, P-08) at 0.80m - 2.20m depth range.

In the following figure, variable energy dynamic cone penetrometer (VDCP) results are shown.



GMS INTERNACIONAL	**Project:** IG1827115a **Date:** 03/12/2021	**Figure 8:** Variable energy Dynamic Cone Penetrometer tests (VDCP).	Trinasolar

4.4. *Vertical Electrical Soundings (VES´s)*

A total of 5 VES tests were performed in accordance with the proposed works using the Wenner method. The tests were evenly distributed across the site to ensure that any variation in electrical resistance was captured. The intervals of the tests were: 0.6, 0.8, 1.0, 1.3, 1.7, 2.2, 2.9, 3.8, 4.8, 6.2, 8.2, 11.0 and 15.0 meters and the testing depth was 15 meters below ground. Test point locations as well as individual raw results are shown in **Annex 4**.

The following table (see below) shows the common resistivities in different materials.

Table 3: Common resistivities in some materials and different states of water

MATERIAL	RESISTIVITY Ω-m
Clay	1-20
Sand	50-500
Sandstone	50-5,000
Sand and dry gravel	1,000-10,000
Sand and gravel with fresh water	50-500
Sand and gravel with saltwater	0.5-5
Clayey sand	50-300
Sand of quartz	30-10,000
Superficial fresh water	20-300
Seawater	<0.2
Distilled water	>500
Conglomerate	1,000-10,000
Limestone	300-10,000
Volcanic breccia	100-2,000
Schist graphited	0.5-5
Schist unaltered	300-3,000
Granite	300-10,000
Gneiss and granite unaltered	100-1,000
Gneiss unaltered	1,000-10,000
Gravel	100-10,000
Basalt	300-10,000
Silt	30-500
Marlstone	50-5,000
Slate	100-1,000
Volcanic tuff	20-100

The table below shows the coordinates and performance date of VES's tests.

Table 4: VES' coordinates

VES ID	Date	X (m W)	Y (m S)
VES-01	06/10/2021	743813	6013761
VES-02	06/10/2021	743759	743759
VES-03	06/10/2021	6013569	6013569
VES-04	06/10/2021	744110	6013649
VES-05	06/10/2021	744043	6013450

The processed results of electrical resistivity tests for La Vendimia PV Solar Project are shown below in **Table 5**.

Table 5: VES´results

VES ID	Resistivity (Ω ·m)	Thickness (m)	Depth (m)
VES-01	68,29	0,60	0,60
	24,39	2,54	3,15
	128,82	2,20	5,35
	64,25	3,41	8,76
	28,47	6,24	15,00
VES-02	67,32	0,67	0,67
	8,84	1,21	1,88
	48,92	3,19	5,07
	21,51	9,93	15,00
VES-03	197,15	0,61	0,61
	23,95	7,03	7,64
	53,97	7,36	15,00
VES-04	162,48	0,39	0,39
	20,72	7,66	8,05
	90,12	6,95	15,00
VES-05	329,21	0,44	0,44
	21,54	4,77	5,21
	58,88	9,79	15,00

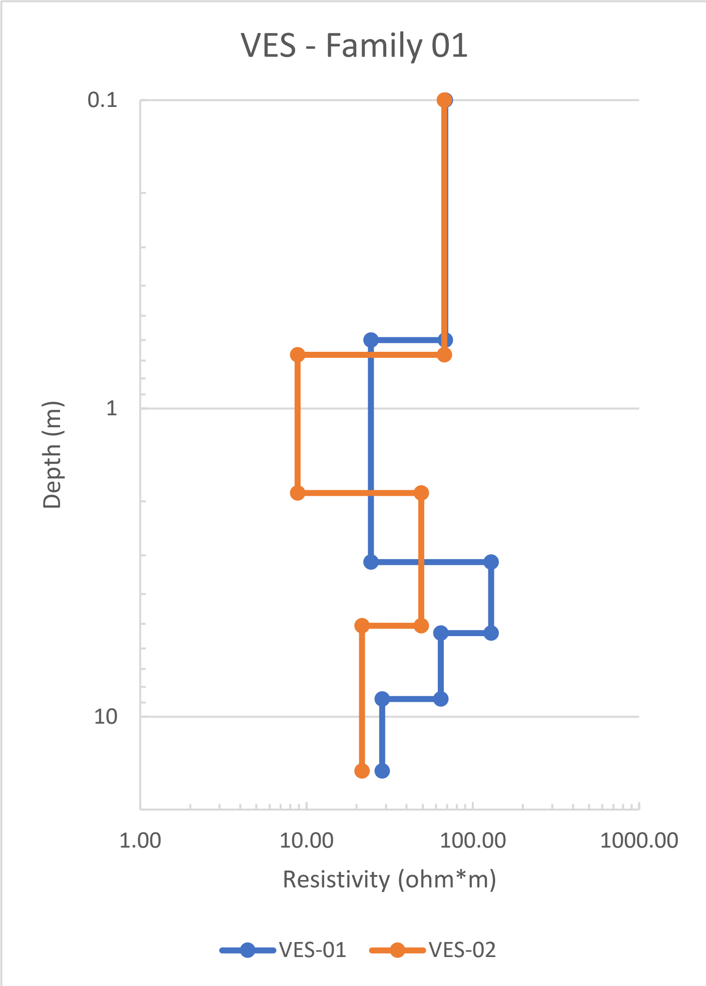
In general, the values of electrical resistivity are disparate across the plot, corresponding to CLAY and SAND with Gravels with a high humidity, which are clearly in line with lithology shown by the trial pits and the rest of carried out tests.

The lowest value of apparent resistivity is 0.84 Ohm·m at 1.88 m depth in VES-02, while highest value is 329.21 Ohm·m at 0.44 m depth in VES-05. In terms of corrosion, low resistivity values produce high corrosivity grade.

The study area shows two different electrical resistivity behaviors (families) with little variation caused by changes in resistivity values at different depths, due to the variability of layers thickness and the difference in heights at which VES have been carried out.

4.4.1. VES Family 01

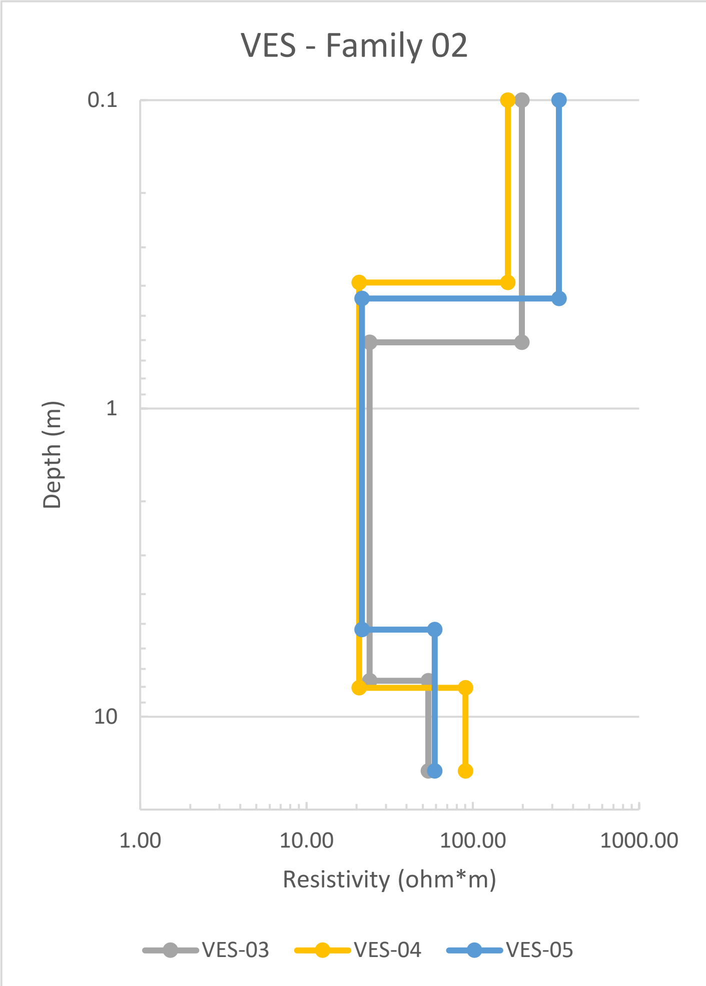
The first range of values presents medium resistivity values (67~68 Ohm·m) in the first 0.60m. Underneath, the results decrease to low values (8-24 Ohm·m) up 2 or 3m depth; afterwards, the range of values increases to medium-high resistivity (48~128 Ohm·m) approximately at 5m depth once again, finally below 5m depth the values drop to 21.5 Ohm·m until the end of the exploration, which is approximately at 15 m depth, these low to medium values of resistivity allow to confirm the presence of water in significant quantities (high moisture) in the granular layers (SAND and GRAVELS).



GMS INTERNACIONAL	**Project:** IG1827115a **Date:** 03/12/2021	**Figure 9:** VES Family 01	Trinasolar

4.4.2. VES Family 02

The first range of values presents medium resistivity values (162~329 Ohm·m) in the first 0.60m. Underlain results drop to lower values (20~24 Ohm·m) up 5 to 8m depth; finally below 5m to 8 depth resistivity increases (53 ~90 Ohm·m) until the end of the exploration, which is at circa 15 m depth. Those low to medium values of resistivity confirm the presence of water in significant quantities (high moisture) in the granular layers (SAND and GRAVELS).



	Project: IG1827115a **Date:** 03/12/2021	**Figure 10:** VES Family 02	

4.5. *Thermal resistivity test*

Ground thermal resistivity measurements are based on the theory that the rate of temperature rise of a line heat source is dependent on the thermal constants of the medium in which it is applied. This information is key to proceed with the thermal design of medium and high voltage earthing electrical wires.

These tests were performed according to the technical specifications sent by the Client using a TLS100 Thermtest unit.

A total of 5 tests were performed inside trial pits, between 0.65 and 0.95m depth. Three measurements were carried out in each trial pits, getting a total of fifteen measurements, with a duration of 5 minutes per each measurement. Measurement depths in trial pits and test locations are indicated in the following table.

Table 6: Geographical coordinates of the thermal resistivity tests

TR Id	TP Id	Depth (m)	X (m W)	Y (m N)
TR-01	TP-03	0,70	743813	6013761
TR-02	TP-06	0,70	743759	743759
TR-03	TP-08	0,80	6013569	6013569
TR-04	TP-11	0,90	744110	6013649
TR-05	TP-12	0,65	744043	6013450

In **Table 7**, the average test results are shown.

Table 7: Thermal resistivity test results

TR Id	Depth (m)	Av. TR (mk/W)	Av. Temp. (°C)
TR-01	0,70	0,515	13,2
TR-02	0,70	0,608	13,0
TR-03	0,80	0,638	13,2
TR-04	0,90	0,473	13,0
TR-05	0,65	0,565	14,1

Complete results and their equivalence compared to common thermal conductivity values are presented in **Annex 5**.

4.6. *CBR in-situ tests*

A total of 5 CBR in situ tests were performed across the site. The tests were carried out using a portable variable energy dynamic cone penetrometer (Panda2 compaction mode) to evaluate the soil strength and determine the quality of the subgrade material for road design purposes. The maximum tested depth was 1.0 m.

The following table shows tests location.

Table 8: Geographical coordinates of the CBR tests.

CBR Id	X (m W)	Y (m S)
CBR-01	743869	743869
CBR-02	6013928	6013928
CBR-03	743798	743798
CBR-04	6013847	6013847
CBR-05	743862	743862

The in situ CBR test results are detailed in **Annex 6**.

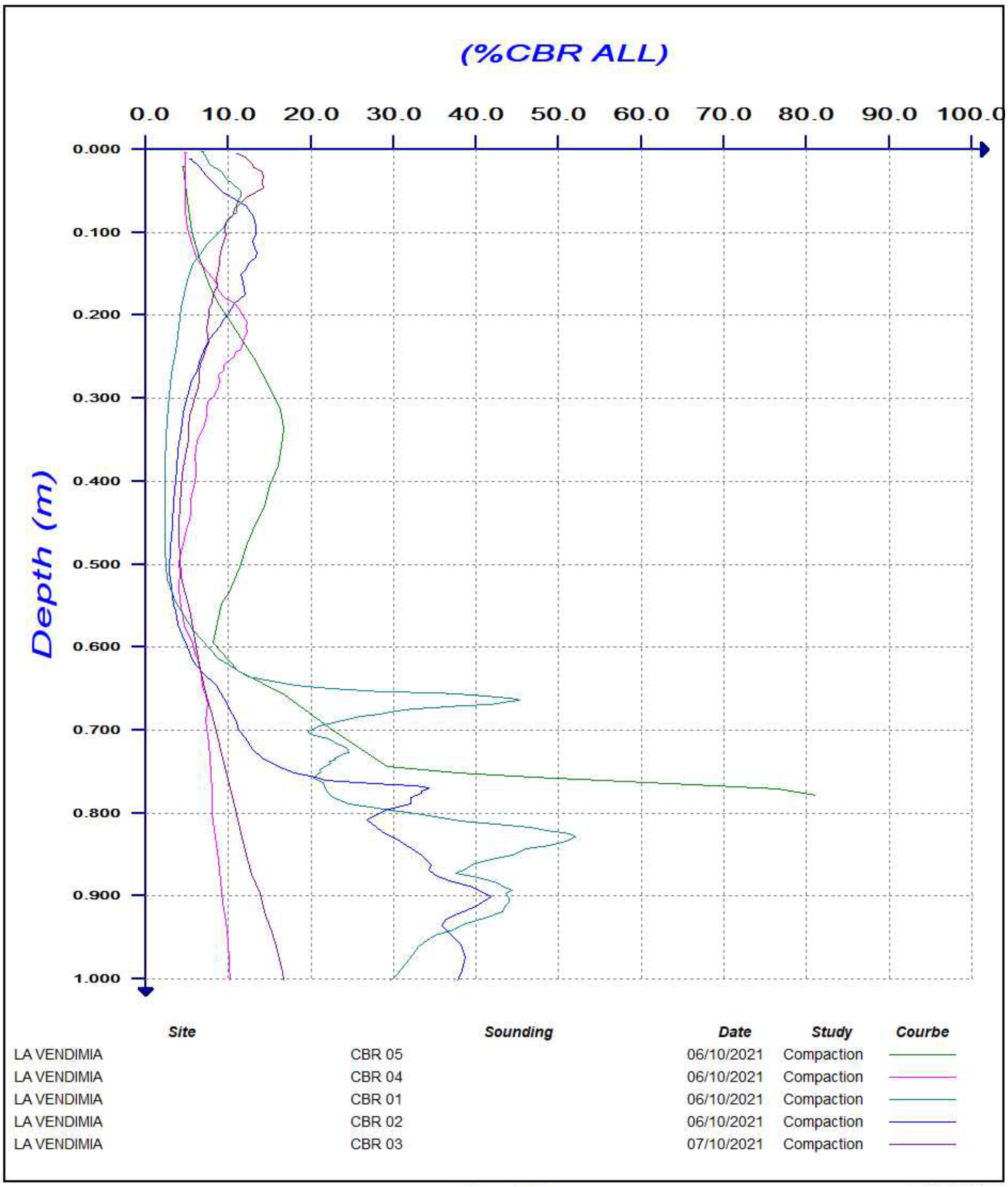
In the following plot two resistance trends may be observed. CBR-03 and CBR-0.4 reached 1.00m depth, with low CBR percent values between 5 and 20. Instead, The CBR-01, CBR-02 and CBR-05 tests, reached higher CBR values, between 20 and 50 below 0.60m depth, Only CBR-05 got refusal at 0.80m depth.

These values are consistent with the geotechnical stratification, as well as with the consistency of the materials found throughout the site.

Compaction control with variable energy dynamic penetrometer

Document : \\192.168.0.3\gms-team\Carpeta_02-Proyectos GMS\18271_Trina Solar\IG1827115a_La Vendimia_GEO\01_FIELD

Site : LA VENDIMIA



GMS Internacional	**Project:** IG1827115a **Date:** 03/12/2021	**Figure 11:** CBR testing results	Trinasolar

4.7. *Laboratory works*

4.7.1. Laboratory works description

All samples collected were classified directly in the field. Altered and undisturbed samples were taken. The following list shows the scheduled tests.

Identification tests:

- 15 Moisture content in the laboratory (NCh 1515)
- 15 Sieve analysis (Grain size) (MCV8_8.102.1_2017)
- 15 Atterberg limits (Plasticity test) (NCh 1517/1, NCh 1517/2)
- 15 Soil density (NCh 1532)
- 2 Soil Collapse (NLT-254/99)
- 2 Consolidation Test (ASTM D2435:2011)
- 1 Simple compression (Nch 3134)

Chemical soil tests:

- 8 pH tests (ASTM D4972/95)
- 8 Sulphate content of soil soluble in aqueous solution (NCh 1444 Of. 1980)
- 8 Chloride contents of soil (NCh 1444 Of. 1980)
- 8 Sulphide content of soil (NCh 1444/2010)
- 8 Soluble Salts of soil (NCh 1444 Of. 1980)
- 8 Organic Matter content (Walkley & Black Method)
- 8 Redox Test (ASTM D1498/2000)
- 3 Baumann-Gully acidity tests (UNE 83962-08)

Compaction tests:

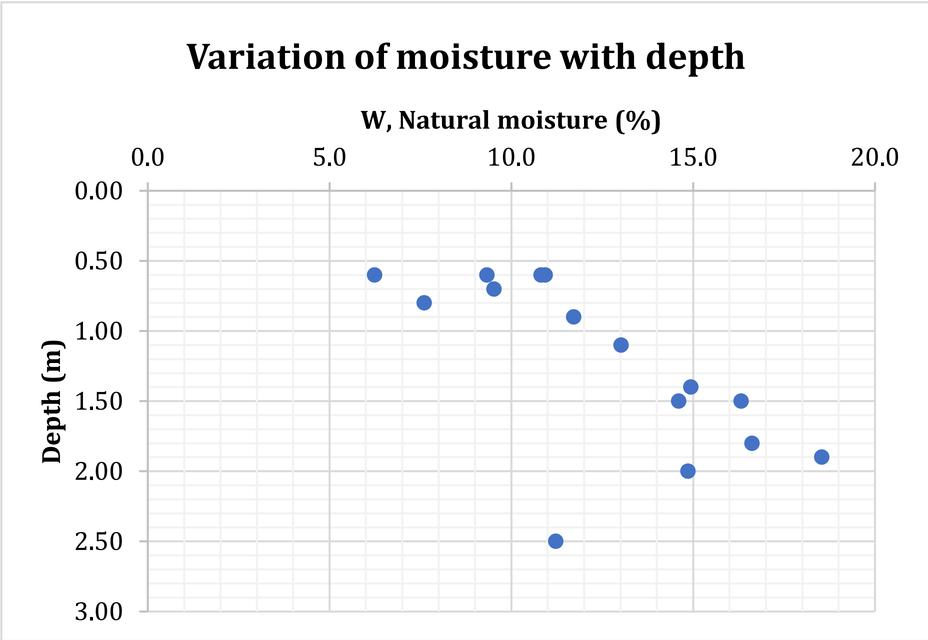
- 5 Modified Proctor (NCh 1534/2 Of. 1979)
- 5 CBR (NCh 1852/2 Of.1981)

4.7.2. Laboratory tests results

4.7.2.1. *Moisture Content*

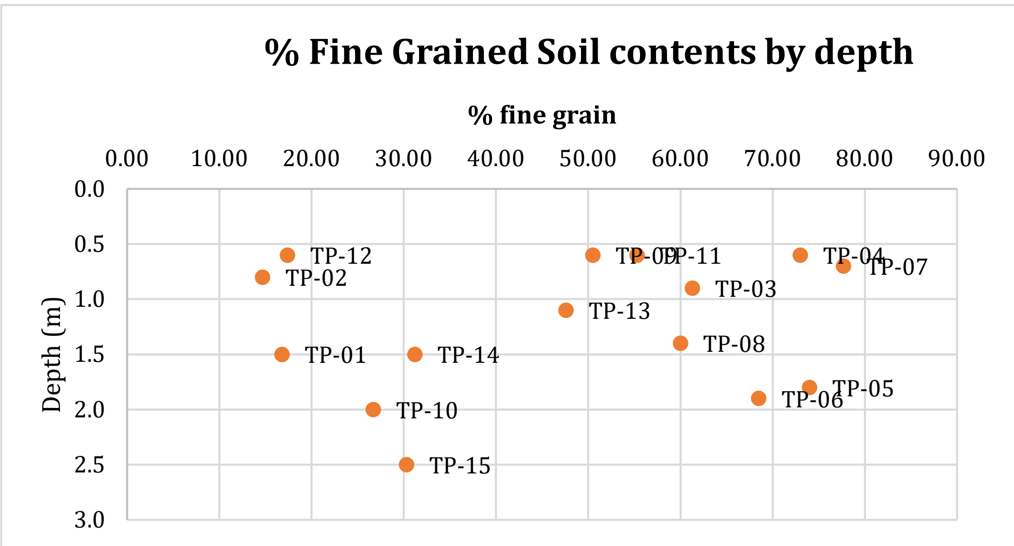
Based on NCh 1515, moisture contents were obtained.

Results obtained show values from 6.23% to 18.53%. The moisture values increase with soil depth as seen in the plot on the **Figure 12**.

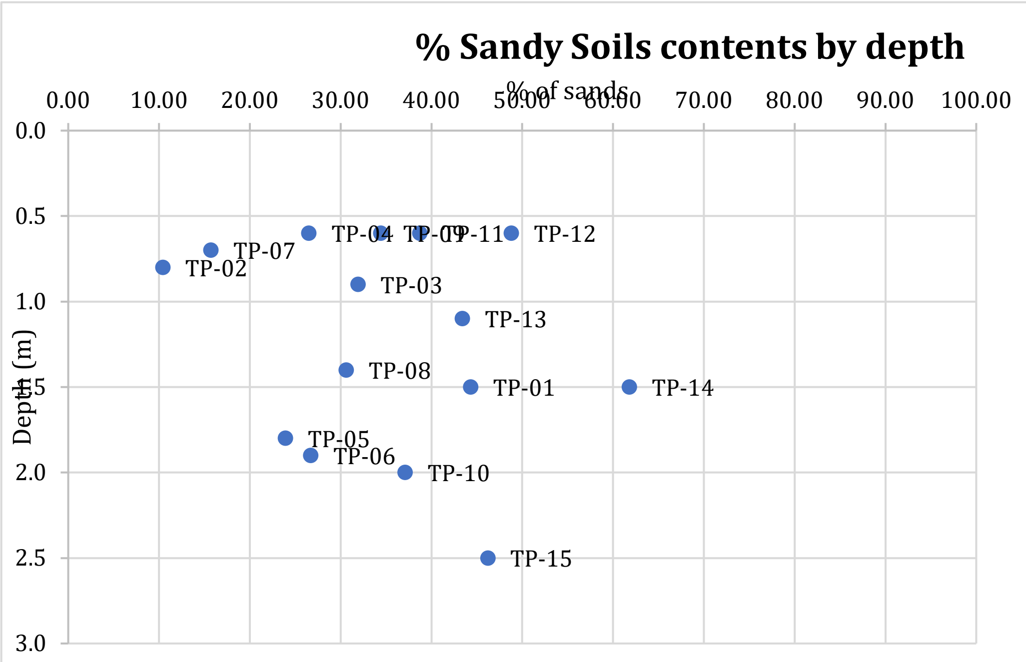


	Project: IG1827115a **Date:** 03/12/2021	**Figure 12:** Moisture content of samples	

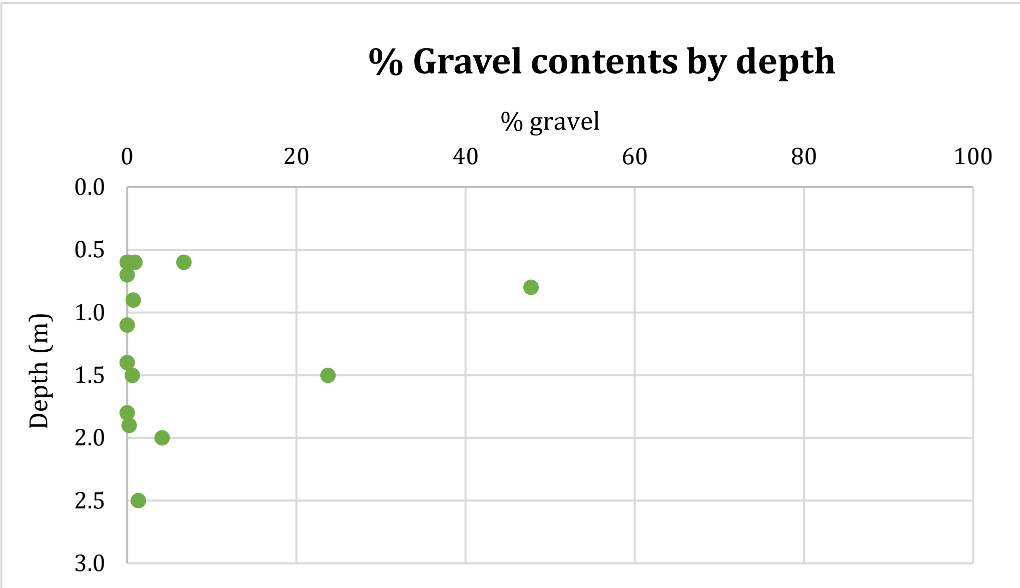
4.7.2.2. *Fine and sand content*



	Project: IG1827115a **Date:** 03/12/2021	**Figure 13:** Fine content of samples	



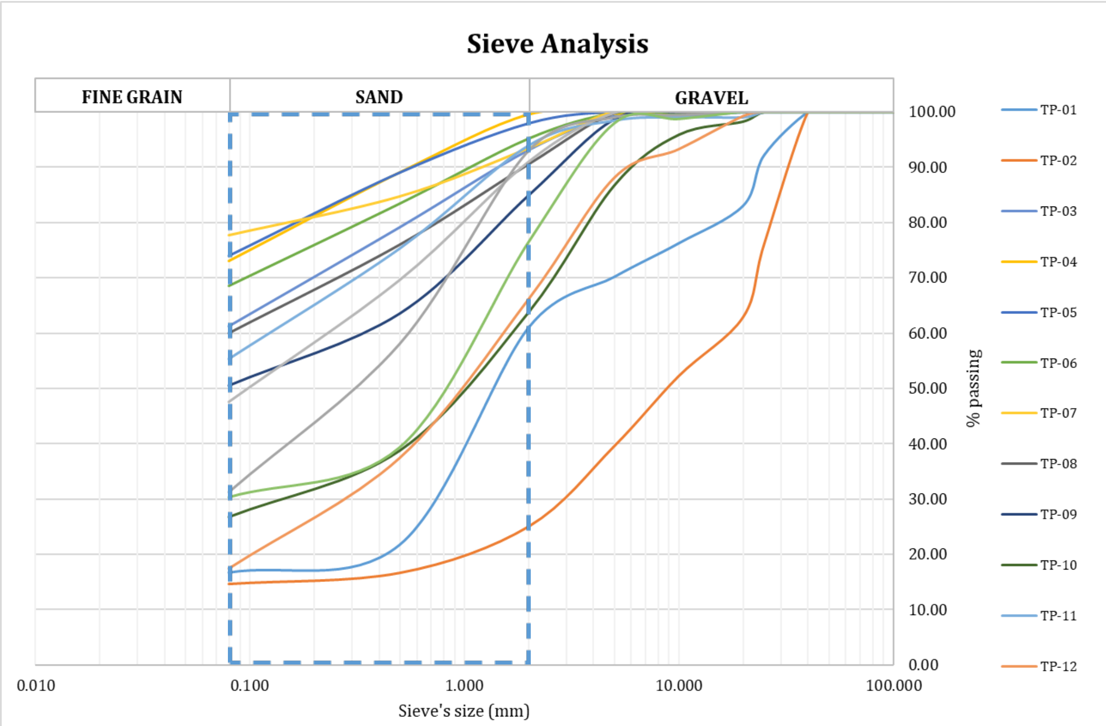
GMS INTERNACIONAL	**Project:** IG1827115a **Date:** 03/12/2021	**Figure 14:** Sand content of samples	Trinasolar



GMS INTERNACIONAL	**Project:** IG1827115a **Date:** 03/12/2021	**Figure 15:** Gravel content of samples	Trinasolar

4.7.2.3. *Sieve analysis*

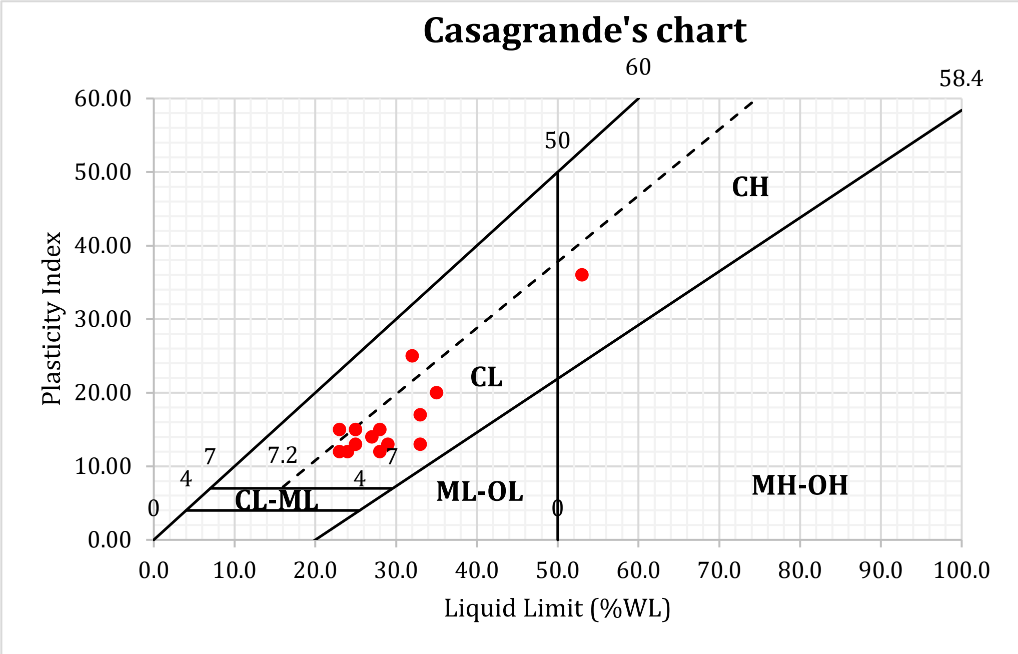
The granulometries of the different samples are shown in the plot below.



	Project: IG1827115a **Date:** 03/12/2021	**Figure 16:** Sieve Analysis	

4.7.2.4. *Casagrande's plasticity chart*

According to the Atterberg limits test results, the following figure show the plasticity chart for the fine-grained soils presented in the project area. The tests results suggest low plasticity for the project.



	Project: IG1827115a **Date:** 03/12/2021	**Figure 17:** Casagrande's Chart	

4.7.2.5. *Swelling*

Clay expansivity is generally associated with a high liquid limit and plasticity index. According with the laboratory tests results, no high plastic clays were encountered across the study area. Only sample in TP-02 belong to high plasticity materials, but fine-grained percent is 14.7% only. For that reason, expansivity and swelling potential may not be considered a significant risk for the project.

4.7.2.6. *Collapse tests*

Based on the ASTM D5333, two collapse tests were performed. The next table shows the results:

Table 9: Collapse test results

Id	Depth (m)	Ie (%)	Degree of Collapse*
TP-14-MI	1.00	0.38	Slight
TP-15-MI	0.60	0.05	None

***Degree of Collapse according to ASTM D5333**

According to laboratory results, the ground is not expected to collapse under the typical design loads of a photovoltaic plant.

4.7.2.7. *Oedometer tests*

The oedometer test is one of the most important and most commonly performed laboratory tests in geotechnical engineering. The oedometer test aims to measure the vertical displacement of a saturated cylindrical soil sample subjected to a vertical load while it is radially constrained.

From this test Compression Index (C_c) and Coefficient of Consolidation (C_v) is obtained.

The following table shows the soil properties determined by the consolidation tests. The complete results obtained from the laboratory test are shown in **Annex 9**.

Table 10: Oedometric test results

Sample	Depth (m)	Initial Void Ratio (e_0)	Compression Index (C_c)	Coefficient of Consolidation (C_V)
TP-14-MI	1.00	0.64	0.007	0.334
TP-15-MI	0.60	0.51	0.007	0.017

4.7.2.8. *Unconfined Compression Test*

In order to determine the compressive strength of the clays, a unconfined uniaxial compression test was carried out on the TP-15 sample at 0.6m depth, in accordance with the Nch 3134 standard, which allows determining the value of the soil resistance (q_u in MPa); test results are presented in table below.

Table 11: Unconfined uniaxial compression test result

Sample	Depth (m)	Unconfined compressive strength Q_u (kPa)	Cohesion C_u (kPa)
TP-15-MI	0.60	23	11

According to compression test result the UG-02 CLAY has a compression resistance of 23kPa; according to Terzaghi and peck (1955) this figure may be associated to a **very soft CLAY** material**.**

4.7.2.9. *Modified Proctor and CBR laboratory testing*

Based on the NCh 1534/2 and NCh 1852 standards, Modified Proctor (95%) and CBR laboratory tests were performed.

The results show values from 1.81 to 2.02 g/cm^3 of maximum density and 12.00% to 25.13% of CBR value for saturated samples with 95% MP density. These values can be found in **Table 12**.

These results are analyzed in **Section 6** to allow for a preliminary road design.

Table 12: Modified Proctor and CBR laboratory tests results

LAB Id	Depth (m)	Maximum Dry Density (g/cm^3)	Optimal Moisture Content (%)	CBR (%)*
TP-02	0,6-0.90	2.02	10.3	25.13
TP-07	0.80-1.10	1.96	10.1	12.75
TP-09	0,6-0.90	1.81	13.0	12.87
TP-11	0.80-1.00	1.91	8.3	12.00
TP-13	0.90-1.10	1.94	10.0	14.87

***95% relative compaction**

4.7.3. Laboratory Summary Table

The complete results obtained from the laboratory test are shown in **Annex 9**.

Table 13: Laboratory Summary Table

TP	TP-01	TP-02	TP-03	TP-04	TP-05	TP-06	TP-07	TP-08	TP-09	TP-10	TP-11	TP-12	TP-13	TP-14	TP-15	TP-14M.I.	TP-15 M.I.
Depth (m)	1.50	0.80	0.90	0.60	1.80	1.90	0.70	1.40	0.60	2.00	0.60	0.60	1.10	1.50	2.50	1.00	0.60
Moisture (%)	14.6	7.6	11.7	10.8	16.6	18.5	9.5	14.9	10.9	14.9	6.2	9.3	13.0	16.3	11.2		
Gravel (%)	23.7	47.7	0.7	0.2	0.0	0.2	0.0	0.0	0.0	4.1	0.90	6.70	0.00	0.60	1.30		
Sand (%)	44.3	10.4	31.9	26.5	23.9	26.7	15.7	30.6	34.4	37.1	38.70	48.80	43.40	61.80	46.20		
Fines (%)	16.80	14.70	61.30	73.00	74.00	68.50	77.70	60.00	50.50	26.70	55.30	17.40	47.60	31.20	30.30		
Liquid Limit (LL)	33.0	53.0	25.0	27.0	28.0	35.0	23.0	32.0	33.0	29.0	25.0	0.0	23.0	24.0	28.0		
Plasticity Index (PI)	13.0	36.0	15.0	14.0	15.0	20.0	15.0	25.0	17.0	13.0	13.0	0.0	12.0	12.0	12.0		
Consistency Index	1.4	1.3	0.9	1.2	0.8	0.8	0.9	0.7	1.3	1.1	1.4		0.8	0.6	1.4		
Sulphates (ppm)	206.00		178.00	171.00		171.00		153.00		182.00		189.00		197.00			
Sol Salts (%)	0.26		0.08	0.06		0.04		0.06		0.18		0.13		0.21			
Chlorides	45.00		26.00	29.00		29.00		23.00		36.00		32.00		34.00			
Redox Potential (mV)	178.00		189.00	181.00		185.00		162.00		206.00		187.00		193.00			
Organic Matter (%)	2.65		1.96	2.12		2.34		2.75		3.07		2.81		2.79			
pH	6.9		6.7	6.8		7.0		6.9		7.0		7.1		6.9			
Baumann-Gully Acidity (ml/kg)	21.5		18.8							23.7							
Initial Void Ratio (e0)																0.64	0.51
Compress. Index (Cc)																0.007	0.007
Coef. Of Consol. (CV)																0.334	0.017
Resistance compresion (qu) (kPa)																	23.0
Cohesion (Cu) (kPa)																	11.0
Colapso a 200 (Ie) (kPa)																0.54	1.58
USCS Classification	SC Clayey SAND	GC Clayey GRAVEL	CL Low Plasticity CLAY	CL Low Plasticity CLAY	CL Low Plasticity CLAY	CL Low Plasticity CLAY	CL Low Plasticity CLAY	CL Low Plasticity CLAY	CL Low Plasticity CLAY	SC Clayey SAND	CL Low Plasticity CLAY	SM Silty SAND	SC Clayey SAND	SC Clayey SAND	SC Clayey SAND		

5. GEOTECHNICAL ASSESSEMENT

5.1. *Formulation*

The following table shows correlations from the technical literature generally used in our geotechnical assessments.

Equations are applied according to technical criteria and soil main features.

When information to determine the parameters analytically is insufficient, then parameters are taken from specialized literature according to previous technical experience.

Table 14: Geotechnical correlations

<table>
<tr><th>Correlation</th><th>Equation</th><th>Author</th></tr>
<tr><td>Panda2 Cone Resistance (MPa) to N_{spt}</td><td>$N_{spt} = q_d(MPa)/0.65$</td><td>Panda2; Soil Solution S.A. (2002)</td></tr>
<tr><td>N_{spt} to Friction Angle, φ' (°) for sands</td><td>$\phi'(°) = 27.1 + 0.30 \cdot N_{spt} - 0.00054 \cdot {N_{spt}}^2$</td><td>Peck (1974)</td></tr>
<tr><td>N_{spt} to Deformation modulus; E (kN/m²)-(NC Sand)</td><td>$E\ (kN/m^2) = 21500 + (1060 * N_{spt})$</td><td>d'Apolonia; (1970)</td></tr>
<tr><td>N_{spt} to Deformation modulus; E (kN/m²)-(OC Sand)</td><td>$E\ = 54000 + (1350 \cdot N_{SPT})$</td><td>d'Apolonia (1970)</td></tr>
<tr><td>N_{spt} to Deformation modulus; E (MPa)-(Fine Sand)</td><td>$E\ =\ 8 \cdot N_{SPT}$</td><td>Meigh and Nixon (1961)</td></tr>
<tr><td>N_{spt} to Deformation modulus; E (MPa)-(Silt and Sandy Silt)</td><td>SILT and Sandy SILT: E = 5 · N_{SPT}</td><td>Meigh and Nixon (1961)</td></tr>
<tr><td>N_{spt} to Undrained Shear Strength in clays; c_u (kN /m²)</td><td>$c_u(kN/m^2) = f_1 \cdot N_{spt}$<table><tr><td>PI (%)</td><td>15</td><td>20</td><td>25</td><td>30</td><td>35</td><td>>40</td></tr><tr><td>f_1</td><td>6.5</td><td>5.5</td><td>5.0</td><td>4.8</td><td>4.5</td><td>4.4</td></tr></table></td><td>Stroud (1974 & 1988)</td></tr>
<tr><td>N_{spt} to Uniaxial Compressive Strength; q_u (Tn/m²)</td><td>$q_u\left(\frac{Tn}{m^2}\right) = (40 \cdot N_{spt}) \cdot \left(\frac{3}{100}\right)$</td><td>Dr. Muzás F.; (2002)</td></tr>
<tr><td>N_{spt} to Horizontal reaction soil modulus; K_h (Tn/m³)</td><td>$K_h\left(\frac{Tn}{m^3}\right) = 40 \cdot N_{spt}/d(m)$</td><td>Dr. Muzás F.; (2002)</td></tr>
<tr><td>Horizontal reaction soil modulus; K_h (MPa) to Deformation modulus; E (MPa)</td><td>$E(MPa) = \frac{K_h(MPa) \cdot 2 \cdot r(m)}{3}$</td><td>Pochman, R, et al.; (1989)</td></tr>
<tr><td>Uniaxial Compressive Strength; q_u (Tn/m²) to Undrained Shear Strength; c_u (Tn/m²)</td><td>$c_u\left(\frac{Tn}{m^2}\right) = q_u\left(\frac{Tn}{m^2}\right) \cdot 1/2$</td><td>Rodríguez Ortiz et al, 1971</td></tr>
<tr><td>Saturated Density (kN/m³)</td><td>$\gamma_{sat} = (\gamma_{solids} + e \cdot \gamma_{water})/(1+e)$</td><td>-</td></tr>
<tr><td>Tip Dynamic energy (kg/m²)</td><td>$R_{pd} = M^2 \cdot H \cdot N/[A \cdot \delta \cdot (M+P)]$</td><td>Olandesi</td></tr>
<tr><td>DCP Index</td><td>$DCP\ Index = n^{o}\ Blows/Fall$</td><td>-</td></tr>
<tr><td>DCP to CBR (CH soils)</td><td>$CBR\ (\%) = 1/(0.017019 \cdot DCP\ Index)$</td><td rowspan="3">US Army Corps of Engineers</td></tr>
<tr><td>DCP to CBR (CL soils with CBR<10)</td><td>$CBR\ (\%) = 1/(0.002871 \cdot DCP\ Index)$</td></tr>
<tr><td>DCP to CBR (Rest of soils)</td><td>$CBR\ (\%) = 292/DCP\ Index^{1.12}$</td></tr>
</table>

5.2. *Geological summary*

Based on the information from the field campaign and the laboratory tests, the following stratigraphy was determined for the site.

Four geotechnical units have been assumed within the study area.

Table 15: Summary of stratigraphy

Stratigraphy	Geological Unit	Depth (m)	Thickness (m)
Topsoil (clayey SILT)	GU-01	0.00 to 0.30/0.40	From 0.30 to 0.40
CLAY	GU-02	0.30/0.40 to 0.70/3.00	From 0.40 to 2.70
Sandy GRAVEL	GU-03	0.70/2.80 to 2.00/3.10	From 0.20 to 2.40
Silty SAND	GU-04	0.80/2.20 to 1.60/3.00	From 0.70 to 2.20

According to the laboratory and field tests, the following geomechanical parameters have been drawn for each geotechnical unit.

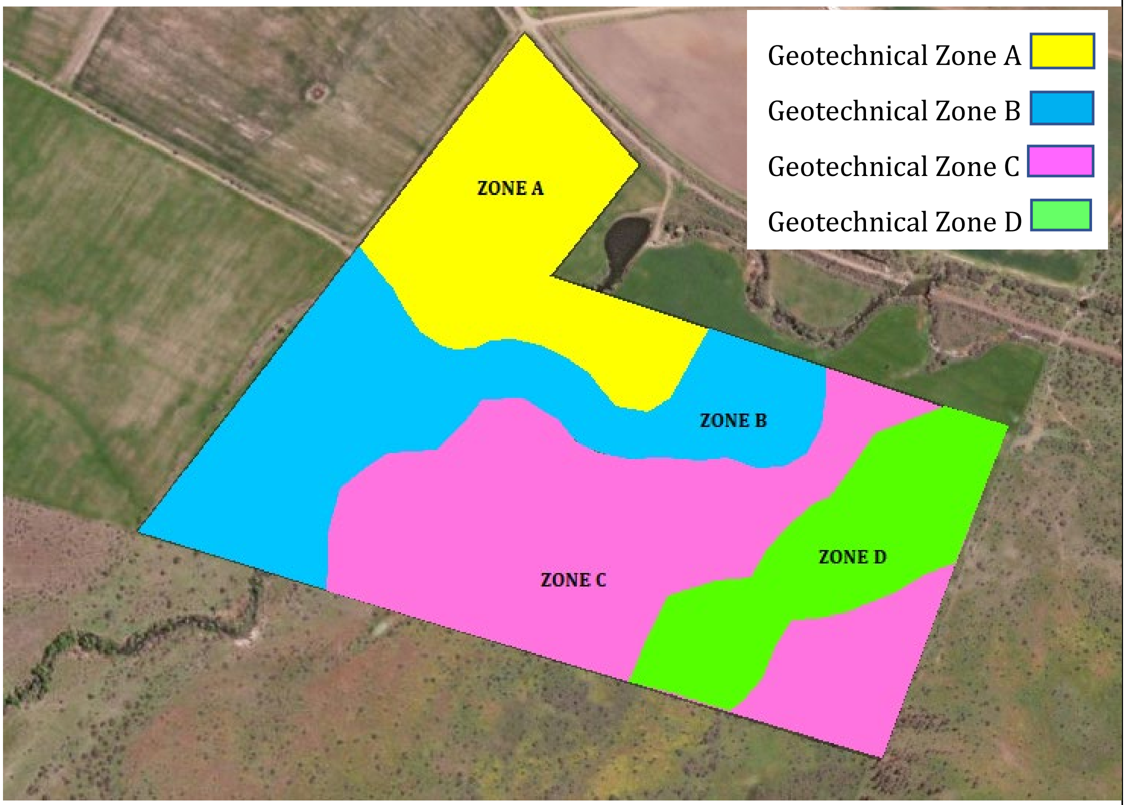
Table 16: Geotechnical characterization of site

G. Unit	Material Description	N_{SPT}	Compactness/ Consistency	Index Properties	Mechanical Properties			
				Unit Weight (kN/m^3)	Effective Cohesion (kN/m^2)	Undrained Shear Strength (kN/m^2)	Internal Friction Angle (°)	Elastic modulus (kN/m^2)
01	Topsoil (clayey SILT)	5	Soft	17	25	28	10	8000
02	CLAY	8	Soft	18	40	48	15	8000
03	Sandy GRAVEL	18	Medium compactness	20	-	-	32	39500
04	Silty SAND	26	Medium compactness	22	-	-	34	48000

Once the geotechnical units were characterized, the existing soil layer combinations in the plot were studied. As a result, four geotechnical zones were defined for the current project. The stratigraphy of the Geotechnical Zones is described in **Table 17** and depicted in **Figure 18**.

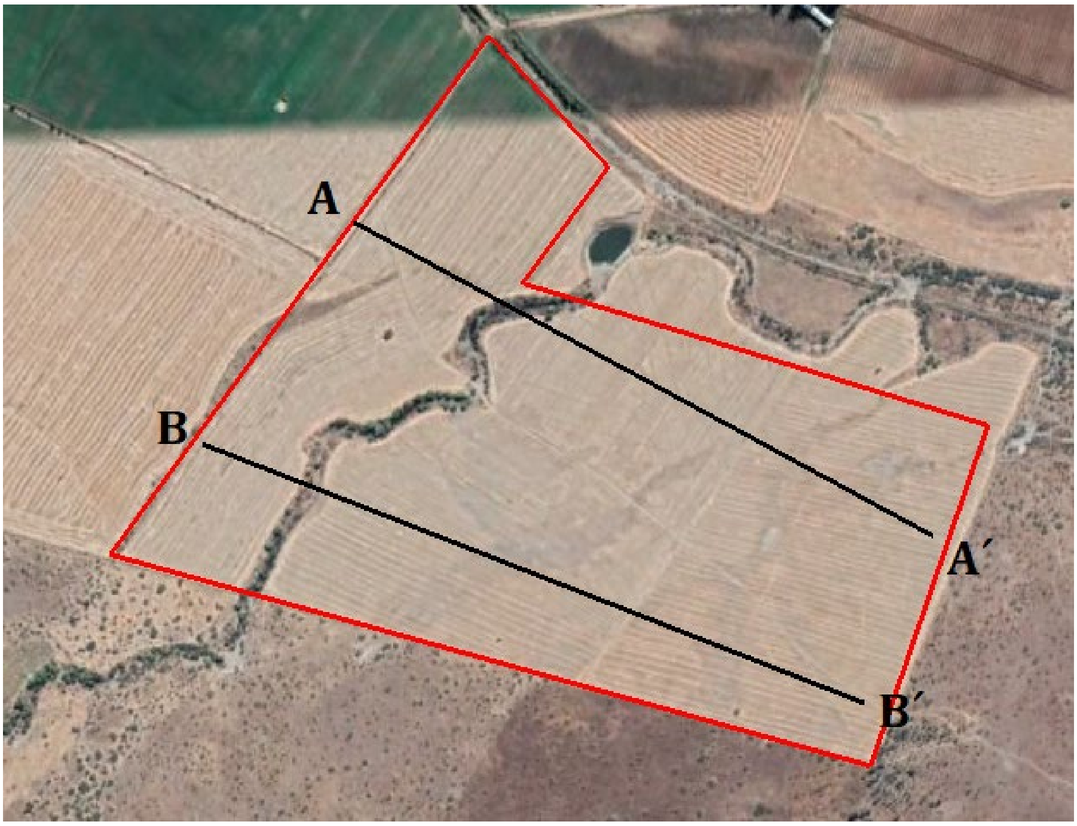
Table 17: Geotechnical zones

Geotechnical Zone	G. Unit	Depth (m)	Average Thick. (m)	Material description	N_{SPT}	Internal Friction Angle (°)	Elastic Modulus (kN/m²)
A	GU-01	0.00 – 0.40	0.40	Clayey SILT with organic material	5	10	8000
	GU-02	0.40 – 1.8	1,40	CLAY	8	15	8000
	GU-03	1.8 – 3.00	2.2	Sandy GRAVEL	16	32	39500
B	GU-01	0.00 – 0.30	0.30	Clayey SILT with organic material	5	10	8000
	GU-02	0.30 – 3.00	2.70	CLAY	8	15	8000
C	GU-01	0.00 – 0.40	0.40	Clayey SILT with organic material	5	10	8000
	GU-02	0.40 – 1.60	1.20	CLAY	8	15	8000
	UG-04	1.60-3.00	1.40	Silty SAND	18	34	48000
D	GU-01	0.00 – 0.40	0.40	Clayey SILT with organic material	5	10	8000
	GU-02	0.40 – 0.80	0.40	CLAY	8	15	8000
	GU-03	0.80– 3.00	1.3	Sandy GRAVEL LENS	18	34	39500
	GU-04	1.60–3.00	1.4	Sandy GRAVEL LENS	16	32	48000

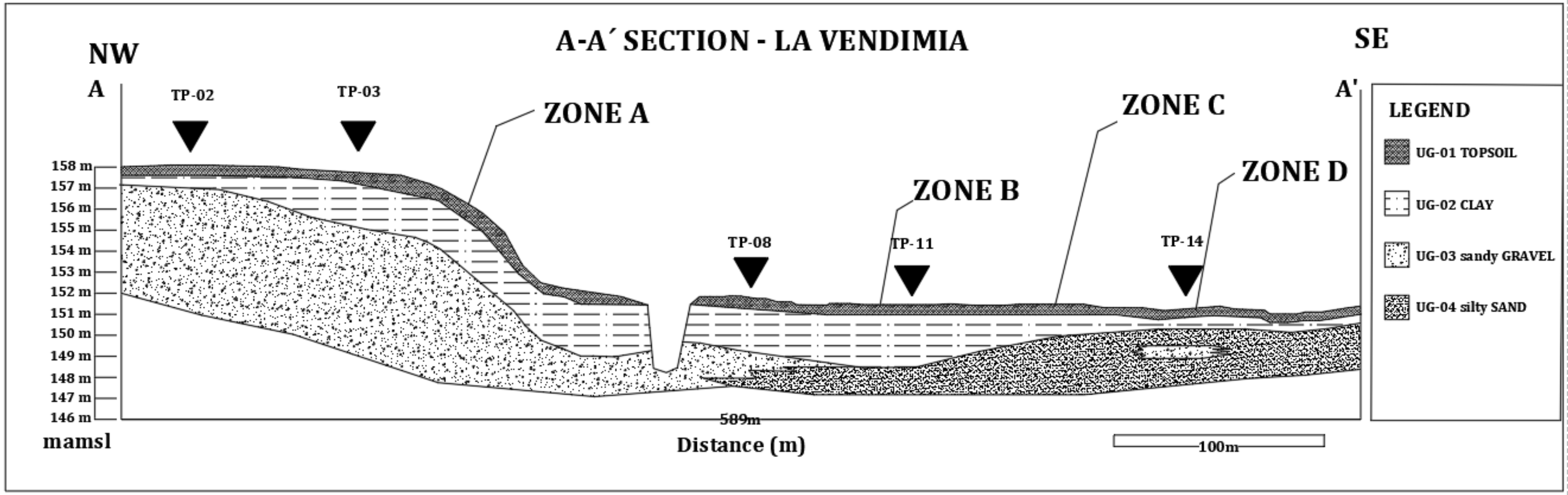


GMS INTERNACIONAL	**Project:** IG1827115a **Date:** 03/12/2021	**Figure 18:** Geotechnical Zones	Trinasolar

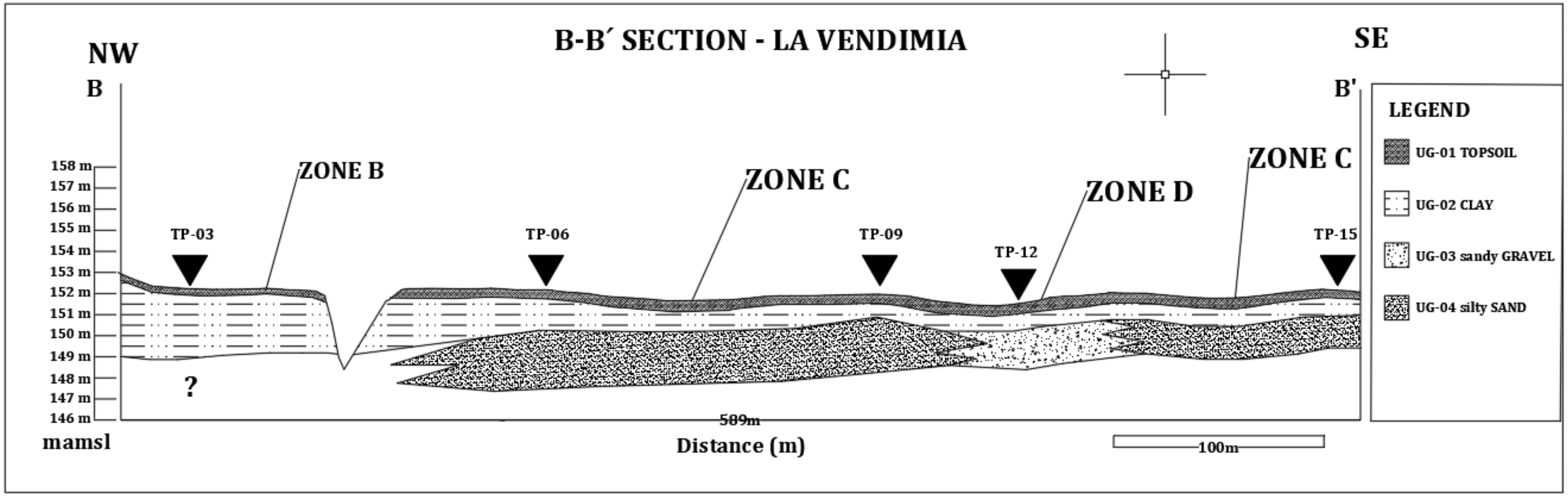
With the aim of further characterizing the geological bodies in the subsurface of the project site, the soil stratigraphy and layer distribution were approximated by means of geological cross-sections. The cross-sections are presented below (see **Figure 19**).



GMS INTERNACIONAL	**Project:** IG1827115a **Date:** 03/12/2021	**Figure 19:** Cross sections	Trinasolar



	Project: IG1827115a **Date:** 03/12/2021	**Figure 20:** NW-SE Cross section -A-A´	



	Project: IG1827115a **Date:** 03/12/2021	**Figure 21:** NW-SE Cross section -B-B´	

5.3. *Shallow foundation analysis*

This section presents the analysis for the shallow foundations to be considered in the possible locations for the transformer house or the power station.

LoadCap® software was used to evaluate the bearing capacity of the shallow foundations. The calculations were performed using the site soil profile based on the geotechnical tests executed at the project location.

The following assumptions were used to perform this analysis:

a) Computation as per layer's weighted averages.

b) Drained and undrained conditions as required.

c) Regulation: Eurocode 7.

d) Depth of analysed foundations are 0.5, 1.0 and 1.5 m below ground level.

e) Four different geotechnical zones have been analysed.

f) Three different foundation solutions have been analysed: mat foundation, strip footing and isolated footing.

g) For strip and isolated footing analysis, bending moments are not expected to occur on the foundation as those will be absorbed vertically by the foundation.

h) Efforts used to calculate bearing capacity are based on our in-house experience as no other information has been provided by the Client. The estimated weight of the proposed substation is a total of 150 kN, that will be uniformly distributed across the total foundation area.

i) The induced seismic load was calculated based on the self-weight of the substation as well as the peak ground acceleration defined in **Section 3.5**.

j) Settlement of the foundation has not been verified through the actual analysis.

It is important to note that the shallow foundation assessments which were calculated using the assumptions summarised above are indicative only, as they are dependent on the input parameters assumed herein. Should the actual design loads and/or foundation dimensions differ from those summarised above, then the shallow foundation analysis would need to be revisited to ensure that the foundation has enough capacity to support the loads exerted on it.

Whilst the actual substation location is unknown, the calculations presented below are indicative only and it is the responsibility of the design engineer and/or foundation engineer to use actual loads.

5.3.1. Mat foundation

In the present analysis a mat foundation has been assumed to resist the transformer loads. The bearing capacity and ballast module results for a 2.50x3.50m mat foundation set at 0.5, 1.0 and 1.5m depth are shown below.

Table 18: Bearing capacity of mat foundation

B (m)	L (m)	Geotechnical Zone	D (m)	Bearing Capacity (kN/m²)	Design Resistance (kN/m²)	Ballast Module (kN/m³)
3.5	**2.5**	A	0.5	41.63	23.13	1665
			1.0	58.82	32.68	2352
			1.5	99.20	55.11	3968
		B	0.5	105.27	58.48	4210
			1.0	110.07	61.15	4402
			1.5	114.88	63.82	4595
		C	0.5	56.23	31.24	2249
			1.0	65.15	36.20	2606
			1.5	138.93	77.19	5537
		D	0.5	46.65	25.91	1865
			1.0	96.48	53.60	3859
			1.5	145.43	80.79	5817

5.3.2. Strip footing

To perform this calculation, two strip footings have been assumed to resist the transformer load. The results obtained for the calculation of bearing capacity and ballast module for strip footings of 1.50x3.50 m side at 0.5, 1.0 and 1.5m depth are shown below.

Table 19: Bearing capacity of strip footing

B (m)	L (m)	Geotechnical Zone	D (m)	Bearing Capacity (kN/m²)	Design Resistance (kN/m²)	Ballast Module (kN/m³)
1.5	**3.5**	A	0.5	48.82	27.12	1952
			1.0	82.66	45.92	3306
			1.5	143.34	79.64	10312
		B	0.5	127.07	70.59	5082
			1.0	132.98	73.88	5319
			1.5	138.89	77.16	5555
		C	0.5	48.82	27.12	1952
			1.0	86.06	47.81	4366
			1.5	145.26	80.70	15708
		D	0.5	42.91	23.84	1716
			1.0	162.74	90.41	6509
			1.5	232.22	129.01	9289

5.3.3. Isolated footing

To perform this calculation, four isolated footings have been assumed to bear the transformer loads. The bearing capacity and ballast module for a 1.00m side isolated footing at 0.5, 1.0 and 1.5m depth are shown below.

Table 20: Bearing Capacity of 4 isolated footings

B (m)	L (m)	Geotechnical Zone	D (m)	Bearing Capacity (kN/m²)	Design Resistance (kN/m²)	Ballast Module (kN/m³)
1.0	**1.0**	A	0.5	220.57	122.54	8822
			1.0	230.07	127.82	9202
			1.5	271.28	150.71	10851
		B	0.5	220.67	122.60	8826
			1.0	230.17	127.87	9206
			1.5	239.67	133.15	9586
		C	0.5	220.57	122.54	8822
			1.0	252.27	140.15	10090
			1.5	428.13	267.85	19285
		D	0.5	106.46	59.15	4258
			1.0	451.91	251.06	18076
			1.5	570.74	317.08	22829

5.3.4. Settlement analysis

In light of the 150kN substation weight and assuming the substation will be built in Geotechnical Zone-A the settlements has been calculated according to "Guía de Cimentaciones en obras de Carreteras, 2009" standard.

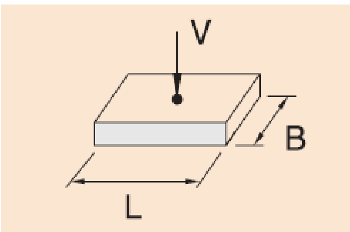
It is worth mentioning that soil settlement is composed of three different settlements: elastic or instant settlement, primary consolidation settlement and secondary consolidation settlement.

Primary consolidation settlements (short term and long-term settlements) were estimated based on the oedometer model. This type of calculation is particularly indicated when the cause of the deformation is the presence of soft clay soils under the foundation.

5.3.5. Instant settlement

Instant settlements were estimated based on the elastic modulus of the soil (E), using the methodology described in the official standard.

Table 21: Instant settlement for rigid isolated footing

Rigid foundations	
Isolated footing	Settlement
	$S = \dfrac{V \cdot (1 - v^2)}{1{,}25 \cdot E \cdot \sqrt{B \cdot L}}$ $L/B \leq 5$

5.3.6. Short term settlement

The settlement calculated according to the previous section corresponds to the end of the primary consolidation process.

For geometric configurations that can resemble the unidirectional oedometric condition (loads of great superficial extension on layers of clay of little thickness) the instantaneous settlement can be considered null.

The problem of non-unidimensional consolidation, which occurs when the compressible clay thicknesses are considerable compared to the plan dimensions of the loaded area, occurs simultaneously with the application of the loads, an initial or instantaneous settlement that must be calculated.

When the settlement problem in question is not critical, it can be calculated using the elastic model (**Table 21**), using as parameters:

$$E_{short\ term} = M \cdot S_u$$

$$V_{short\ term} = 0.5$$

Whereas:

S_u = Shear resistance without soil drainage

M = Constant of proportionality that is different for each specific case. Its value is between 100 and 200 but, on occasions, it may be outside that range.

5.3.7. Long term settlements.

The calculation of the oedometric settlement can be carried out at the centre of the support area.

The calculation was made by horizontal levels whose thickness, L_i, should be limited. In general, it is not considered necessary to consider more than ten different levels.

For each level, σ'_o and σ'_F will be determined, which are the effective vertical pressures at the centre of the level in question before applying the load σ'_o, and in the long term, after applying, σ'_F.

The strain (or shortening) at the centre of each of these levels is given by any of the following three expressions:

$$\varepsilon_i = \frac{1}{1+e_0}\left[C_c \cdot log_{10}\left(\frac{\sigma'_f}{\sigma'_0}\right)\right] \qquad \text{When } \sigma'_o \geq P_c$$

$$\varepsilon_i = \frac{1}{1+e_0}\left[C_s \cdot log_{10}\left(\frac{\sigma'_f}{\sigma'_0}\right)\right] \qquad \text{When } \sigma'_o \leq P_c$$

$$\varepsilon_i = \frac{1}{1+e_0}\left[C_s \cdot log_{10}\left(\frac{p_c}{\sigma'_0}\right) + C_c \cdot log_{10}\left(\frac{\sigma'_f}{p_c}\right)\right] \quad \text{When } \sigma'_o < P_c < \sigma'_f$$

Whereas:

ε_i = unit deformation or shortening in the centre of stratum i.

e = pore index

e_o = initial pore index

C_c = Compression coefficient

C_s = Swelling coefficient

σ' =Effective vertical pressure at the centre of the level considered.

σ'_o = Effective vertical pressure at the centre of the level considered before application of the load.

σ'_f = Effective vertical pressure I the centre of the level considered after application of the load.

P_c = Preconsolidation pressure

Once the unit shortening of each layer has been calculated, the desired settlement is:

$$S = \alpha \Sigma \varepsilon i L i$$

Whereas:

L_i = Layer thickness

α = Dimensionless coefficient that considers the greatest deformability that exist in the ground due to possible lateral expansion and which does not occur in the oedometric test.

The parameter **α** can be estimated by the equation:

$$\alpha = 1 + \frac{1}{2} \cdot \frac{H}{B} \leq 1.5$$

Whereas:

H = Depth of the compressible zone below the foundation plane

B = Width (or smallest dimension) of the loaded area

5.4. *Settlements' summary*

Based on the previous formulas, the expected total settlements have been determined for each type of foundation analyzed in sections **5.3.1, 5.3.2** and **5.3.3** , the **Table 22** in the next page shows the results obtained.

Spain
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08030 Barcelona
+34 93 782 36 65

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Col Roma Sur, CDMX
+52 1 733 105 0051

Chile
Camino El Alba 9500 B 323
Las Condes, Santiago de Chile
+56 2 223 7207

Table 22: Calculated settlement for each type of foundation

Foundation	Foundation depth (D, m)	Instant settlement (mm)	Short settlement (mm)	Long settlement (mm)	TOTAL settlement (mm)
Isolated footing	0.5	1.59	2.30	3.44	**7.33**
Isolated footing	1.00	0.93	1.02	1.23	**3.18**
Isolated footing	1.5	0.51	0.00	0.00	**0.51**
Strip footing	0.5	1.86	3.01	2.24	**7.10**
Strip footing	1.00	0.91	1.34	0.60	**2.84**
Strip footing	1.5	0.19	0.00	0.00	**0.19**
Mat foundation	0.5	2.88	4.66	7.97	**15.51**
Mat foundation	1.00	1.41	2.07	3.55	**7.02**
Mat foundation	1.5	0.30	0.00	0.00	**0.30**

The total settlement in all cases is less than 16 mm, which **is not thought to be critical for foundation stability.** Therefore, it may be assumed that the GU-02 does not represent a risk to the structure in the GZ-A zone. Please note that the topsoil has not been considered for this calculation as we recommended that it should be removed.

5.5. *Preliminary Recommendations for Shallow Foundation Construction*

Considering that there are no potential risks for shallow foundation, it is recommended to follow below general (non-binding) recommendations:

- Adequate substation drainage system. Installing a 15cm gravel layer and geotextile along with a layer of insulation sheets (extending beyond de foundation area) under the foundation to ensure that pore pressure build-up does not occur under the proposed foundation.
- The construction of flexible rather than rigid foundation systems to allow for possible small differential settlements/uprise movements.
- Removal of topsoil layer (GU-01) before the foundation installation as it may have a high-water content and low compactness. Also ensuring that, upon the removal of the vegetation and the consequent loosening and change in natural moisture content of the soil, the stability of the foundation will still be intact and not affected by the potential scour of the topsoil.
- Levelling and removal of all debris prior to the foundation installation, to ensure eccentric loads are not acting in the foundation.

Regarding the type of the foundation, it is important to bear in mind that the larger the foundation dimensions, less stress will be transmitted to the ground, in addition, the greater the embedment depth, the less the expected seat will be, therefore, although the settlements are minimal for the area where the substation is to be built (GZ-A) and considering the points mentioned above, it is possible to assume that the **ground is stable under the loads**

and foundations analysed, however, **it is recommended to use mat foundations at low depth (0.5m to 1.0m) to mitigate differential settlements as much as possible.**

Since **water table was observed in the southern zone of the plot**, where shallow water depths due to intense rainfall may be reached**, if the substation base would be placed in that very area it should be placed above ground level and adequate drainage system shall be designed**, additionally, it is recommended to use plum concrete would be water-resistant.

Other recommendations for shallow foundation design across the study area:

- A different solution would entail setting the foundation level at -1.5m depth below the clay layer where the structural load is partially compensated by the weight of removed soil. Hence, an almost complete reduction of settlements would be expected. In this case, appropriate water-proof isolation system shall be duly implemented to avoid water entering the foundation system.
- Regarding electrical power transformers, it may be also doable to build a mat foundation that distributes the loads and prevents differential settlements, then install a geotextile membrane below the foundation to prevent pore pressure build-up, following the same design procedure as mentioned above.
- According to the results obtained in **section 5.3**, **it is not recommended to build the substation and / or additional buildings in the GZ-B**, because the thickness of the GU-02 clay is greater as shown in **Figure 21**, therefore the levels Consolidation will be greater than those calculated in **section 5.3**. According to the information provided by the client, there are no significant structures located in this geotechnical zone, therefore, in case of redesigning the PV layout, it is necessary to calculate the expected settlements based on the new location of the structures.

5.6. *Pile Foundation*

5.6.1. Pile rammability

After carefully analysing the trial pits in conjunction with the penetrometer tests and VES, **the direct ramming of piles may be expected to be feasible across the site all the way from 1.5m depth** down, therefore **predrilling may not be required**. However, please note that due to **presence of gravels at shallow depth, shallow refusal risk may as well be encountered**, meanly in the northern zone, where the presence of gravel layers is more frequent. Pile H-shaped sections may be robust enough to pass through that layer and therefore be rammed without predrill. Otherwise, C-shaped sections may not be directly rammed despite its section's thickness; hence, **it is highly recommended that Pull-Out test are carried out to evaluate the feasibility of C piles direct ramming**, which would provide more reliable geotechnical results based on direct tests, while the following issues would be addressed:

- Feasibility to directly drive piles on the study area for the different pile types.
- Predrill and refill with debris ramming option feasibility and resistance.

- Different pile sections may be studied so that different soil-structure behaviors are analyzed.
- More accurate geotechnical parameters based on direct tests may be obtained.

5.7. *Slope stability*

A slope stability assessment was carried out for the identified geotechnical zones present in the study area considering their stratigraphy.

The analysis has been carried out for a maximum slope depth of 3.0 meters and for temporary and long-term conditions. The results are presented in the next table.

Table 23: Stable slopes

Geotechnical Zone	Trench Depth (m)	Temporary slope (H/V)	Long-term slope (H/V)
A	1.0	1/5	1/5
	2.0	1/5	1/5
	3.0	1/5	1/3
B	1.0	1/5	1/5
	2.0	1/5	1/5
	3.0	1/5	1/5
C	1.0	1/5	1/5
	2.0	1/5	1/3
	3.0	1/5	1/3
D	1.0	1/5	1/5
	2.0	1/3	1/3
	3.0	4/5	4/3

5.8. *Surface Water Level*

During the field works, water table was found at 1.1 m depth during the month of October 2021. Please be advised, however, that groundwater levels may fluctuate with rainfall, drainage, and levelling.

5.9. *Seismicity and liquefaction*

This analysis is based on the available seismic coefficients also summarized in **Figure 7**, as well as the data collected during the field works campaign. Based on that, the maximum peak ground acceleration is 0.4·g m/s^2 for a return period of 475 years. These values are expected to produce seismically induced dynamic loads that may be critical.

Liquefaction occurs when certain types of soils affected by earthquakes develop high interstitial pressures quickly (without drainage), resulting in a loss of resistance to shear and soil breakage, which behaves as if it were a liquid (VALLEJO, L. I. G.; FERRER, M.; ORTUÑO, 2002).

This phenomenon causes foundation failure, slope breakage and landslides.

As observed in areas affected by liquefaction (VALLEJO, L. I. G.; FERRER, M.; ORTUÑO, 2002) this takes place in the following circumstances:

- Earthquakes with magnitude equal or greater than 5.5 with acceleration greater than or equal to 0.2·g.
- Below 15 meters deep there have been no liquefaction.
- In most cases water table was shallow, less than 3 meters; below 5 meters liquefaction susceptibility is very low.

Properties that characterize liquefiable soils are the following:

- Degree saturation of 100%.
- Average diameter D_{50} between 0.05 and 1.00 mm.
- Coefficient of uniformity $Cu=D_{60}/D_{10}<15$.
- Fine content less than 10%.
- Low degree compaction: N<10 for depths < 10m and N<20 for depths >10.

In one trial pit only, groundwater was observed through the pores of the walls thereof, however, at the time of the study, (October) rainfall conditions were moderately low; therefore, it is expected that during peak rainfall season, the water table may raise to shallower depths. Despite these conditions, rather compact granular materials as well as presence of cohesive soil makes **soil liquefaction quite unlikely during a seismic event.**

6. ROAD MATERIALS

The feasibility of the use and classification of the existing material as subgrade for the proposed roads in the study area was analysed.

This study is based on the laboratory CBR tests carried out, as well as in the particle size distribution and mechanical properties of the analysed materials in accordance with the applied regulations (Highways England, 2009) and AASHTO classification.

The soil was preliminary classified based on the AASHTO classification system to determine its suitability as a subgrade material as shown in **Table 24.** The classification is based on the geotechnical properties of the soil measured by laboratory tests, such as granulometry, Atterberg limits laboratory and California Bearing Ratio. In the absence of specific design conditions, the present analysis should be considered as preliminary only.

Table 24: ASSHTO Classification

AASHTO Classification
A-2-7/A-4/A-2-4

Additionally, during laboratory works, the Modified Proctor tests were performed in 5 samples and the results are presented in **Section 4.7.2.8** (**Table 12**). These results show values from 1.81 to 2.02 g/cm^3 of maximum dry density and 8.3% to 13.0% of optimal moisture content.

Through the study area two different soil behaviours have been made evident; the first one (‘*CBR Zone 1*’) presents a CBR value from 12% - 14.87% in the zones where clay material is present, while ‘*CBR Zone 2*’ presents a CBR value starting at 25.13% in zones where gravel is more likely (see **Figure 23**). It should be noted that the vegetal layer, which is estimated to fill the upper 40 cm of soil, must be removed due to its high organic matter content and low compaction.

GMS INTERNACIONAL	**Project:** IG1827115a **Date:** 03/12/2021	**Figure 22:** CBR Zones	Trinasolar

The subgrade surface modulus of the soil was estimated based on the measured CBR laboratory value. According to international guidelines (Highways England, 2009), the estimated subgrade surface modulus (E) of the soil for a CBR value of 12% and 25% are **E= 70MPa, 103MPa respectively**, based on the following formula (Highways England, 2009):

$$E\ (MPa) = 17.6 \cdot (CBR)^{0.55}$$

It is also worth mentioning that the CBR laboratory value differs from the CBR in-situ tests due to the different testing and material conditions.

7. CORROSION ASSESSMENT

7.1. Corrosivity to concrete

According to the reference standards (UNE 83962-08), it is determined that soil is aggressive against concrete for Baumann-Gully acidity greater than 200 ml/kg. According to the laboratory results (**Table 25**), this value is not exceeded with in the retrieved samples.

Table 25: Results of Baumann-Gully and Sulphate test performed in samples.

Sample ID	Depth (m)	Baumann-Gully Acidity (ml/kg)	Sulphate on soil (SO_4) (mg/kg)	Sulphate on soil (SO_4) (%)
TP-01	1.5	21.5	206	0,0206
TP-03	0.9	18.8	178	0,0178
TP-10	2.0	23.7	182	0,0182

In addition, according to national standard (NCh170_2016, n.d.) as the sulphate content of the soil does not exceed the 0.10% weight horizon, it is considered as **not aggressive** and therefore it is classified as **'S0 Class'**.

Based on the results of the Baumann-Gully test, as well as sulphate (SO_4) tests for this project, it is considered that **there is no aggressiveness of the soil against concrete structures**.

7.2. Corrosivity to metal piles

Chemical laboratory tests have been performed on soil samples recovered from the study area. The results are shown in the following table:

Table 26: Results of chemical test performed in samples

Sample ID	Depth (m)	Chloride	Sulphate (SO4)	Organic Matter	Soluble Salts	RedOx	pH
		ppm	ppm	%	%	mV	
TP-01	1.5	45	206	2.65	0.26	178	6.9
TP-03	0.90	26	178	1.96	0.08	189	6.7
TP-04	0.60	29	171	2.12	0.06	181	6.8
TP-06	1.90	29	171	2.34	0.04	185	7
TP-08	1.40	23	153	2.75	0.06	162	6.9
TP-10	2.00	36	182	3.07	0.18	206	7
TP-12	0.60	32	189	2.81	0.13	187	7.1
TP-14	1.50	34	197	2.79	0.21	193	6.9

The laboratory minutes referring to these tests are included in **Annex 9**.

7.2.1. NACE standard

The soil corrosivity was evaluated for the current project according to the official standard NACE (NACE_RP-5002, 2002) based on the previous laboratory results.

According to the NACE standard, soils are classified as:

Table 27:NACE standard soil classification

Parameter	Corrosivity	Concentration (NACE) in ppm	Collected soil samples concentration in ppm	Associated corrosivity range
Chloride	Severe	>5000	23-45	**Low**
	High	1500 – 5000		
	Corrosive	500 – 1500		
	Low	<500		
Sulphate	Severe	>10000	153-206	**Corrosive**
	High	1500 – 10000		
	Corrosive	150 – 1500		
	Low	<150		
pH	Severe	<5.5	6.7-7.1	**Corrosive**
	High	5.5 – 6.5		
	Corrosive	6.5 – 7.5		
	Low	7.5 - 9		

The assessed values are presented in following table as results.

Table 28: Summary soil corrosion according to NACE standard.

Sample ID	Depth (m)	Geotechnical Unit	Aggressivity level		
			Chlorides	**Sulphates**	**pH**
TP-01	1.5	GU-03	Low	Corrosive	Corrosive
TP-03	0.90	GU-02	Low	Corrosive	Corrosive
TP-04	0.60	GU-02	Low	Corrosive	Corrosive
TP-06	1.90	GU-04	Low	Corrosive	Corrosive
TP-08	1.40	GU-02	Low	Corrosive	Corrosive
TP-10	2.00	GU-04	Low	Corrosive	Corrosive
TP-12	0.60	GU-02	Low	Corrosive	Corrosive
TP-14	1.50	GU-04	Low	Corrosive	Corrosive

From the results above (**Table 28**), it can be noted that the materials found in **Geological Units** correspond to corrosivity values from **'Low'** to **'Corrosive'** soil type, suggesting that coating of steel piles may be required.

7.2.2. AWWA standard

The soil corrosivity was evaluated for the current project according to the AWWA C-105 standard (AWWA Standard - Pipe corrosion, 2004) based on the previous laboratory results.

According to the AWWA C-105, soils are classified as:

Table 29: Values for determining the degree of corrosion using AWWA standard

Parameter	Results	Index
Resistivity, ρ (Ω·m)	<15	10
	15 – 18	8
	18 – 21	5
	21 – 25	2
	25 - 30	1
	>30	0
pH	0 – 2	5
	2 – 4	3
	4 – 6.5	0
	6.5 – 7.5	0
	7.5 – 8.5	0
	>8.5	3
Redox Potential, E_{redox} (mV vs. enh)	>100	0
	50 - 100	3.5
	0 - 50	4
	<0	5
Humidity	Always wet	2
	Usually wet	1
	Usually dry	0

Additionally, based on the aforementioned parameters, the soil is classified with a corresponding level of potential corrosivity. The soil classes and its respective corrosive potentials are summarised in:

Table 30: Soil aggressiveness according to AWWA standard

Total (s)	Aggressiveness
s ≥ 10	Very corrosive
8 ≤ s ≤ 10	Corrosive
5 ≤ s ≤ 8	Moderate
2 ≤ s ≤ 5	Slightly corrosive
0 ≤ s ≤ 2	Very slightly corrosive

The assessed values are presented in following table as final results.

Table 31: Corrosion grade results according to AWWA C-105

Sample ID	Depth (m)	Geotechnical Unit	Aggressivity level
TP-01	1.5	GU-03	Slightly corrosive
TP-03	0.90	GU-02	Slightly corrosive
TP-04	0.60	GU-02	Very slightly corrosive
TP-06	1.90	GU-04	Very corrosive
TP-08	1.40	GU-02	Slightly corrosive
TP-10	2.00	GU-04	Moderate
TP-12	0.60	GU-02	Moderate
TP-14	1.50	GU-04	Moderate

From the results above (**Table 31**), it can be noted that the soil corrosion varies from ´slightly corrosive´ to ´very Corrosive´, this variation is observed from west to east respectively, therefore, that **coating of steel piles is recommended**; it is worth mentioning that the degree of corrosion may also vary with depth, however, there are currently no geochemical data to better define areas of high corrosive potential.

8. CONCLUSIONS AND RECOMMENDATIONS

GMS Internacional Chile SPA has been hired by Trina Solar to carry out a Geotechnical survey on the La Vendimia PV Project, located about 4 km from Cauquenes city, in the Maule region. The coordinates of the project area are 743989 m E and 6013574 m N, with an elevation of approximately 140 meters above the sea level.

A total of 15 trial pits, 15 VDCP (Panda2), 5 California Bearing Ratio (CBR) tests in situ, 4 Vertical Electrical Soundings and 4 Thermal resistivity Tests were performed for this project. During the execution of the excavations, 15 altered and 2 unaltered soil samples were collected to perform physical and chemical analysis directly in the laboratory, such as moisture analysis, sieve analysis, Atterberg limits, density of soil, the Baumann-Gully acidity test and other analyses previously mentioned.

8.1. *Geotechnical characterization*

Based on the information obtained in the field and laboratory testing, four geotechnical units were determined with the following parameters (**Table 15**) and four geotechnical zones are defined for the whole site (**Table 17** and **Figure 18**)

During the fieldwork carried out in October 2021, Only in TP-15 groundwater was found at 1.10m depth through the pores of the walls thereof. The water levels may fluctuate with rainfall, drainage, and levelling.

8.2. *Geotechnical assessment*

8.2.1. Shallow foundations

The shallow foundation analysis was performed; the loads and dimensions used are based on the information assumed and detailed herein.

Regarding the construction of shallow foundations as a general rule, the **following recommendations have been yielded:**

- The **ground is stable under the loads and foundations as analysed herein**.
- **It is recommended to use mat foundation at 0.5m to 1.0m to mitigate differential settlements as much as possible;**
- A greater embedment depth, may decrease settlements if layer is different from clay;
- Shallow foundations should be installed on an even, levelled ground so that no eccentric load acts on foundations due to irregular terrain;
- Shallow foundations should be installed bellow the topsoil (GU-01), removing it from the ground before foundation construction;
- Install a bed of gravel and geotextile underneath the foundation.

If design loads, foundation dimensions, foundation conditions, and/or the actual location differ from those summarized above, the analysis of the shallow foundation should be reviewed to ensure that the foundations have enough capacity to support the loads.

8.2.2. Rammability

Following detailed data analysis, it is concluded that **the direct ramming of piles may be feasible from 1.5m depth across the site**, therefore **predrilling may not be required**. **Due to the presence of gravels at shallow depth, however, shallow refusal may be anticipated as well**, meanly in the northern zone, where the presence of gravel layers is more frequent. Due to that variability, **it is highly recommended to carry out a pull-out test campaign** so that the following aspects may be assessed:

- Feasibility to directly drive piles across the study area for the different pile types (particularly C-piles);
- Predrill and refill with debris ramming option feasibility and resistance;
- Different pile sections are studied so that different soil-structure behaviors are analyzed;
- More accurate geotechnical parameters based on direct tests.

8.2.3. Slope stability

A general slope stability assessment of the site was carried out within the identified Geotechnical zones identified considering its stratigraphy. Analysis have been performed for different slope depths and for temporary and long-term conditions and its results are presented below.

Stables slopes were calculated, and results are shown in **Table 22**

8.3. *CBR testing*

A total of 5 in situ CBR tests were performed in the survey area. Two behavior was observed: CBR-03 and CBR-0.4 reached 1.00m depth, with low CBR percent values, between 5 and 20. Instead, The CBR-01, CBR-02 and CBR-05, reached CBR higher values, between 20 and 50 below 0.60m depth.

8.4. *Vertical Electrical Soundings (VES)*

A total of 4 VES were performed across the site. In general, the lowest value of apparent resistivity is 0.84 Ohm·m at 1.88 m depth in VES-02, while highest value is 329.21 Ohm·m at 0.44 m depth in VES-05. Two main families may be observed.

The first behaviour is characterized by low electrical resistivity values from 8 to 68 Ohm·m in the first meter, these values indicate the presence of clay materials at the top, later the resistivity values increase with depth until reaching values of up to 128 Ohm·m, which correspond to granular materials, finally the resistivity drops again to values of up to 21 Ohm·m, which suggests an increase in humidity or presence of water at depths greater than 5m.

The second behaviour is characterized by having high values of electrical resistivity at the top, with values of up to 329 Ohm·m that correspond to fine materials and gravels with low humidity, later the resistivity decreases reaching values of 20 Ohm·m, suggesting an increase in the water content. this behaviour is maintained up to a depth of approximately

8 m, below this depth, the values suggest a lithological change represented by slight increases in electrical resistivity.

The results obtained are shown in **Annex 4**.

In terms of corrosion, low resistivity values produce high corrosivity grade.

8.5. *Road materials*

Through the study area two different soil behaviours have been evidenced; the first one ('*CBR Zone 1*') presents a CBR value of 12 while the second zone ('*CBR Zone 2*') presents a CBR value from 25.

In the absence of specific design conditions, the present analysis should only be considered as preliminary.

The estimated subgrade surface modulus (E) of the soil for a CBR value of 12% and 25%, are **E= 70MPa, and E=103MPa respectively**.

8.6. *Risks*

8.6.1. Soil Corrosivity

8.6.1.1. *Concrete*

Based on the results of the sulphate (<10%) and Baumann-Gully tests (absent for tests performed) for this project, soil is considered as **not aggressive** against concrete.

8.6.1.2. *Metal piles*

In general, according to NACE- RP-5002 and AWWA C-105 standards soil corrosion ranges from low to very corrosive.

A variation of soil corrosion according to depth and geographic location of the samples is observed. According to the AWWA C-105 regulation, the western area of the project presents low soil corrosion values, while the eastern area presents highly corrosive values.

It is recommended to conduct a soil corrosion survey in accordance with DIN 50929 standard, which uses a broader set of chemical tests than used in this report to determine the degree of soil corrosion more accurately.

8.6.2. Geotechnical risks

The main risk detected in this study is the presence of gravel due to the variation in the depth in which they appear, in addition to the fact that they can also appear in the lenses form, which could refuse the piles installed by ramming direct.

8.6.1. Expansivity and Swelling potential

Clay expansivity is generally associated with a high liquid limit and plasticity index. According with the laboratory tests results, no high plasticity clays were encountered across the study area. For that reason, **expansivity and swelling potential is not considered a risk** for the actual project.

8.6.2. Geomorphological risks

The project site is situated in a relatively flat area. Some vegetation was found next to channels that could lightly impact the construction.

It should be borne in mind that the removal of trees and vegetation from site may cause the loss and/or loosening of the topsoil.

8.6.3. Hydrological risks

Please refer to GMS Internacional separate hydrological assessment report.

8.6.4. Seismic risks

Based on the previously mentioned information, the maximum peak ground acceleration is 0.4 m/s^2 for a return period of 475 years. Based on the calculations performed **seismic loads may be critical** in the design of shallow foundations. In addition, **soil liquefaction is not expected to occur** during a seismic event.

9. BIBLIOGRAPHY

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10. LIMITATIONS AND EXCEPTIONS

This geotechnical report has been prepared by GMS Internacional Chile SPA for the exclusive use of Trina Solar and their design team for specific application to the proposed project.

I. The work on the project has been carried out in accordance with reasonable and acceptable engineering practices. No other warranty, either written or implied, is applicable to this project.

II. Subsurface conditions may vary from those encountered at the test pits and test locations. The field tests and probe logs are intended to represent solely the conditions at each location when the sampling occurred.

III. Classifications of the recovered soil samples are based on recognised standards.

IV. The interpretations and recommendations in this report are based solely on the information available at the time this report was prepared.

V. If the location or design of the structures is altered, the conclusions and recommendations presented herein should not be considered valid unless GMS Internacional, SL has been given the opportunity to review the changes.

VI. It is strongly recommended that GMS Internacional, SL is provided with the opportunity for a general review of the final design and specifications in order that the earthwork and foundation recommendations may be properly interpreted and implemented. If GMS Internacional, SL is not accorded the privilege of making this review, we can assume no responsibility for the misinterpretation of our recommendations.

VII. The nature and extent of variations between exploration locations and observed conditions may not become evident until construction. It is suggested that GMS Internacional, SL be retained to provide continuous soil engineering services during the earthwork and foundation construction phases of the work. This is to observe compliance with the design concepts, specifications and/or recommendations and to allow design changes if subsurface conditions differ from those anticipated prior to construction.

VIII. The use of the information contained in this report for bidding purposes should be done at the client's option and risk.

IX. This report, including its conclusions, recommendations and findings should be related to the terms and conditions and the scope of works agreed between the Consultant and the Client. The words PRELIMINARY or DRAFT written on any page throughout the report meas that the information contained therein shall NOT be considered for construction design.

X. Both the Executive Summary and the Conclusions and Recommendations sections of this report should not be specifically relied upon out of the content of the whole report and particularly out of the context and the development, if any, proposed.

XI. Any assessments made in this report are based on the ground conditions as revealed by the exploratory works, which may include boreholes, open pits or any further geotechnical and geophysical techniques, together with the results of any field or laboratory testing undertaken and, where appropriate, other relevant data which may have been obtained for the sites including previous site investigation reports. Any special conditions appertaining to the site which have not been revealed by the abovementioned site investigation may therefore have not been considered in the report. The assessment may be subject to amendment in the light of additional information becoming available. Any amendments shall be issued after the Client has accepted the initial version. The Consultant will inform the Client about any version released after the initial report has been accepted.

XII. Any recommendations and interpretations contained in this report represent the consultant's opinion only. This opinion has been arrived at in accordance with currently accepted geotechnical and geophysical industry practices at the time of reporting and based on current legislation in force at that time.

XIII. GMS Internacional does not accept any liability for the stainless steel pile's structural calculations, including connections between the stud and the superstructure, the pile's resistance to external acting forces and the pile's own structural settings including pile length.

XIV. The calculations in this report have been carried out following ultimate limit state models. Such models do not fully represent actual soil behaviour or the behaviour of the structure. Hence, such models must be regarded as tentative only and they should solely be used in preliminary design stages. In-situ tests, as well as laboratory-based tests, shall be carried out to validate the results herein.

XV. Ramming in and pull out tests shall be carried out whenever so required in order to obtain actual traction and actual load parameters of soils, thereby validating or disregarding any assumptions and recommendations in this report. A lateral load test must be carried out on site in order to validate the working hypothesis. Both horizontal and vertical stress shall be accounted for in all tests. Calculations and pull-out maps are, therefore, for orientation only and should not be used for design purposes without having verified actual pull-out strengths on the field.

XVI. Estimated refusal depths are for orientation purposes. Only those locations where dynamic percussion tests (dynamic penetration or SPT tests) have been carried out hold actual information on refusal depth. Refusal depths different from those obtained in this report shall be conveniently determined.

XVII. The driving machine shall be sufficiently powered in order to achieve the desired ramming depth.

XVIII. The final stud (stain steel piles) design and length is the sole responsibility of The Client.

XIX. In no case, should the studs be hammered until the upper end is deformed. If required, the upper excess stud length shall be cut off.

XX. Should further assessment on corrosion of studs be needed, additional soil samples shall be tested and full corrosivity tests performed. Where the data available from previous site investigation reports, as supplied by the Client, has been used, it has been assumed that the information is correct. No responsibility can be accepted by the Consultant for inaccuracies within the data supplied.

XXI. The opinion of the possible configuration of strata between or beyond exploratory holes, pit locations or such, or on the possible presence of features based on visual, verbal or published evidence, is for guidance only and no liability can be accepted for the accuracy.

XXII. Comments on groundwater conditions are based on observations made at the time of the investigation unless otherwise stated. It must be borne in mind that groundwater levels vary due to seasonal or other effects.

XXIII. The copyright in this report and other plans and documents prepared by the Consultant is owned by him and no such report, plan or document may be reproduced, published, or adapted without his written consent. Complete copies of this report may, however, be made and distributed by the Client as an expedient in dealing with matters related to its commission.

XXIV. This report is prepared and written in the context of the proposals stated in the introduction to this report and should not be used in a differing context. Furthermore, new information, improved practices and legislation may necessitate an alteration to the report in whole or in part after its submission. Therefore, with any change in circumstances or after the expiry of one year from the date of the report, the report should be referred to the Consultant for re-assessment and, if necessary, re-appraisal.

XXV. Whatever the materials and structures beyond survey limits (horizontal and vertical) may be, they may have not been taken into consideration for the bearing capacity and settlements analysis of shallow foundations and piles. The calculated bearing capacity and allowable settlement model are for information only; design figures should be taken from each individual SPT test.

GEOTECHNICAL REPORT LA VENDIMIA PV SOLAR PROJECT, MAULE (CHILE)

Annex 1: Site Location Map

Issued by:

GMS Internacional Chile SPA

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Las Condes, Santiago de Chile
Chile

P +56 2 223 7207

info@gmsinternacional.com
www.gmsinternacional.com

Submitted to:

Trina Solar Holdiing

Nueva Tajamar 555, of 1501
Las Condes, Santiago de Chile
Chile

www.trinasolar.com

1. Project's Location

Illustration 1: Site Location

GEOTECHNICAL FACTUAL REPORT
LA VENDIMIA PV SOLAR PROJECT
MAULE (CHILE)

Annex 2: Trial Pit Logs

Issued by:

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Submitted to:

Trina Solar

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1. Trial Pit's Location

Illustration 1: Trial Pit Location

Spain
Calle Cuba 7, Local
08030 Barcelona
+34 93 782 36 65

México
Vto. Presidente M Aleman 189
Col Roma Sur, CDMX
+52 1 733 105 0051

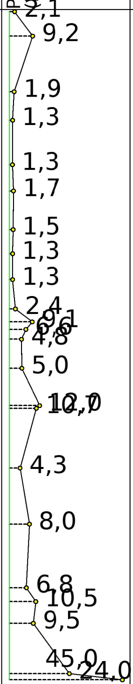
Chile
Camino El Alba 9500 B 323
Las Condes, Santiago de Chile
+56 2 223 7207

TRIAL PIT LOG

Consultant:	GMS Internacional, S.L.	Number:	TP-01
Client:	Trina Solar	Coordinates X Y (m):	X:743868; Y:6013928
ID Project:	IG1827115a_La Vendimia	Date:	14/10/2021

Comments
END OF TRIAL PIT: 3.10m

Scale (m)	Lithology	Description	Depth (m)	Sample	Water Table	Resistivity mk/W	PANDA2 (MPa)	Photography
		TOPSOIL: soft brown clayey SILT, slightly moist.	0.30					
		Firm dark brown CLAY, slightly moist.	0.70					
1 / 2		Dense light brown sandy GRAVELS, dry. Rounded to Sub-rounded centimetric gravels.	3.10	R 1.50 – 1.55				



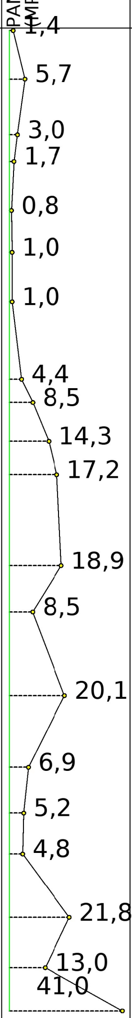
Samples: S-Thin walls, O-Osterberg, M-Mazier, R-Reworked, Rs- SPT reworked
Piezometer: ATA-Open tube, CSG-Casagrande

TRIAL PIT LOG

Consultant: GMS Internacional, S.L.	Number: TP-02
Client: Trina Solar	Coordinates X Y (m): X:743798; Y:6013847
ID Project: IG1827115a_La Vendimia	Date: 14/10/2021

Comments
END OF TRIAL PIT: 3.00m

Scale (m)	Lithology	Description	Depth (m)	Sample	Water Table	Resistivity mk/W	PANDA2 (MPa)	Photography
		TOPSOIL: soft brown clayey SILT, slightly moist.	0.40					
1		Moderately dense dark brown clayey GRAVELS, moist.	1.50	R 0.80 – 0.85				
2		Dense to very dense brown sandy GRAVELS, slightly moist.	3.00					



Samples: S-Thin walls, O-Osterberg, M-Mazier, R-Reworked, Rs- SPT reworked
Piezometer: ATA-Open tube, CSG-Casagrande

TRIAL PIT LOG

Consultant: GMS Internacional, S.L.
Client: Trina Solar
ID Project: IG1827115a_La Vendimia

Number: TP-03
Coordinates X Y (m): X:743813; Y:6013761
Date: 14/10/2021

Comments
END OF TRIAL PIT: 3.00m

Scale (m)	Lithology	Description	Depth (m)	Sample	Water Table	Resistivity mk/W	PANDA2 (MPa)
		TOPSOIL: soft brown clayey SILT, slightly moist.	0.40				1,8; 3,2; 1,9; 1,2
1		Soft dark brown CLAY, slightly moist.	2.80	R 0.90 - 0.95		0.515 - 0.70	1,3; 1,1; 1,6; 1,2; 1,8; 2,1; 2,3; 3,1; 3,1; 2,4; 3,6; 2,9; 3,5; 13,7; 16,5; 6,2; 7,4; 24,8
2		Dense light brown clayey GRAVELS, dry.	3.00				

Photography

Samples: S-Thin walls, O-Osterberg, M-Mazier, R-Reworked, Rs- SPT reworked
Piezometer: ATA-Open tube, CSG-Casagrande

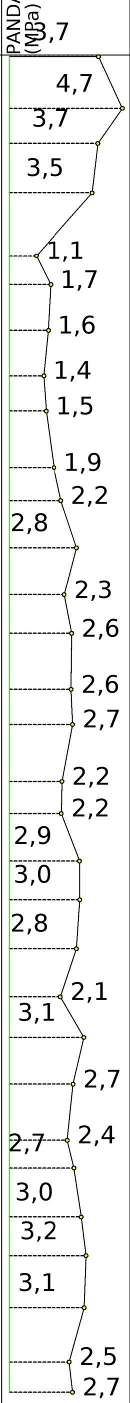
TRIAL PIT LOG

Consultant: GMS Internacional, S.L.
Client: Trina Solar
ID Project: IG1827115a_La Vendimia

Number: TP-04
Coordinates X Y (m): X:743729; Y:6013692
Date: 14/10/2021

Comments
END OF TRIAL PIT: 3.00m

Scale (m)	Lithology	Description	Depth (m)	Sample	Water Table	Resistivity mk/W	PANDA2 (MPa)	Photography
		TOPSOIL: soft dark brown silty CLAY, dry.	0.30					
1		Soft dark brown CLAY, moist.		0.60 R 0.65				
2			3.00					



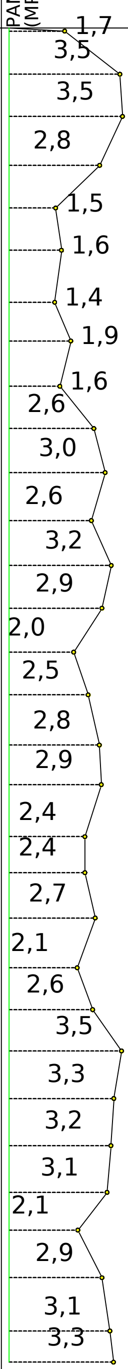
Samples: S-Thin walls, O-Osterberg, M-Mazier, R-Reworked, Rs- SPT reworked
Piezometer: ATA-Open tube, CSG-Casagrande

TRIAL PIT LOG

Consultant: GMS Internacional, S.L.	Number: TP-05
Client: Trina Solar	Coordinates X Y (m): X:743628; Y:6013619
ID Project: IG1827115a_La Vendimia	Date: 14/10/2021

Comments
END OF TRIAL PIT: 3.00m

Scale (m)	Lithology	Description	Depth (m)	Sample	Water Table	Resistivity mk/W	PANDA2 (MPa)	Photography
		TOPSOIL: soft dark brown SILT with roots, slightly moist.	0.30					
1		Soft dark brown CLAY, slightly moist.	3.00	R 1.80 – 1.85				
2								

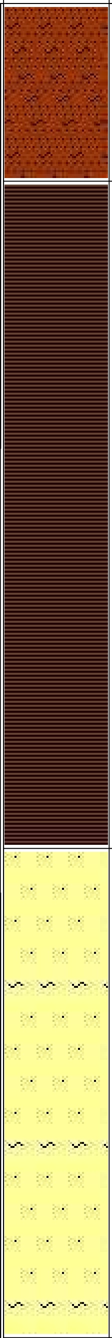


Samples: S-Thin walls, O-Osterberg, M-Mazier, R-Reworked, Rs- SPT reworked
Piezometer: ATA-Open tube, CSG-Casagrande

TRIAL PIT LOG

Consultant: GMS Internacional, S.L.	Number: TP-06
Client: Trina Solar	Coordinates X Y (m): X:743759; Y:6013569
ID Project: IG1827115a_La Vendimia	Date: 14/10/2021

Comments
END OF TRIAL PIT: 3.00m

Scale (m)	Lithology	Description	Depth (m)	Sample	Water Table	Resistivity mk/W	Sample Unaltered	PANDA2 (MPa)	Photography
		TOPSOIL: soft brown clayey SILT, slightly moist.	0.40						
1		soft dark brown CLAY, slightly moist.	1.90			0.608 mk/W 0.70	U 0.70		
2		Dense to very dense light brown silty SAND, dry.	3.00	R 1.90 1.95					

PANDA2 (MPa) values from top to bottom: 0,9; 3,0; 3,0; 3,5; 2,3; 0,7; 2,7; 2,7; 2,5; 4,4; 4,2; 3,8; 3,5; 3,8; 2,6; 3,2; 4,0; 4,9; 4,5; 6,6; 17,0; 30,4; 9,6; 28,3; 12,8; 11,6; 11,4; 11,8; 12,3; 23,2; 12,2

Samples: S-Thin walls, O-Osterberg, M-Mazier, R-Reworked, Rs- SPT reworked
Piezometer: ATA-Open tube, CSG-Casagrande

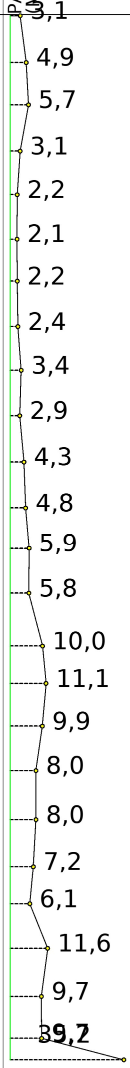
TRIAL PIT LOG

Consultant: GMS Internacional, S.L.
Client: Trina Solar
ID Project: IG1827115a_La Vendimia

Number: TP-07
Coordinates X Y (m): X:743862; Y:6013633
Date: 13/10/2021

Comments
END OF TRIAL PIT: 3.00m

Scale (m)	Lithology	Description	Depth (m)	Sample	Water Table	Resistivity mk/W	Sample Unaltered	PANDA2 (MPa)	Photography
		TOPSOIL: soft brown silty CLAY, dry.	0.40						
1 2		Soft dark brown silty CLAY, moist.	2.20	R 0.70–0.75					
		Moderately dense to dense brown silty FINE SAND, moist.	3.00						



Samples: S-Thin walls, O-Osterberg, M-Mazier, R-Reworked, Rs- SPT reworked
Piezometer: ATA-Open tube, CSG-Casagrande

TRIAL PIT LOG

Consultant:	GMS Internacional, S.L.	Number:	TP-08
Client:	Trina Solar	Coordinates X Y (m):	X:744037; Y:6013814
ID Project:	IG1827115a_La Vendimia	Date:	13/10/2021

Comments
END OF TRIAL PIT: 3.00m

Scale (m)	Lithology	Description	Depth (m)	Sample	Water Table	Resistivity mk/W	Sample Unaltered	PANDA2 (MPa)	Photography
		TOPSOIL: Moderately brown silty CLAY with roots, slightly moist.	0.40					2,2; 3,3; 1,3; 1,3	
1		Soft dark brown silty CLAY with isolated gravels, slightly moist.	2.20	R 1.40 – 1.45		0.638 mk/W 0.80	U 0.60	2,2; 1,5; 1,8; 1,3; 1,2; 1,2; 1,3; 1,7; 2,1; 2,0; 2,7; 1,9; 2,2; 3,1; 3,6; 3,8; 3,1; 2,6	
2		Dense orangish brown sandy GRAVELS,rounded to sub-rounded centimetric gravels.	3.00					2,8; 2,4; 2,4; 7,0; 6,5; 32,6	

Samples: S-Thin walls, O-Osterberg, M-Mazier, R-Reworked, Rs- SPT reworked
Piezometer: ATA-Open tube, CSG-Casagrande

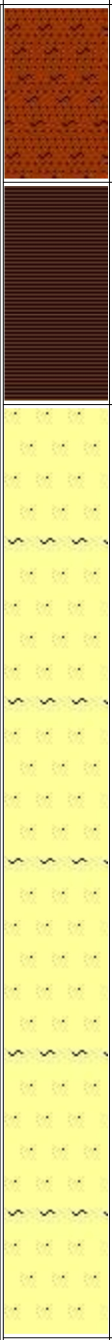
TRIAL PIT LOG

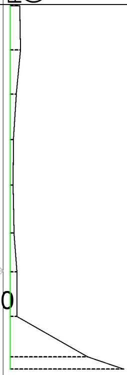
Consultant: GMS Internacional, S.L.
Client: Trina Solar
ID Project: IG1827115a_La Vendimia

Number: TP-09
Coordinates X Y (m): X:743903; Y:6013521
Date: 13/10/2021

Comments
END OF TRIAL PIT: 3.00m

Scale (m)	Lithology	Description	Depth (m)	Sample	Water Table	Resistivity mk/W	Sample Unaltered	PANDA2 (MPa)	Photography
		TOPSOIL: soft brown clayey SILT, dry.	0.40						
		Soft toirme brown silty CLAY, moist.	0.90	R 0.60 – 0.65			U 0.60		
1		Dense to very dense brown silty FINE SAND, moist.	3.00						
2									





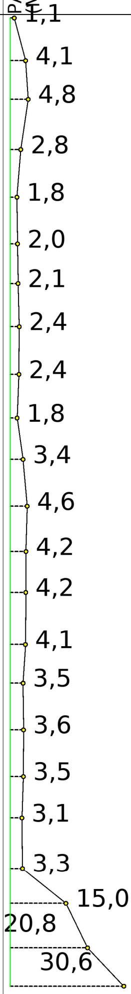
Samples: S-Thin walls, O-Osterberg, M-Mazier, R-Reworked, Rs- SPT reworked
Piezometer: ATA-Open tube, CSG-Casagrande

TRIAL PIT LOG

Consultant: GMS Internacional, S.L.	Number: TP-10
Client: Trina Solar	Coordinates X Y (m): X:743947; Y:6013571
ID Project: IG1827115a_La Vendimia	Date: 13/10/2021

Comments
END OF TRIAL PIT: 3.00m

Scale (m)	Lithology	Description	Depth (m)	Sample	Water Table	Resistivity mk/W	Sample Unaltered	PANDA2 (MPa)
		TOPSOIL: soft brown clayey SILT with roots, dry.	0.30					
1		Soft toirm brown silty CLAY, slightly moist.	1.70					
2		Dense light brown silty SAND, slightly moist. some reddish zones (oxide).	3.00	R 2.00–2.05				



Photography

Samples: S-Thin walls, O-Osterberg, M-Mazier, R-Reworked, Rs- SPT reworked
Piezometer: ATA-Open tube, CSG-Casagrande

TRIAL PIT LOG

Consultant: GMS Internacional, S.L.	Number: TP-11
Client: Trina Solar	Coordinates X Y (m): X:744110; Y:6013649
ID Project: IG1827115a_La Vendimia	Date: 13/10/2021

Comments
END OF TRIAL PIT: 3.00m

Scale (m)	Lithology	Description	Depth (m)	Sample	Water Table	Resistivity mk/W	Sample Unaltered	PANDA2 (MPa)	Photography
		TOPSOIL: soft brown clayey SILT, dry.	0.40						
1 2		Soft, brown silty CLAY, slightly moist.This layer presents a sandy 20cm thick stratum at 1.80m depth.	3.00	R 0.60 - 0.65		0.473 mk/W 0.90		1,5; 4,0; 3,8; 1,6; 1,0; 0,6; 0,5; 0,5; 0,7; 1,2; 1,7; 3,7; 5,4; 3,5; 4,0; 3,5; 2,1; 1,8; 4,0; 3,3; 3,5; 3,9; 5,9; 4,9; 4,6; 5,1; 4,9; 5,5; 5,5; 6,0; 4,6	

Samples: S-Thin walls, O-Osterberg, M-Mazier, R-Reworked, Rs- SPT reworked
Piezometer: ATA-Open tube, CSG-Casagrande

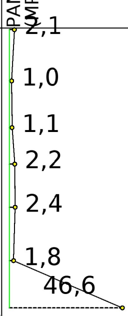
TRIAL PIT LOG

Consultant: GMS Internacional, S.L.
Client: Trina Solar
ID Project: IG1827115a_La Vendimia

Number: TP-12
Coordinates X Y (m): X:744043; Y:6013450
Date: 13/10/2021

Comments
END OF TRIAL PIT: 3.00m

Scale (m)	Lithology	Description	Depth (m)	Sample	Water Table	Resistivity mk/W	PANDA2 (MPa)	Photography
		TOPSOIL: soft, dark brown silty CLAY, moist.	0.30					
		Loose to medium dense compactness, brown silty FINE SAND, moist.	0.80	R 0.60 – 0.65		0.565 mk/W 0.65		
1		Dense to very dense compactness, brown sandy GRAVELS, dry.Sub-rounded centimetric gravels of quartz.						
2			3.00					



Samples: S-Thin walls, O-Osterberg, M-Mazier, R-Reworked, Rs- SPT reworked
Piezometer: ATA-Open tube, CSG-Casagrande

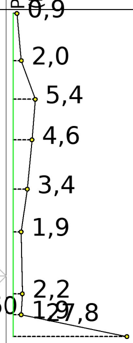
TRIAL PIT LOG

Consultant: GMS Internacional, S.L.
Client: Trina Solar
ID Project: IG1827115a_La Vendimia

Number: TP-13
Coordinates X Y (m): X:744150; Y:6013529
Date: 13/10/2021

Comments
END OF TRIAL PIT: 3.00m

Scale (m)	Lithology	Description	Depth (m)	Sample	Water Table	Resistivity mk/W	Sample Unaltered	PANDA2 (MPa)
		TOPSOIL: soft to medium, brown silty CLAY, dry.	0.35				U 0.60	
		Soft, dark brown CLAY, moist.	0.95					
1		Dense, brown, silty FINE SAND, moist. This layer presents 15 cm thick iron and magnesium oxides	1.60	R 1.10 1.15				
2		Dense compactness, brown sandy GRAVELS, moist. Sub-rounded centimetric (until 20cm size) gravels of quartz.	3.00					



Photography

Samples: S-Thin walls, O-Osterberg, M-Mazier, R-Reworked, Rs- SPT reworked
Piezometer: ATA-Open tube, CSG-Casagrande

TRIAL PIT LOG

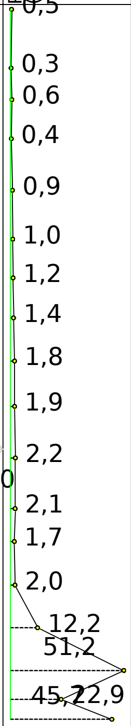
Consultant: GMS Internacional, S.L.
Client: Trina Solar
ID Project: IG1827115a_La Vendimia

Number: TP-14
Coordinates X Y (m): X:744218; Y:6013593
Date: 13/10/2021

Comments
END OF TRIAL PIT: 3.00m

Scale (m)	Description	Depth (m)	Sample	Water Table	Resistivity mk/W	Sample Unaltered
	TOPSOIL: soft, dark brown clayey SILTwith roots, slightly moist.	0.40				
	Soft, dark brown CLAY, slightly moist.	0.80				
1	Dense, light brown, silty FINE SAND, slightly moist. This layer presents iron and magnesium oxides in the base.	1.70	R 1.50–1.55			U 1.00
	Dense compactness, light brown sandy GRAVELS, moist.	2.00				
2	Dense, light brown silty SAND, moist.	3.00				

PANDA2 (MPa)



Photography

Samples: S-Thin walls, O-Osterberg, M-Mazier, R-Reworked, Rs- SPT reworked
Piezometer: ATA-Open tube, CSG-Casagrande

TRIAL PIT LOG

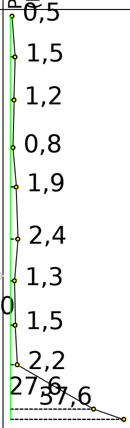
Consultant: GMS Internacional, S.L.
Client: Trina Solar
ID Project: IG1827115a_La Vendimia

Number: TP-15
Coordinates X Y (m): X:744183; Y:6013413
Date: 13/10/2021

Comments
END OF TRIAL PIT: 3.20m

Scale (m)	Lithology	Description	Depth (m)	Sample	Water Table	Resistivity mk/W	Sample Unaltered	PANDA2 (MPa)
		TOPSOIL: soft, reddish brown clayey SILTwith roots.	0.40					
		Soft, brown CLAY, slightly moist.	0.80				U 0.60	
1		Loose to medium dense compactness, brown, silty SAND with isolated gravels, moist.			1.10			
2				R 2.50 – 2.55				
			3.20					

PANDA2 (MPa):



Photography

Samples: S-Thin walls, O-Osterberg, M-Mazier, R-Reworked, Rs- SPT reworked
Piezometer: ATA-Open tube, CSG-Casagrande

GEOTECHNICAL REPORT LA VENDIMIA PV SOLAR PROJECT, MAULE (CHILE).

Annex 3: Variable Energy Dynamic Cone Penetrometer Logs (Panda2)

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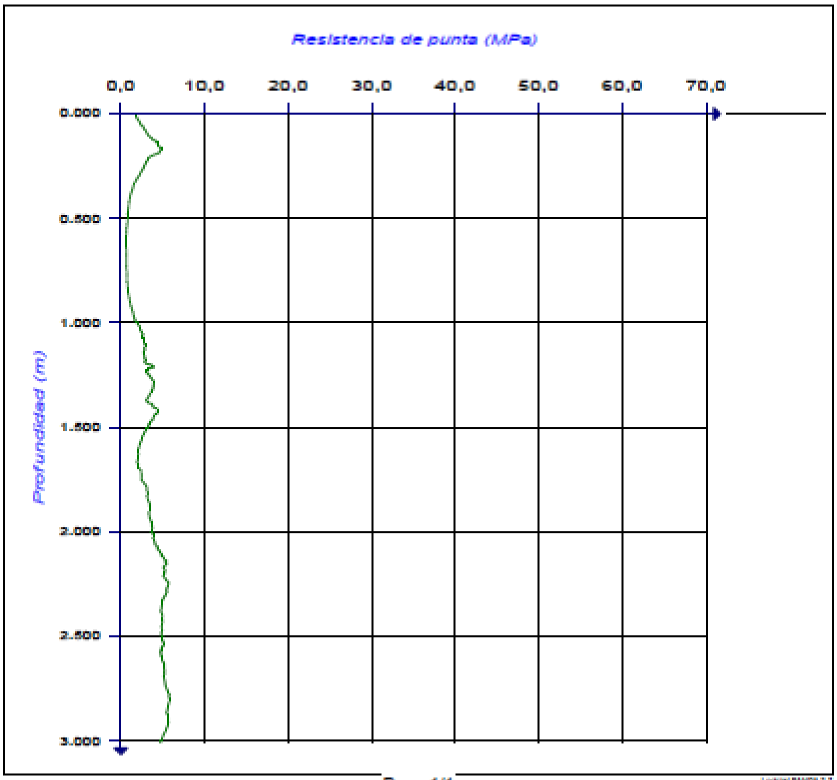
1. Panda2's Location

Illustration 1: Variable Energy Dynamic Cone Penetrometer Location

2. Panda2s Plots

Control de compactación con penetrometro dinamico a energía variable

Documento :Z:\Carpeta_02-Proyectos GMS\18271_Trina Solar\IG1827115a_La Vendimia_GEO\01_FIELD_WORKS\4. DPL-P			
Sitio : LA VENDIMIA			
Sondaje : P 11			
Asfalto : 0,00 m	Prof. pre-perforacion :0,000 m	Sección : 4 cm²	Prof. Napa :indeterminada
Masa :Martillo Panda 2	Cond. de interrupción :Tempo	Fecha : 06/10/2021	Hora :14:03:00
Operador :		Organismo :	
Comentarios :			



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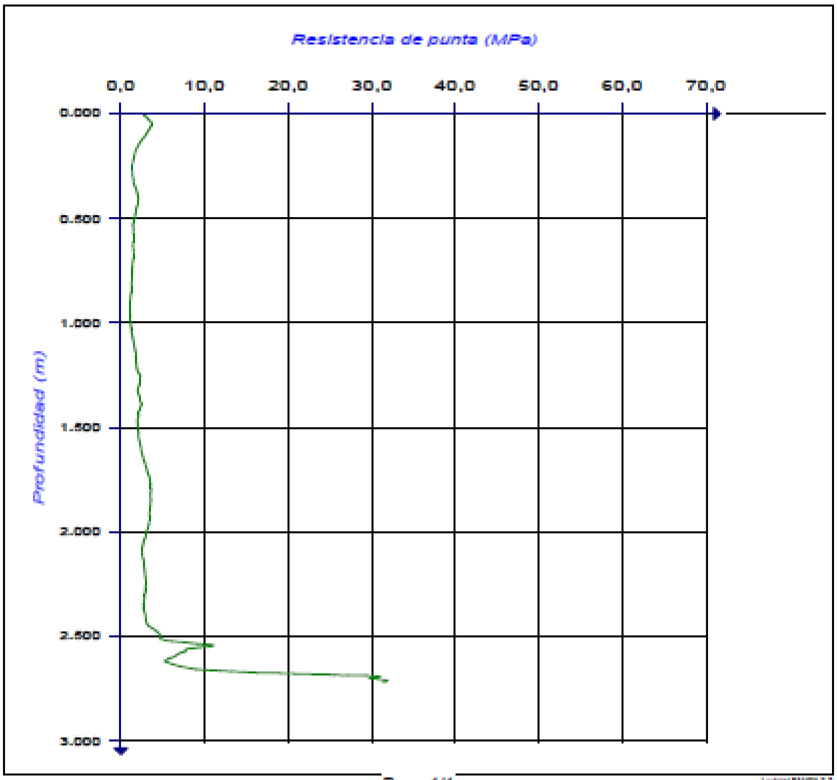
Control de compactación con penetrometro dinamico a energía variable

Documento :Z:\Carpeta_02-Proyectos GMS\18271_Trina Solar\IG1827115a_La Vendimia_GEO\01_FIELD_WORKS\4. DPL-P			
Sitio : LA VENDIMIA			
Sondaje : P 08			
Asfalto : 0,00 m	Prof. pre-perforacion :0,000 m	Sección : 4 cm²	Prof. Napa :Indeterminada
Masa :Martillo Panda 2	Cond. de interrupción :Tempo	Fecha : 05/10/2021	Hora :22:37:00
Operador :		Organismo :	
Comentarios :			



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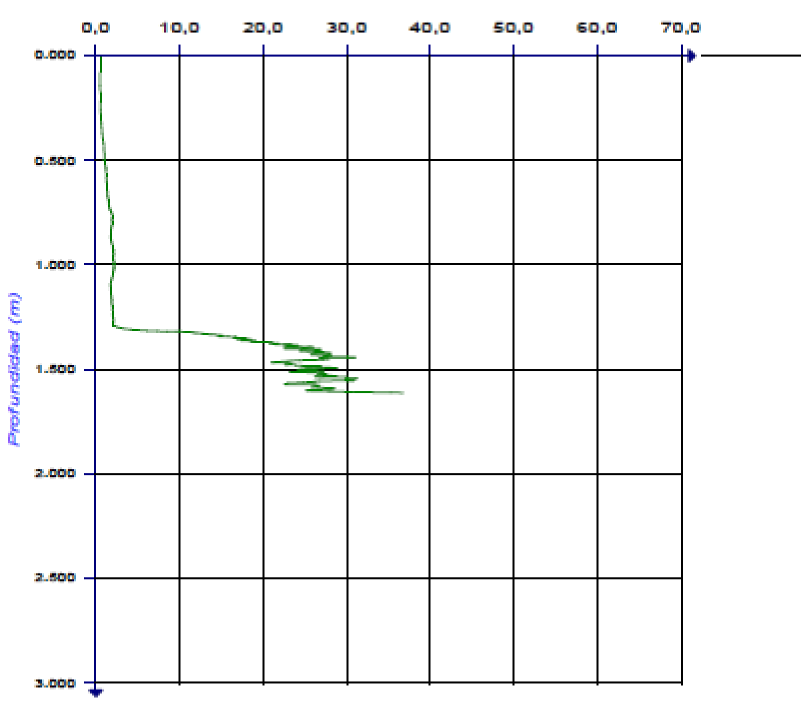
Control de compactación con penetrometro dinamico a energía variable

Documento :Z:\Carpeta_02-Proyectos GMS\18271_Trina Solar\IG1827115a_La Vendimia_GEO\01_FIELD_WORKS\4. DPL-P			
Sitio : LA VENDIMIA			
Sondaje : P 14			
Asfalto : 0,00 m	Prof. pre-perforacion :0,000 m	Sección : 4 cm²	Prof. Napa :Indeterminada
Masa :Martillo Panda 2	Cond. de interrupción :Tempo	Fecha : 06/10/2021	Hora :15:02:00
Operador :		Organismo :	
Comentarios :			



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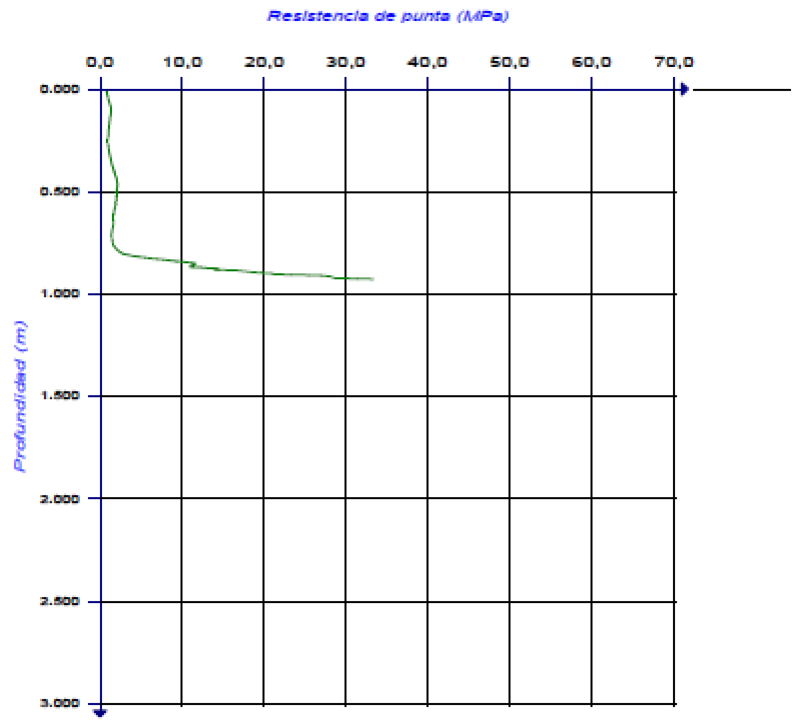
Control de compactación con penetrometro dinamico a energía variable

Documento :Z:\Carpeta_02-Proyectos GMS\18271_Trina Solar\IG1827115a_La Vendimia_GEO\01_FIELD_WORKS\4. DPL-P			
Sitio : LA VENDIMIA			
Sondaje : P 15			
Asfalto : 0,00 m	Prof. pre-perforacion :0,000 m	Sección : 4 cm²	Prof. Napa :Indeterminada
Masa :Martillo Panda 2	Cond. de interrupción :Tempor	Fecha : 06/10/2021	Hora :15:21:00
Operador :		Organismo :	
Comentarios :			



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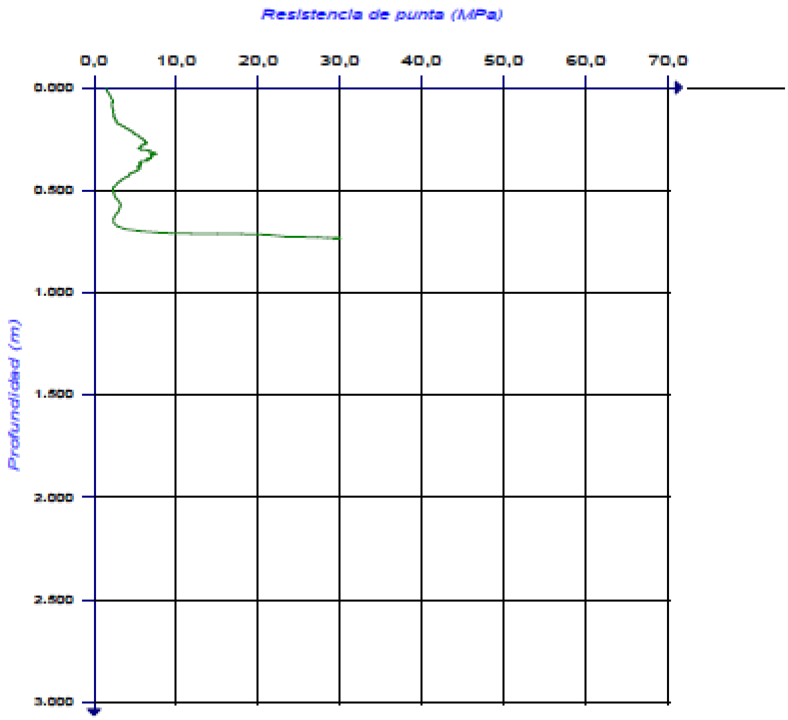
Control de compactación con penetrometro dinamico a energía variable

Documento :Z:\Carpeta_02-Proyectos GMS\18271_Trina Solar\IG1827115a_La Vendimia_GEO\01_FIELD_WORKS\4. DPL-P			
Sitio : LA VENDIMIA			
Sondaje : P 13			
Asfalto : 0,00 m	Prof. pre-perforacion :0,000 m	Sección : 4 cm²	Prof. Napa :Indeterminada
Masa :Martillo Panda 2	Cond. de interrupción :Tempor	Fecha : 06/10/2021	Hora :15:34:00
Operador :		Organismo :	
Comentarios :			



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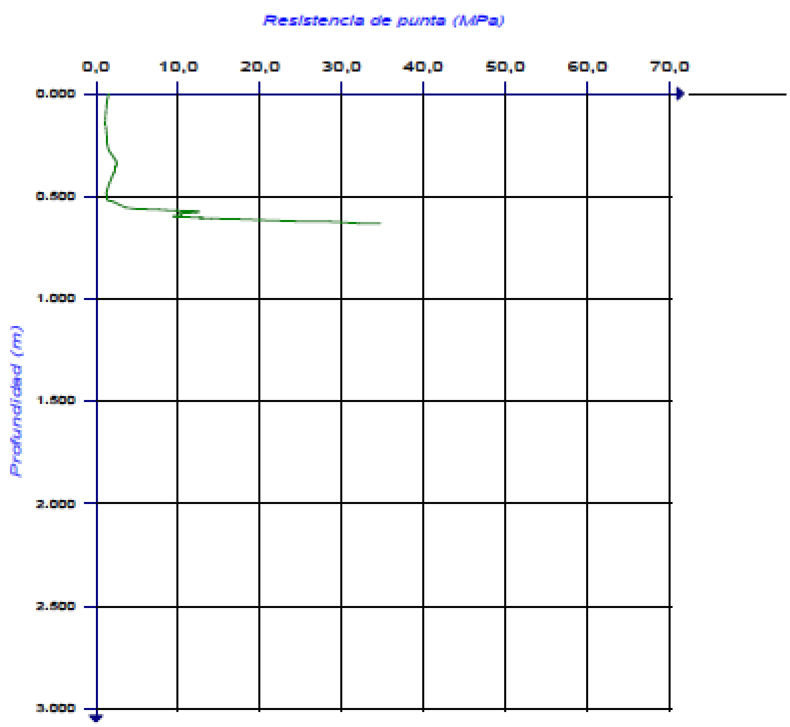
Control de compactación con penetrometro dinamico a energía variable

Documento :Z:\Carpeta_02-Proyectos GMS\18271_Trina Solar\IG1827115a_La Vendimia_GEO\01_FIELD_WORKS\4. DPL-P			
Sitio : LA VENDIMIA			
Sondaje : P 12			
Asfalto : 0,00 m	Prof. pre-perforacion :0,000 m	Sección : 4 cm²	Prof. Napa :Indeterminada
Masa :Martillo Panda 2	Cond. de interrupción :Tempor	Fecha : 06/10/2021	Hora : 15:50:00
Operador :		Organismo :	
Comentarios :			



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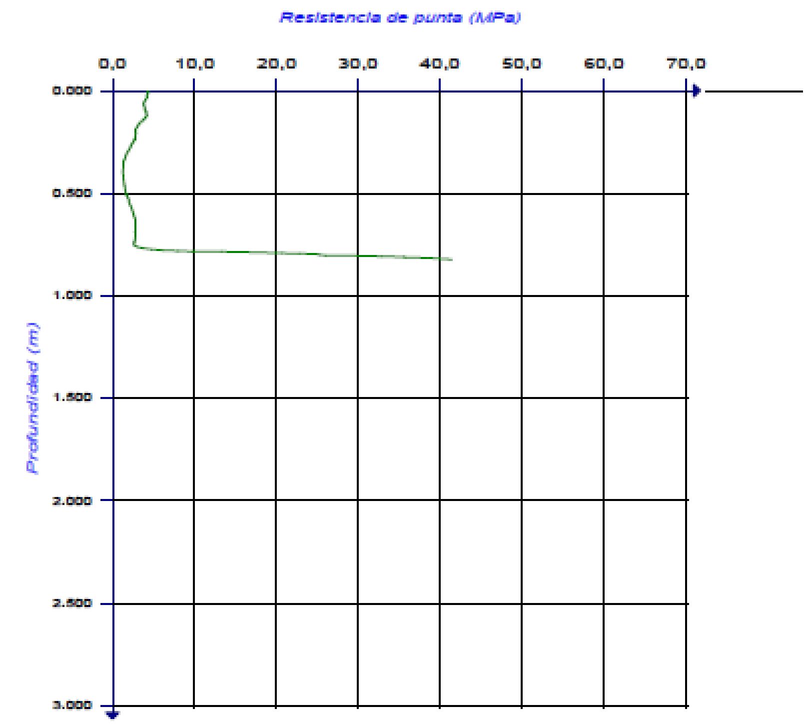
Control de compactación con penetrometro dinamico a energia variable

Documento :Z:\Carpeta_02-Proyectos GMS\18271_Trina Solar\IG1827115a_La Vendimia_GEO\01_FIELD_WORKS\4. DPL-P			
Sitio : LA VENDIMIA			
Sondaje : P 09			
Asfalto : 0,00 m	Prof. pre-perforacion :0,000 m	Sección : 4 cm²	Prof. Napa :Indeterminada
Masa :Martillo Panda 2	Cond. de interrupción :Tempor	Fecha : 06/10/2021	Hora :16:36:00
Operador :		Organismo :	
Comentarios :			



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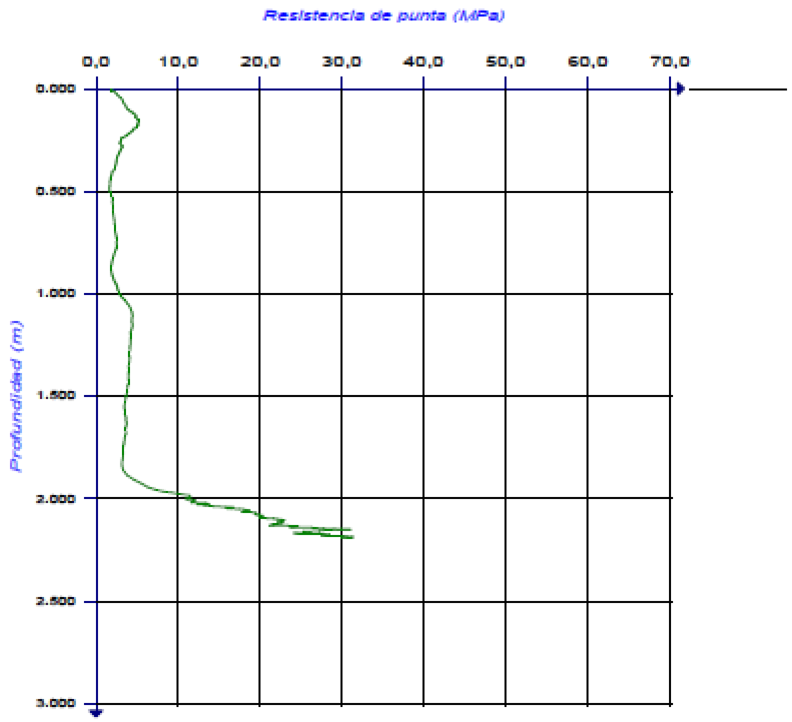
Control de compactación con penetrometro dinamico a energía variable

Documento :Z:\Carpeta_02-Proyectos GMS\18271_Trina Solar\IG1827115a_La Vendimia_GEO\01_FIELD_WORKS\4. DPL-P			
Sitio : LA VENDIMIA			
Sondaje : P 10			
Asfalto : 0,00 m	Prof. pre-perforacion :0,000 m	Sección : 4 cm²	Prof. Napa :Indeterminada
Masa :Martillo Panda 2	Cond. de interrupción :Tempor	Fecha : 06/10/2021	Hora :16:48:00
Operador :		Organismo :	
Comentarios :			



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Control de compactación con penetrometro dinamico a energía variable

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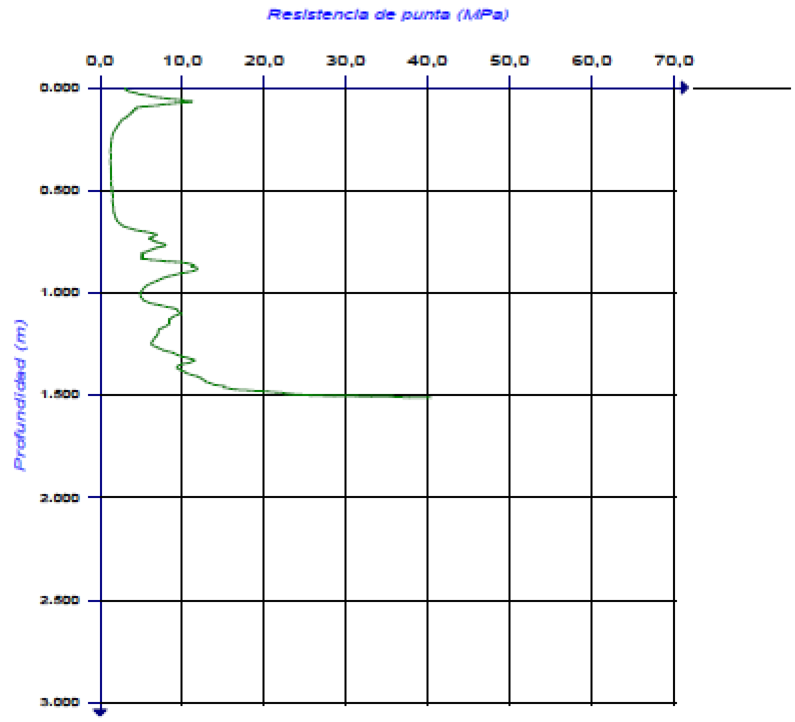
Sitio : LA VENDIMIA			
Sondaje : P 01			
Asfalto : 0,00 m	Prof. pre-perforacion :0,000 m	Sección : 4 cm²	Prof. Napa :indeterminada
Masa :Martillo Panda 2	Cond. de interrupción :Tempor	Fecha : 06/10/2021	Hora :19:28:00
Operador :		Organismo :	
Comentarios :			



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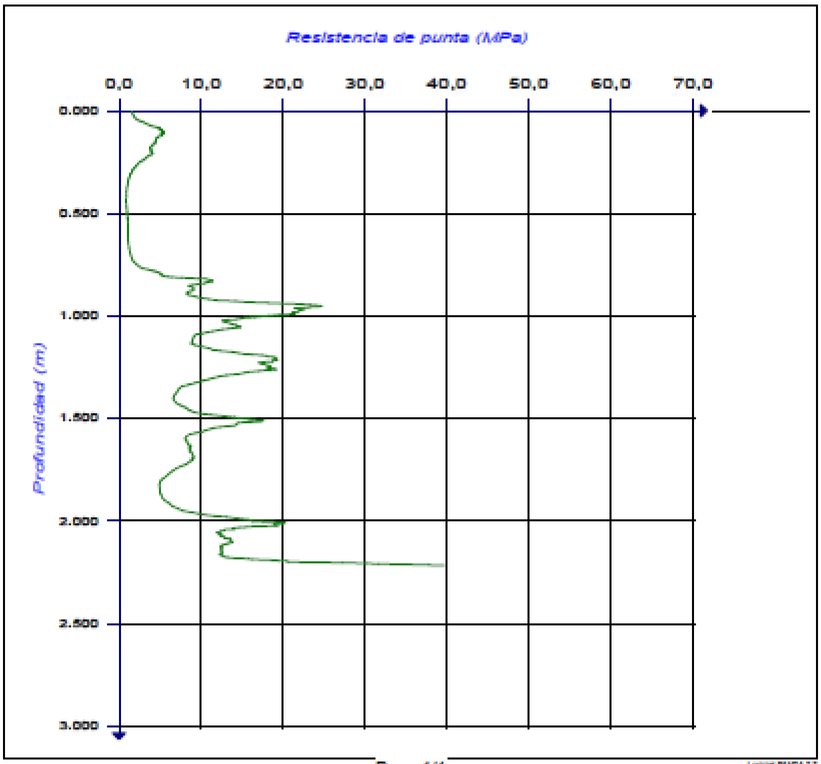
Control de compactación con penetrometro dinamico a energía variable

Documento :Z:\Carpeta_02-Proyectos GMS\18271_Trina Solar\IG1827115a_La Vendimia_GEO\01_FIELD_WORKS\4. DPL-P			
Sitio : LA VENDIMIA			
Sondaje : P 02			
Asfalto : 0,00 m	Prof. pre-perforacion :0,000 m	Sección : 4 cm²	Prof. Napa :Indeterminada
Masa :Martillo Panda 2	Cond. de interrupción :Tempor	Fecha : 06/10/2021	Hora :19:43:00
Operador :		Organismo :	
Comentarios :			



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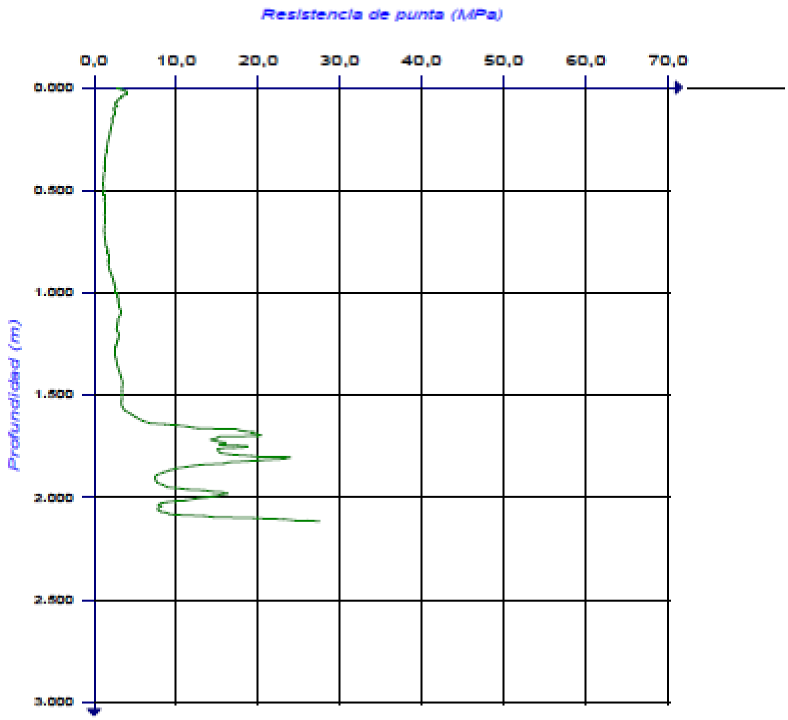
Control de compactación con penetrometro dinamico a energía variable

Documento :Z:\Carpeta_02-Proyectos GMS\18271_Trina Solar\IG1827115a_La Vendimia_GEO\01_FIELD_WORKS\4. DPL-P			
Sitio : LA VENDIMIA			
Sondaje : P 03			
Asfalto : 0,00 m	Prof. pre-perforacion :0,000 m	Sección : 4 cm²	Prof. Napa :Indeterminada
Masa :Martillo Panda 2	Cond. de interrupción :Tempor	Fecha : 06/10/2021	Hora :20:23:00
Operador :		Organismo :	
Comentarios :			



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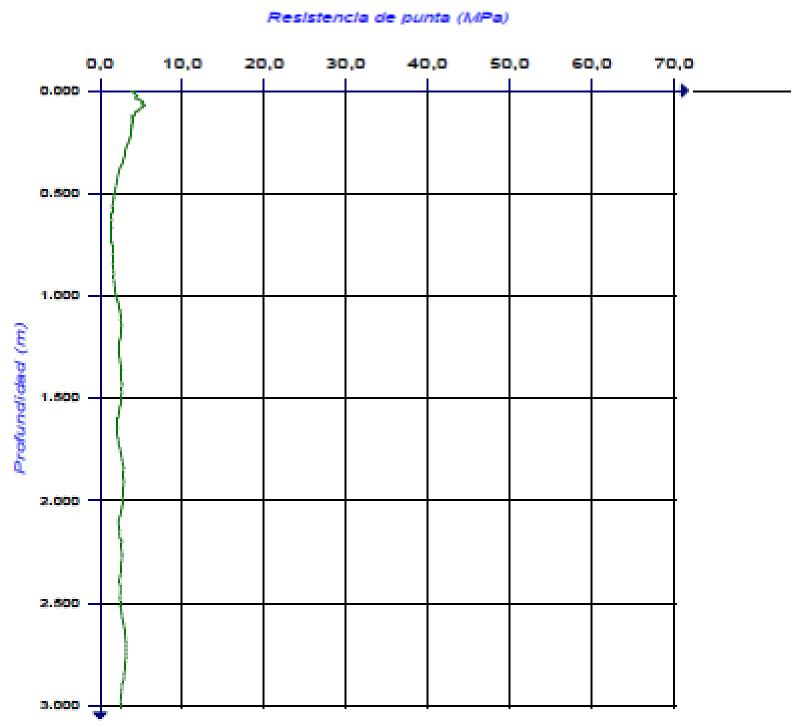
Control de compactación con penetrometro dinamico a energia variable

Documento :Z:\Carpeta_02-Proyectos GMS\18271_Trina Solar\IG1827115a_La Vendimia_GEO\01_FIELD_WORKS\4. DPL-P			
Sitio : LA VENDIMIA			
Sondaje : P 04			
Asfalto : 0,00 m	Prof. pre-perforacion :0,000 m	Sección : 4 cm²	Prof. Napa :Indeterminada
Masa :Martillo Panda 2	Cond. de interrupción :Tempor	Fecha : 07/10/2021	Hora :15:18:00
Operador :		Organismo :	
Comentarios :			



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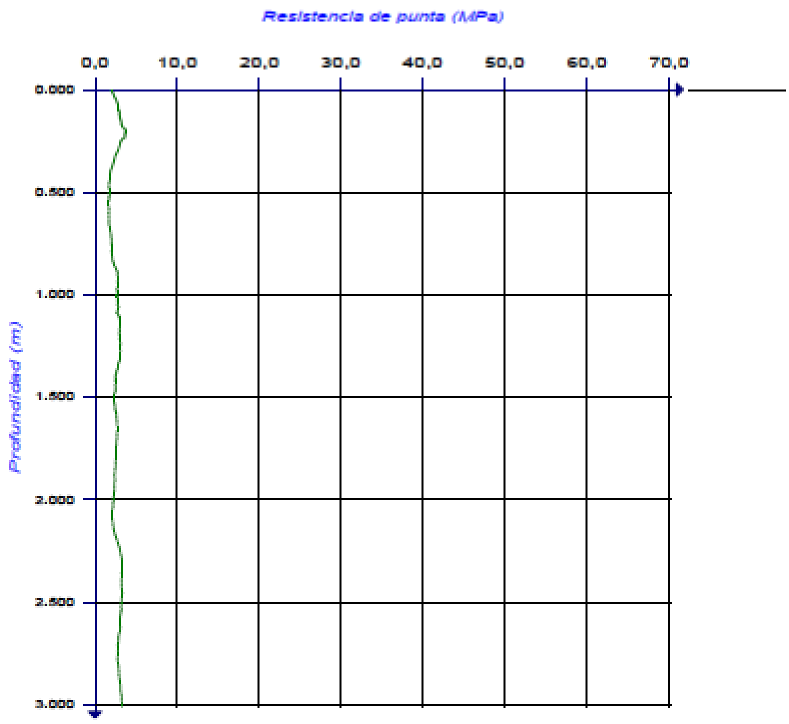
Control de compactación con penetrometro dinamico a energia variable

Documento :Z:\Carpeta_02-Proyectos GMS\18271_Trina Solar\IG1827115a_La Vendimia_GEO\01_FIELD_WORKS\4. DPL-P			
Sitio : LA VENDIMIA			
Sondaje : P 05			
Asfalto : 0,00 m	Prof. pre-perforacion :0,000 m	Sección : 4 cm²	Prof. Napa :Indeterminada
Masa :Martillo Panda 2	Cond. de interrupción :Tempor	Fecha : 07/10/2021	Hora :15:42:00
Operador :		Organismo :	
Comentarios :			



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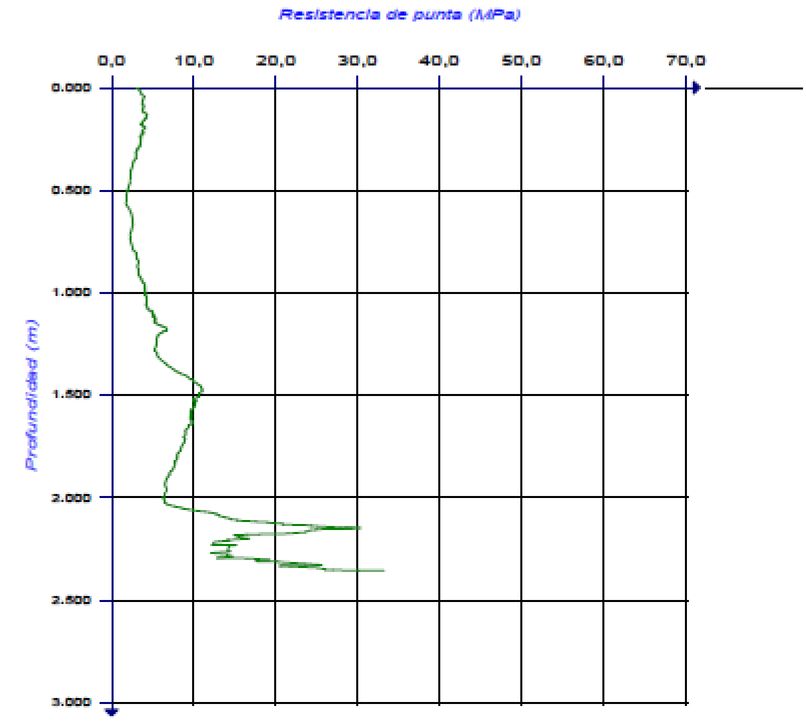
Control de compactación con penetrometro dinamico a energía variable

Documento :Z:\Carpeta_02-Proyectos GMS\18271_Trina Solar\IG1827115a_La Vendimia_GEO\01_FIELD_WORKS\4. DPL-P			
Sitio : LA VENDIMIA			
Sondaje : P 07			
Asfalto : 0,00 m	Prof. pre-perforacion :0,000 m	Sección : 4 cm²	Prof. Napa :Indeterminada
Masa :Martillo Panda 2	Cond. de Interrupción :Tempor	Fecha : 07/10/2021	Hora :16:44:00
Operador :		Organismo :	
Comentarios :			



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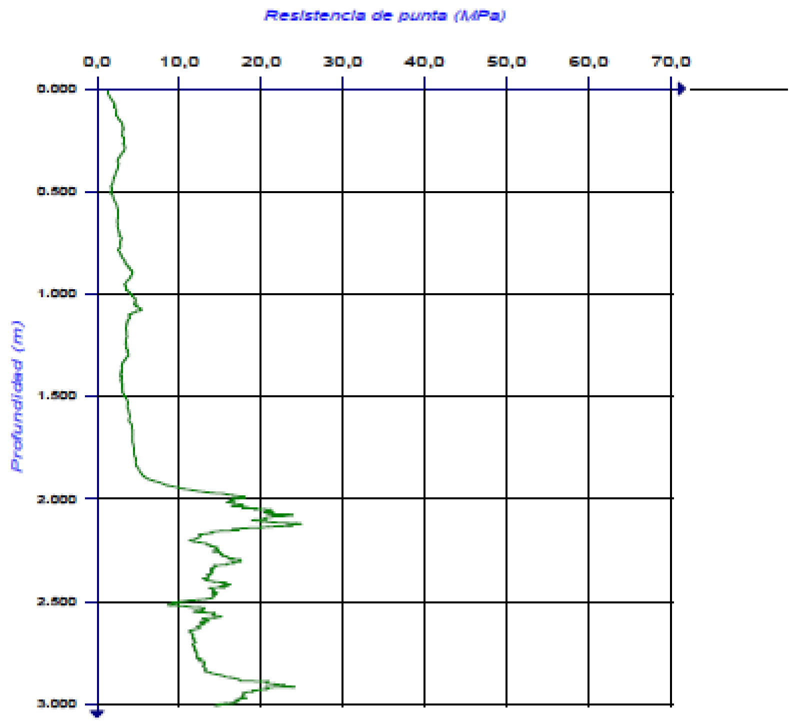
Control de compactación con penetrometro dinamico a energía variable

Documento :Z:\Carpeta_02-Proyectos GMS\18271_Trina Solar\IG1827115a_La Vendimia_GEO\01_FIELD_WORKS\4. DPL-P			
Sitio : LA VENDIMIA			
Sondaje : P 06			
Asfalto : 0,00 m	Prof. pre-perforacion :0,000 m	Sección : 4 cm²	Prof. Napa :Indeterminada
Masa :Martillo Panda 2	Cond. de interrupción :Tempor	Fecha : 07/10/2021	Hora :17:10:00
Operador :		Organismo :	
Comentarios :			



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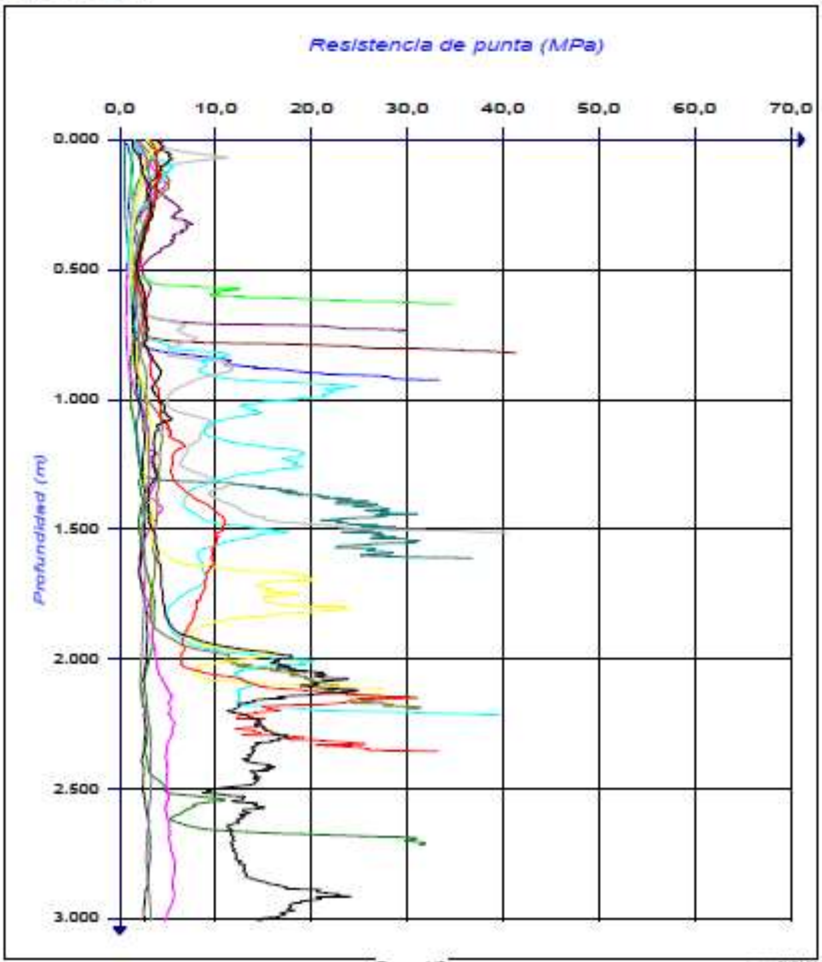
3. Panda2 SUMMARY

Control de compactación con penetrometro dinamico a energía variable

Documento :Z:\Carpeta_02-Proyectos GMS\18271_Trina Solar\IG1827115a_La Vendimia_GEO\01_FIELD_WORKS\4. DPL-P

Sitio : LA VENDIMIA



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Sitio	Sondaje	Fecha	Estudio	Curva
LA VENDIMIA	P 08	05/10/2021	Compactación	
LA VENDIMIA	P 11	06/10/2021	Compactación	
LA VENDIMIA	P 14	06/10/2021	Compactación	
LA VENDIMIA	P 15	06/10/2021	Compactación	
LA VENDIMIA	P 13	06/10/2021	Compactación	
LA VENDIMIA	P 12	06/10/2021	Compactación	
LA VENDIMIA	P 09	06/10/2021	Compactación	
LA VENDIMIA	P 10	06/10/2021	Compactación	
LA VENDIMIA	P 01	06/10/2021	Compactación	
LA VENDIMIA	P 02	06/10/2021	Compactación	
LA VENDIMIA	P 03	06/10/2021	Compactación	
LA VENDIMIA	P 04	07/10/2021	Compactación	
LA VENDIMIA	P 05	07/10/2021	Compactación	
LA VENDIMIA	P 07	07/10/2021	Compactación	
LA VENDIMIA	P 06	07/10/2021	Compactación	

GEOTECHNICAL REPORT LA VENDIMIA PV SOLAR PROJECT, MAULE (CHILE)

Annex 4: Vertical Electric Sounding (VES's)

Issued by:

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Submitted to:

Trina Solar Holding

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1. VES's Location

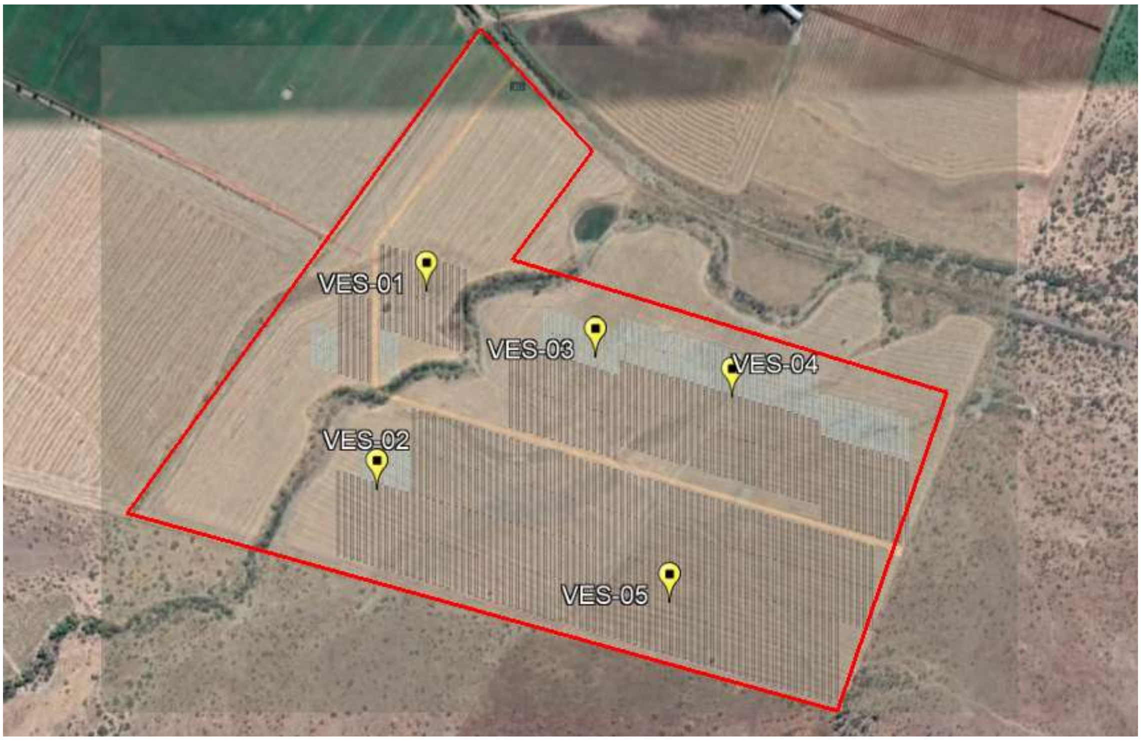
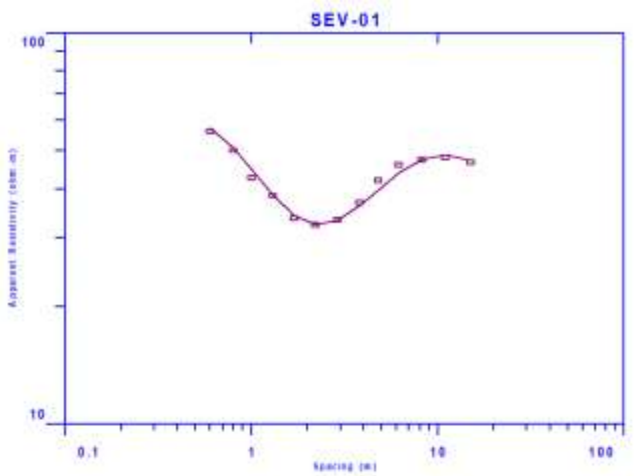
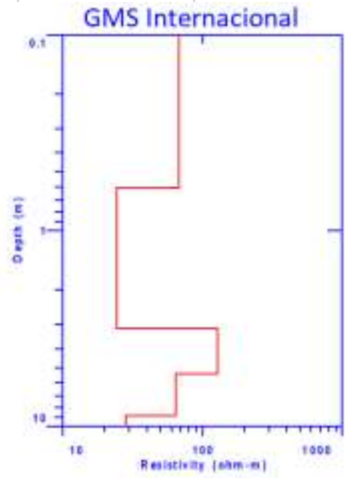


Illustration 1: VES Location

2. VES Summary

SEV	1				
PROJECT	LA VENDIMIA				
DATE	06/10/2021				
CLIENT	Trina Solar				
COORDINATES					
X	Y				
743819.74 m E	6013764.08 m S				
WENNER ARRAY					
Wenner Spacing a (m)	0-S/0-ES Spacing (m)	0-H/0-E Spacing (m)	US-ES (mV)	IH-E (mA)	Apparent Resistivity (Ohm*m)
0,60	0,30	0,90	240,00	16,20	56,00
0,80	0,40	1,20	144,00	14,50	50,10
1,00	0,50	1,50	93,00	13,70	42,60
1,30	0,65	1,95	60,40	12,90	38,40
1,70	0,85	2,55	37,40	11,90	33,60
2,20	1,10	3,30	26,00	11,10	32,40
2,90	1,45	4,35	19,70	10,80	33,30
3,80	1,90	5,70	17,00	11,00	36,80
4,80	2,40	7,20	17,00	12,20	42,00
6,20	3,10	9,30	12,40	10,50	46,10
8,20	4,10	12,30	9,19	10,00	47,40
11,00	5,50	16,50	6,65	9,59	48,00
15,00	7,50	22,50	5,58	11,30	46,70





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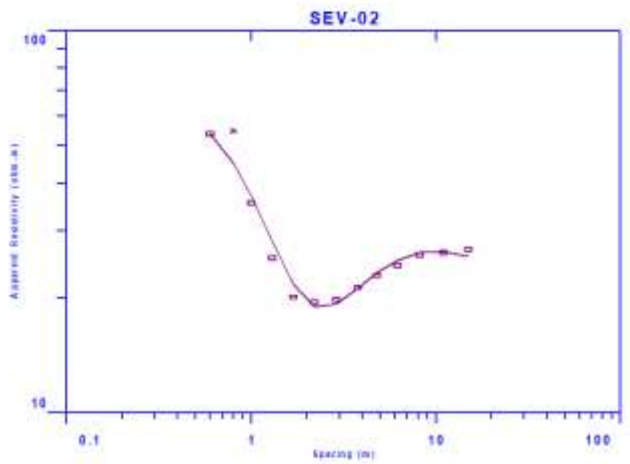
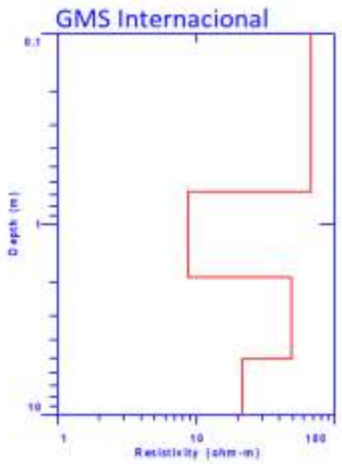
SEV	2
PROJECT	LA VENDIMIA
DATE	07/10/2021
CLIENT	Trina Solar
COORDINATES	
X	Y
743761.32 m E	6013566.66 m S

WENNER ARRAY

Wenner Spacing a (m)	0-S/0-ES Spacing (m)	0-H/0-E Spacing (m)	US-ES (mV)	IH-E (mA)	Apparent Resistivity (Ohm*m)
0,60	0,30	0,90	6,14	0,43	53,70
0,80	0,40	1,20	43,90	8,54	54,70
1,00	0,50	1,50	56,30	10,00	35,50
1,30	0,65	1,95	21,20	6,83	25,40
1,70	0,85	2,55	12,90	6,88	20,10
2,20	1,10	3,30	10,40	7,35	19,50
2,90	1,45	4,35	7,58	7,00	19,80
3,80	1,90	5,70	6,71	7,53	21,30
4,80	2,40	7,20	5,75	7,60	22,90
6,20	3,10	9,30	5,61	9,00	24,30
8,20	4,10	12,30	4,81	9,60	25,90
11,00	5,50	16,50	3,09	8,14	26,30
15,00	7,50	22,50	2,15	7,55	26,80

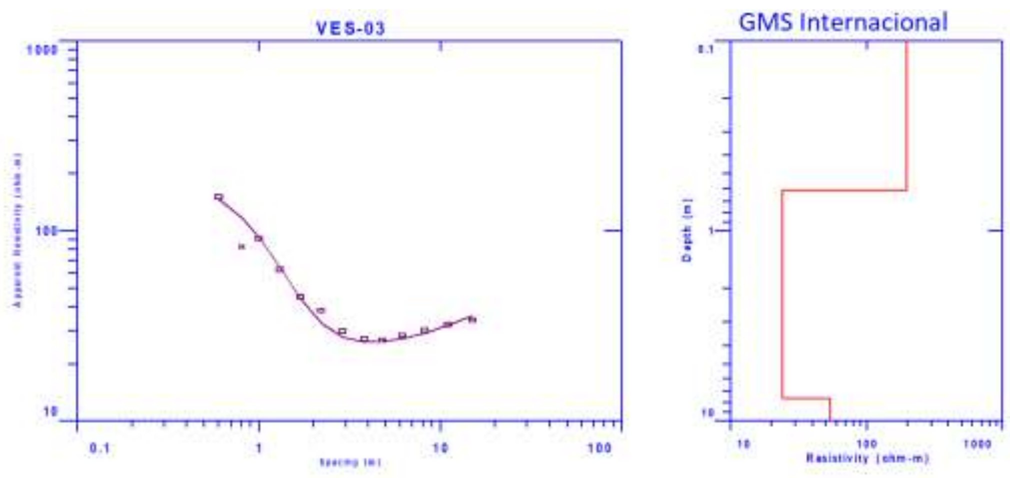




SEV	3
PROJECT	LA VENDIMIA
DATE	07/10/2021
CLIENT	Trina Solar
COORDINATES	
X	Y
743977.97 m E	6013692.63 m S

WENNER ARRAY

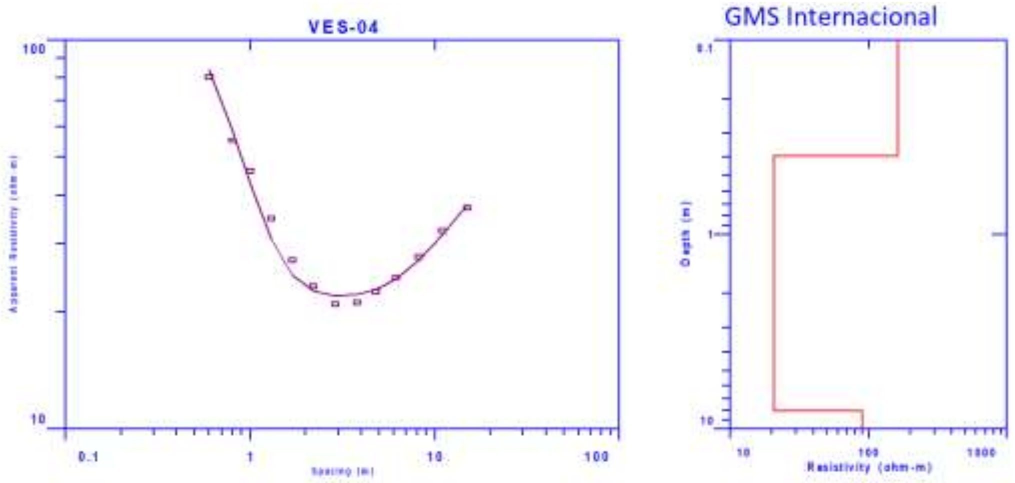
Wenner Spacing a (m)	0-S/0-ES Spacing (m)	0-H/0-E Spacing (m)	US-ES (mV)	IH-E (mA)	Apparent Resistivity (Ohm*m)
0,60	0,30	0,90	274,00	6,87	151,00
0,80	0,40	1,20	162,00	7,40	82,70
1,00	0,50	1,50	95,70	6,61	91,20
1,30	0,65	1,95	60,20	7,88	62,60
1,70	0,85	2,55	27,90	6,60	45,20
2,20	1,10	3,30	19,70	7,16	38,10
2,90	1,45	4,35	15,10	9,29	29,70
3,80	1,90	5,70	10,20	9,06	27,00
4,80	2,40	7,20	9,37	10,60	26,60
6,20	3,10	9,30	5,78	8,01	28,20
8,20	4,10	12,30	5,86	10,10	30,00
11,00	5,50	16,50	4,54	9,79	32,10
15,00	7,50	22,50	4,30	12,00	33,90



SEV	4	
PROJECT	LA VENDIMIA	
DATE	07/10/2021	
CLIENT	Trina Solar	
COORDINATES		
X	Y	
744109.36 m E	6013648.36 m S	

WENNER ARRAY

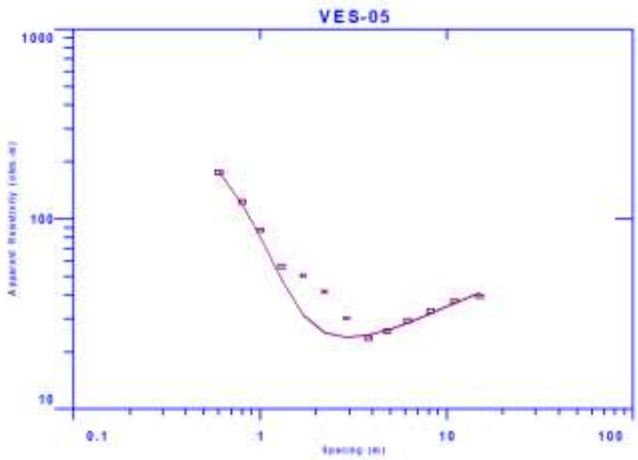
Wenner Spacing a (m)	0-S/0-ES Spacing (m)	0-H/0-E Spacing (m)	US-ES (mV)	IH-E (mA)	Apparent Resistivity (Ohm*m)
0,60	0,30	0,90	174,00	8,15	80,40
0,80	0,40	1,20	83,90	7,65	55,20
1,00	0,50	1,50	52,50	7,17	46,10
1,30	0,65	1,95	31,30	7,37	34,80
1,70	0,85	2,55	17,90	7,04	27,20
2,20	1,10	3,30	13,10	7,82	23,30
2,90	1,45	4,35	8,77	7,69	20,90
3,80	1,90	5,70	5,71	6,47	21,10
4,80	2,40	7,20	5,64	7,60	22,50
6,20	3,10	9,30	4,17	6,64	24,50
8,20	4,10	12,30	3,25	6,13	27,70
11,00	5,50	16,50	3,08	6,60	32,30
15,00	7,50	22,50	3,21	8,20	37,00

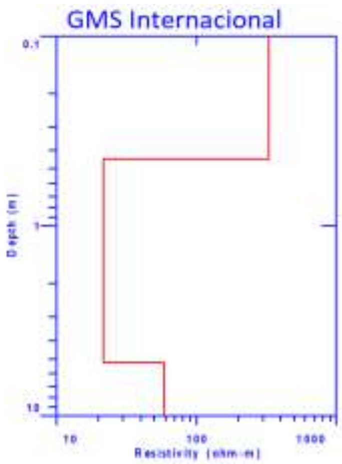


SEV	5	
PROJECT	LA VENDIMIA	
DATE	07/10/2021	
CLIENT	Trina Solar	
COORDINATES		
X	Y	
744049.80 m E	6013448.95 m S	

WENNER ARRAY

Wenner Spacing a (m)	0-S/0-ES Spacing (m)	0-H/0-E Spacing (m)	US-ES (mV)	IH-E (mA)	Apparent Resistivity (Ohm*m)
0,60	0,30	0,90	296,00	6,35	176,00
0,80	0,40	1,20	118,00	4,85	123,00
1,00	0,50	1,50	74,20	5,35	87,50
1,30	0,65	1,95	32,20	4,33	56,30
1,70	0,85	2,55	17,30	3,67	50,50
2,20	1,10	3,30	21,00	6,99	41,60
2,90	1,45	4,35	9,48	5,74	30,20
3,80	1,90	5,70	6,27	6,35	23,60
4,80	2,40	7,20	7,95	8,26	25,80
6,20	3,10	9,30	6,43	8,45	29,20
8,20	4,10	12,30	6,99	11,00	32,90
11,00	5,50	16,50	9,10	17,00	37,00
15,00	7,50	22,50	4,99	10,80	39,20





GEOTECHNICAL REPORT LA VENDIMIA PV SOLAR PROJECT, MAULE (CHILE)

Annex 5: Thermal Resistivity

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			THERMAL CONDUCTIVITY 1	THERMAL CONDUCTIVITY 2	THERMAL CONDUCTIVITY 3	AVERAGE THERMAL CONDUCTIVITY	THERMAL RESISTIVITY 1	THERMAL RESISTIVITY 2	THERMAL RESISTIVITY 3	AVERAGE THERMAL RESISTIVITY	THERMAL CONDUCTIVITY 1	THERMAL CONDUCTIVITY 2	THERMAL CONDUCTIVITY 3	AVERAGE THERMAL CONDUCTIVITY	THERMAL RESISTIVITY 1	THERMAL RESISTIVITY 2	THERMAL RESISTIVITY 3	AVERAGE THERMAL RESISTIVITY	TEMPERATURA 1	TEMPERATURA 2	TEMPERATURA 3	TEMPERATURA MEDIA
ID	**Loc. ID**	**Depth (m)**	**W/mK**	**W/mK**	**W/mK**	**W/mK**	**mK/W**	**mK/W**	**mK/W**	**mK/W**	**w/cm°C**	**w/cm°C**	**w/cm°C**	**w/cm°C**	**cm°C/W**	**cm°C/W**	**cm°C/W**	**cm°C/W**	**°C**	**°C**	**°C**	**°C**
TR-01	TP-03	0,70	1,936	1,925	1,965	1,942	0,5165289	0,519	0,509	**0,515**	0,019	0,019	0,020	0,019	51,65	51,95	50,89	51,50	13,1	13,2	13,3	13,2
TR-02	TP-06	0,70	1,639	1,650	1,642	1,644	0,610	0,606	0,609	**0,608**	0,016	0,017	0,016	0,016	61,01	60,61	60,90	60,84	13	13	12,9	13,0
TR-03	TP-08	0,80	1,539	1,595	1,566	1,567	0,650	0,627	0,639	**0,638**	0,015	0,016	0,016	0,016	64,98	62,70	63,86	63,84	13,2	13,2	13,2	13,2
TR-04	TP-11	0,90	2,195	2,070	2,085	2,117	0,456	0,483	0,480	**0,473**	0,022	0,021	0,021	0,021	45,56	48,31	47,96	47,28	13	13	13	13,0
TR-05	TP-12	0,65	1,809	1,724	1,781	1,771	0,553	0,580	0,561	**0,565**	0,018	0,017	0,018	0,018	55,28	58,00	56,15	56,48	14,1	14,1	14,1	14,1

GEOTECHNICAL REPORT LA VENDIMIA PV SOLAR PROJECT, MAULE (CHILE)

Annex 6: CBR Logs

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1. CBR's Location

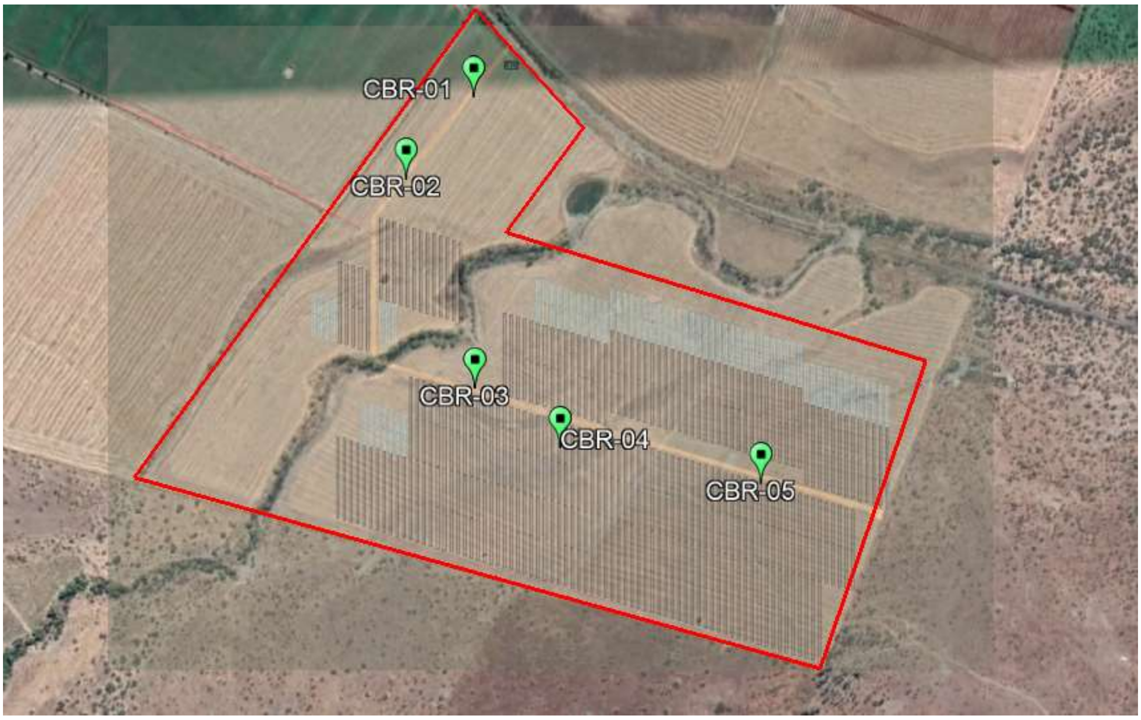


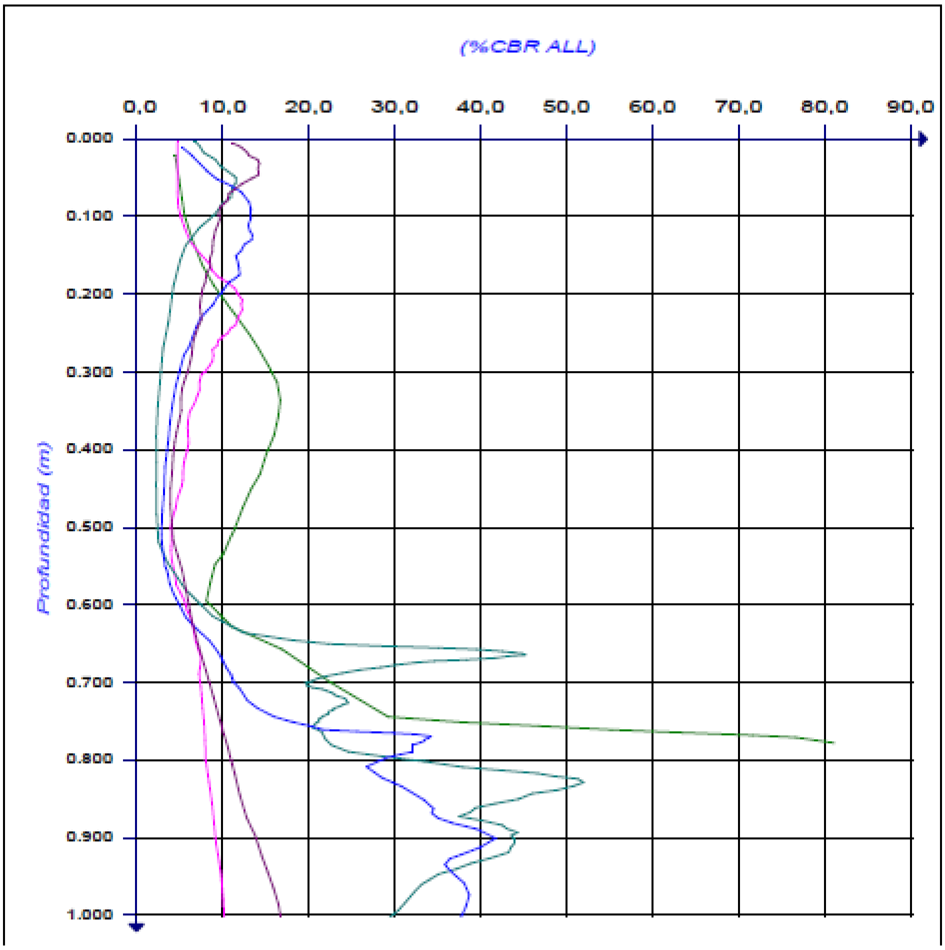
Illustration 1: CBR Location

2. CBR's Charts

Control de compactación con penetrometro dinamico a energía variable

Documento :Z:\Carpeta_02-Proyectos GMS\18271_Trina Solar\IG1827115a_La Vendimia_GEO\01_FIELD_WORKS\4. DPL-P

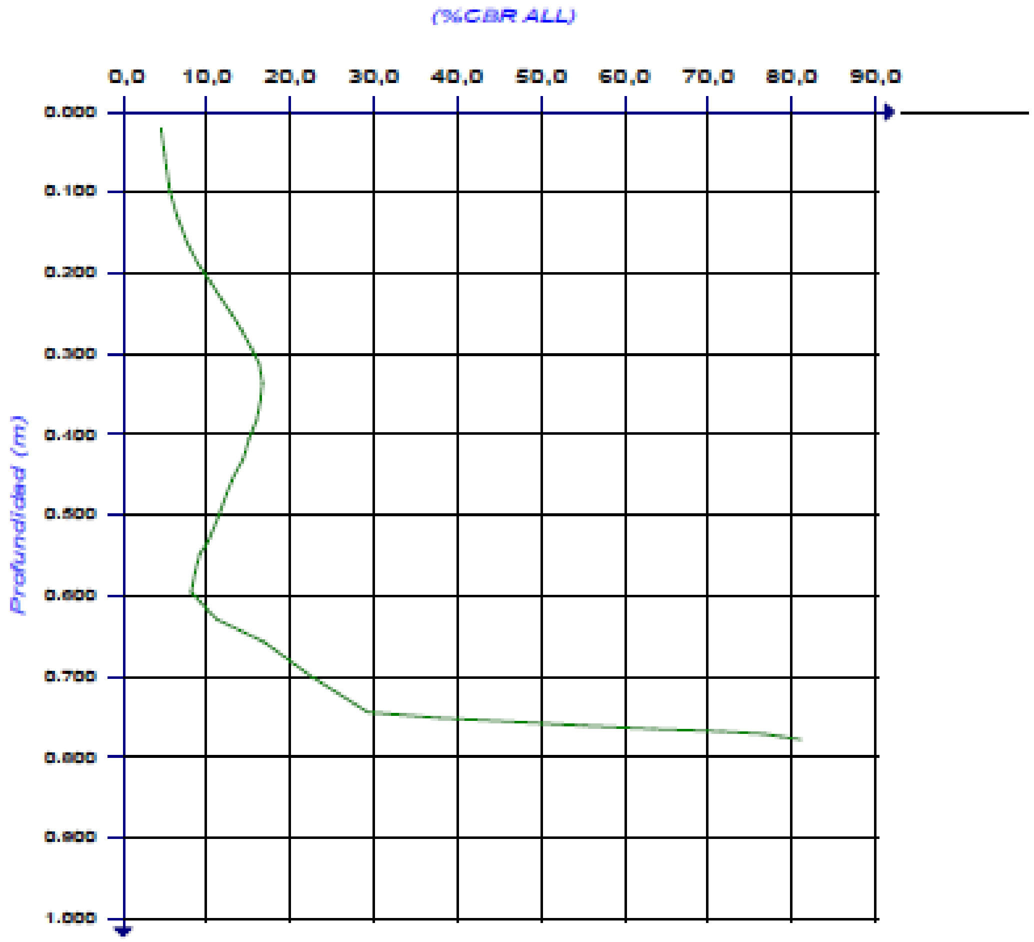
Sitio : LA VENDIMIA



Sitio	Sondaje	Fecha	Estudio	Curva
LA VENDIMIA	CBR 05	06/10/2021	Compactación	
LA VENDIMIA	CBR 04	06/10/2021	Compactación	
LA VENDIMIA	CBR 01	06/10/2021	Compactación	
LA VENDIMIA	CBR 02	06/10/2021	Compactación	
LA VENDIMIA	CBR 03	07/10/2021	Compactación	

Control de compactación con penetrometro dinamico a energía variable

Documento :Z:\Carpeta_02-Proyectos GMS\18271_Trina Solar\IG1827115a_La Vendimia_GEO\01_FIELD_WORKS\4. DPL-P			
Sitio : LA VENDIMIA			
Sondaje : CBR 05			
Asfalto : 0,00 m	Prof. pre-perforacion :0,000 m	Sección : 2 cm²	Prof. Napa :indeterminada
Masa :Martillo Panda 2	Cond. de interrupción :Tempor	Fecha : 06/10/2021	Hora : 15:39:00
Operador :		Organismo :	
Comentarios :			



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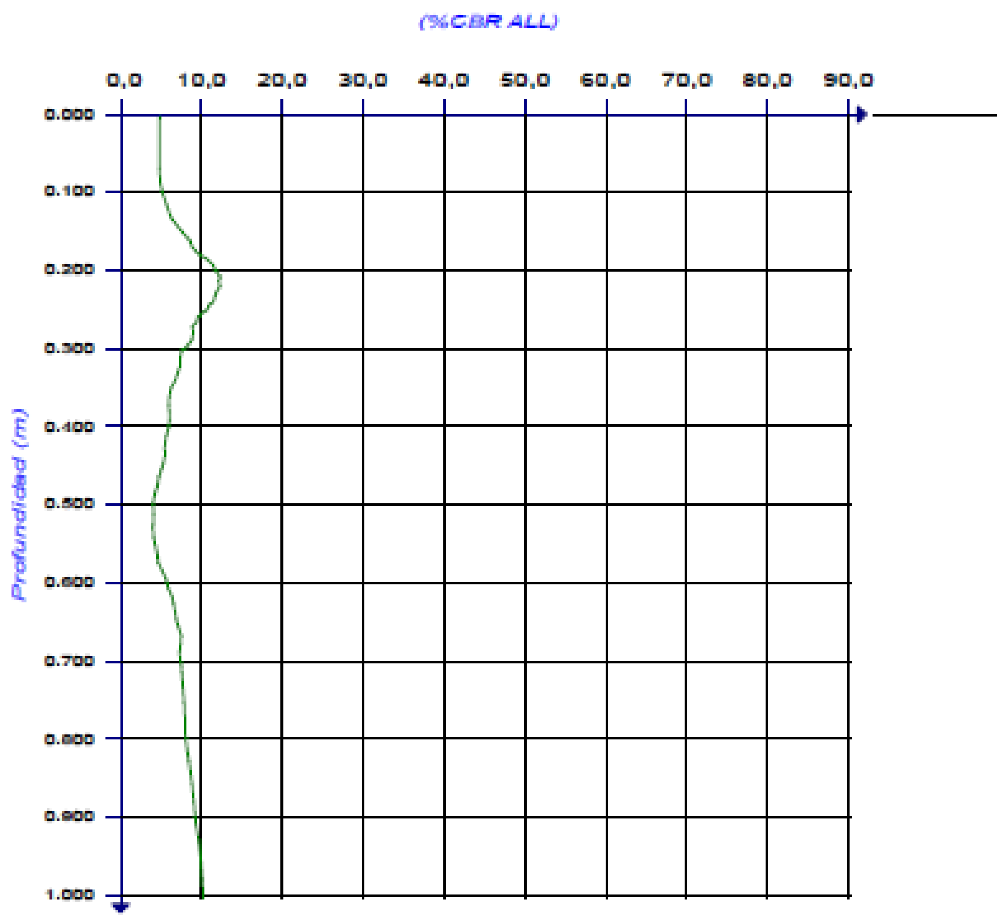
Documento :Z:\Carpeta_02-Proyectos GMS\18271_Trina Solar\IG1827115a_La Vendimia_GEO\01_FIELD_WORKS\4. DPL-P			
Sitio : LA VENDIMIA			
Sondaje : CBR 04			
Asfalto : 0,00 m	Prof. pre-perforacion :0,000 m	Sección : 2 cm²	Prof. Napa :Indeterminada
Masa :Martillo Panda 2	Cond. de interrupción :Tempor	Fecha : 06/10/2021	Hora :16:57:00
Operador :		Organismo :	
Comentarios :			



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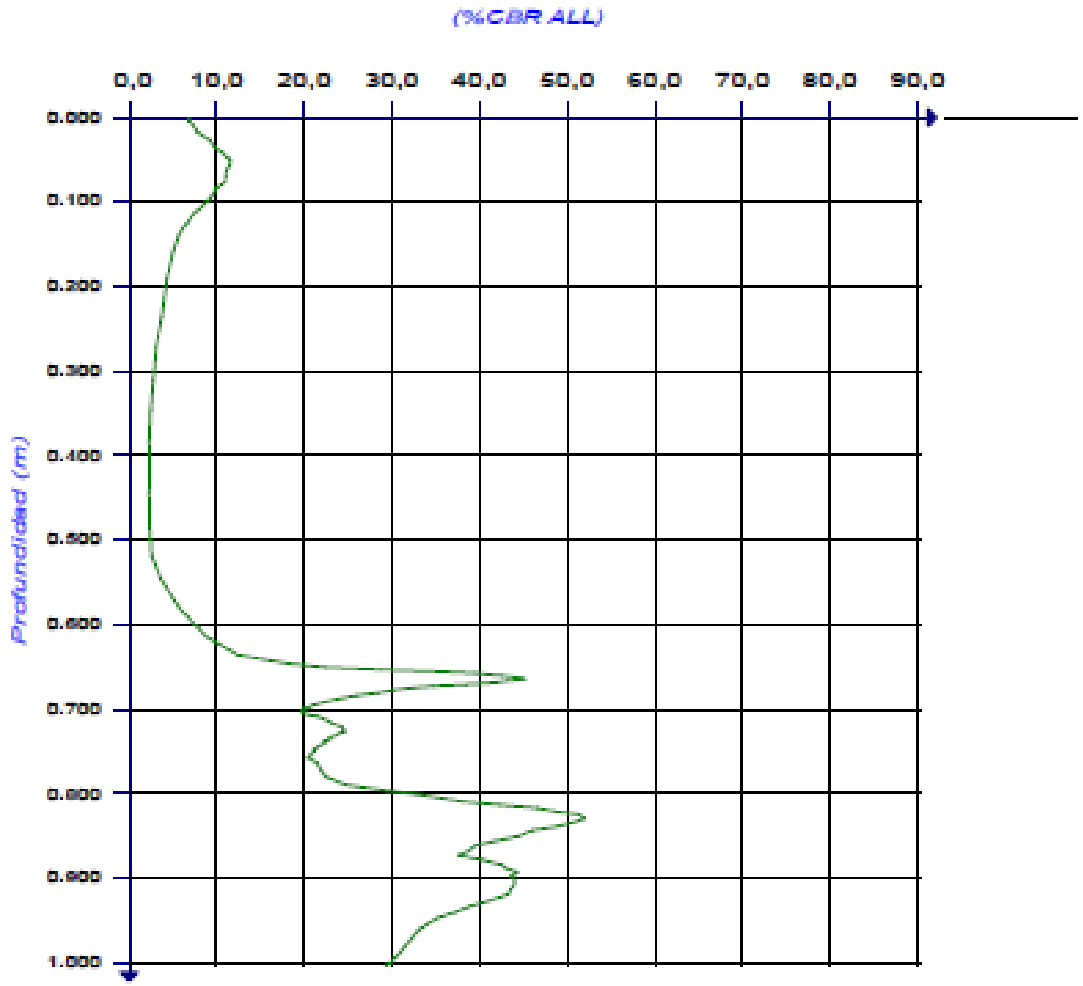
Documento :Z:\Carpeta_02-Proyectos GMS\18271_Trina Solar\IG1827115a_La Vendimia_GEO\01_FIELD_WORKS\4. DPL-P			
Sitio : LA VENDIMIA			
Sondaje : CBR 01			
Asfalto : 0,00 m	Prof. pre-perforacion :0,000 m	Sección : 2 cm²	Prof. Napa :Indeterminada
Masa :Martillo Panda 2	Cond. de interrupción :Tempor	Fecha : 06/10/2021	Hora : 19:24:00
Operador :		Organismo :	
Comentarios :			



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Control de compactación con penetrometro dinamico a energía variable

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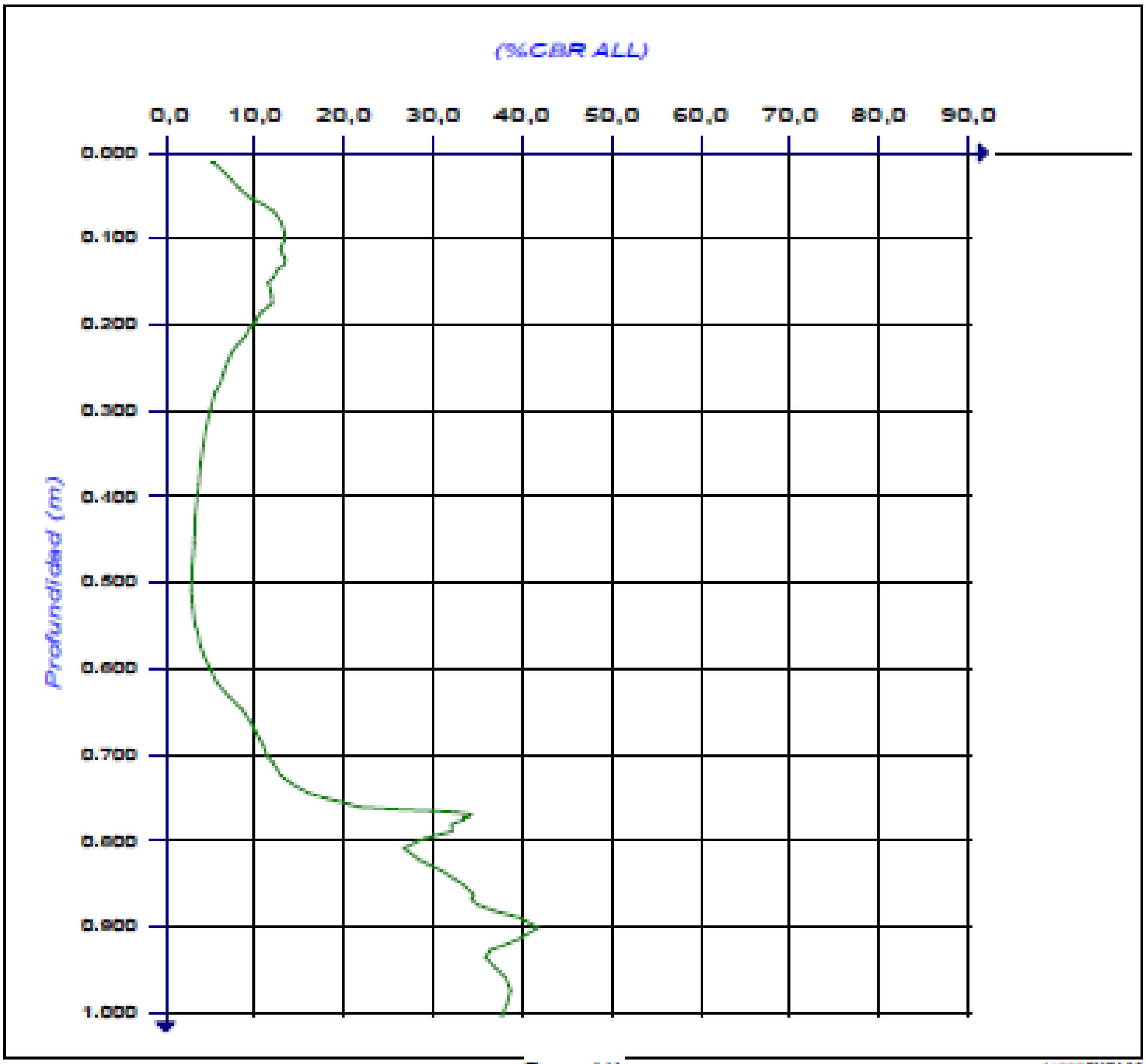
Sitio : LA VENDIMIA			
Sondaje : CBR 02			
Asfalto : 0,00 m	Prof. pre-perforacion :0,000 m	Sección : 2 cm²	Prof. Napa :Indeterminada
Masa :Martillo Panda 2	Cond. de interrupción :Tempo	Fecha : 06/10/2021	Hora :19:56:00
Operador :		Organismo :	
Comentarios :			



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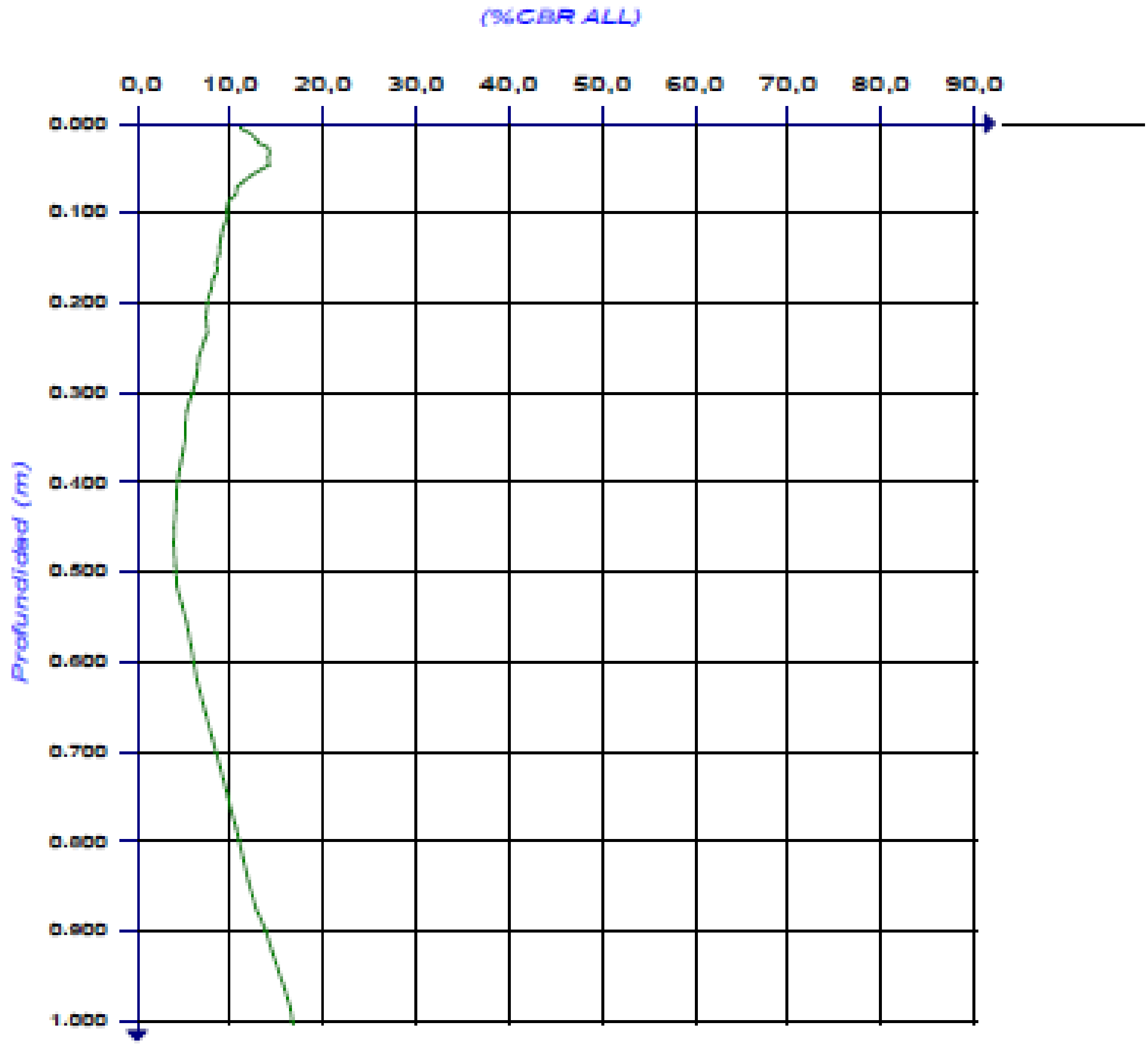
Control de compactación con penetrometro dinamico a energía variable

Documento :Z:\Carpeta_02-Proyectos GMS\18271_Trina Solar\IG1827115a_La Vendimia_GEO\01_FIELD_WORKS\4. DPL-F
Sitio : LA VENDIMIA

Sondaje : CBR 03			
Asfalto : 0,00 m	Prof. pre-perforacion :0,000 m	Sección : 2 cm²	Prof. Napa :Indeterminada
Masa :Martillo Panda 2	Cond. de interrupción :Tempor	Fecha : 07/10/2021	Hora :16:57:00
Operador :		Organismo :	
Comentarios :			



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Logiciel PANDA 2.7

GEOTECHNICAL REPORT LA VENDIMIA PV SOLAR PROJECT, MAULE (CHILE)

Annex 7: Equipment Description

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1. Trial Pit Excavation

A trial pit is an excavation of the ground which helps to obtain detailed information regarding composition, strength, stratification, and discontinuities of subsurface. Trial Pits have been excavated using a JBC backhoe machine.

Illustration 1: Blackhoe machine used to carry out trial pits

The following information has been estimated/obtained from each trial pit:

- UTM Coordinates, given in WGS84 datum.
- Trial pits logging in accordance with BS 5930:2015 and BS EN 1997-2:2007.
- Photographic documentation.
- Identification and recording of the groundwater table, if it is present.
- Disturbed sampling for soil geotechnical laboratory testing.
- Samples labelling with project name, trial pit location, date and time collection and depth.

2. Vertical Electrical Sounding (VES)

Underground soil electrical surveying has long demonstrated to be extremely helpful for soil resistivity modelling purposes.

The four-electrode method has been chosen to meet resistivity modelling goals in the current project. Vertical Electrical Surveys (VES) are very well known and documented in the industry. In this method DC electrical currents are transmitted to the ground using four pikes rammed into the ground; two pikes (electrodes) are used to introduce DC currents into the ground and two additional pikes (voltage or potential electrodes) are used to obtain resistant values. Final electrical current values are measured after a few seconds and electric potential difference arises between both electrodes. Pikes are aligned following the building main direction. The measurement is then repeated by placing pikes at different distances, allowing different measurements at different depths. To calculate the actual resistivity that shall be devoted to earthing design, pikes drawing can be applied more accurately by using either Wenner, Schlumberger, Pole-Dipole or Dipole-Dipole arrangements. Wenner method has been selected for this project with a spacing of 0.60, 0.80, 1.0, 1.3, 1.7, 2.2, 2.9, 3.8, 4.8, 6.2, 8.2, 11.0 and 15.0 meters.

All above has been used to obtain data field curves. From raw field measurements, curves and apparent resistivity figures, a vertical arrange of depth, layer thickness and actual resistivity values are obtained.

Illustration 2. AEMC 6471 equipment

The digital ground resistance tester model 6471 is a portable measurement instrument designed to measure different ground resistance configuration and soil resistivity. This model allows Wenner and Schlumberger Soil resistivity measurement configuration.

The AEMC 6471 can measure a wide range of resistivity (0.01Ω to 99.99 kΩ), is automatically auto-ranging, perform frequency test and current test.

3. Panda 2 CBR and VDCP Testing device

The Panda2 is a portable dynamic cone penetrometer used for the evaluation of the soil strength. Panda2 provides immediate repeatable results so that on-site decisions can be made right away. It can be used in confined spaces and locations with difficult access, with no support equipment required. It is used for soil investigations, ground investigations, site investigations and compaction control. The Panda2 (Figure 1) is a lightweight equipment (total weight of 20kg), hand held Dynamic Cone Penetrometer which uses variable energy and can be operated by a single person to test soil in almost any location to a depth of about 6 metres, by either using a 1.7kg hammer or an automatic hammer.

The NSPT correlation recommended by the manufacturer ranges NSPT= (0.30 to 0.60) *qd (MPa). NF-P-94-105 French Standard recommends the use of this method.

The metal rod that is driven into the soil consists of a stainless-steel cone having an area of 4 and 2 cm2 for the DPL and CBR respectively.

Illustration 3: Panda2 testing device

4. Thermal Resistivity measurement

The thermal resistivity of the site was carried out using KD-2 Pro device. The KD2 Pro is a battery-operated, menu-driven device that measures thermal conductivity and resistivity, volumetric specific heat capacity and thermal diffusivity. We designed the KD2 Pro for ease of use and maximum functionality.

The equipment consists of a control unit and needle sensor (TR-1). The large (10 cm long, 2.4 mm diameter) single needle TR-1 sensor measures thermal conductivity and thermal resistivity. The TR-1 was designed primarily for soil, and other granular or porous materials. It can either be inserted the pilot pin or drill an appropriately sized hole for the TR-1 sensor. The relatively large diameter and typically longer heating time of the TR-1 sensor minimize errors from contact resistance in granular samples or solid samples with pilot holes.

The read time is the time, in minutes, the KD2 Pro takes to gather data for computing thermal properties. It applies heat to the sensor for half of the set time and takes measurements over the full time. The KD2 Pro waits thirty seconds for temperature equilibration before heating starts, so the entire measurement time should be the "Read Time" plus 30 seconds. The sensor takes sixty temperature readings during the read time.

Illustration 4: KD2Pro equipment

GEOTECHNICAL REPORT LA VENDIMIA PV SOLAR PROJECT, MAULE (CHILE)

Annex 8: Photographic Report

Prepared by:

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Trina Solar Holding

Nueva Tajamar 555, of 1501
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1. Site Overview

Illustration 1: General view of the site

2. Panda2 Testing

Illustration 2: P-14 being performed

Illustration 4: P-04 being performed

3. Vertical Electrical Resistivity

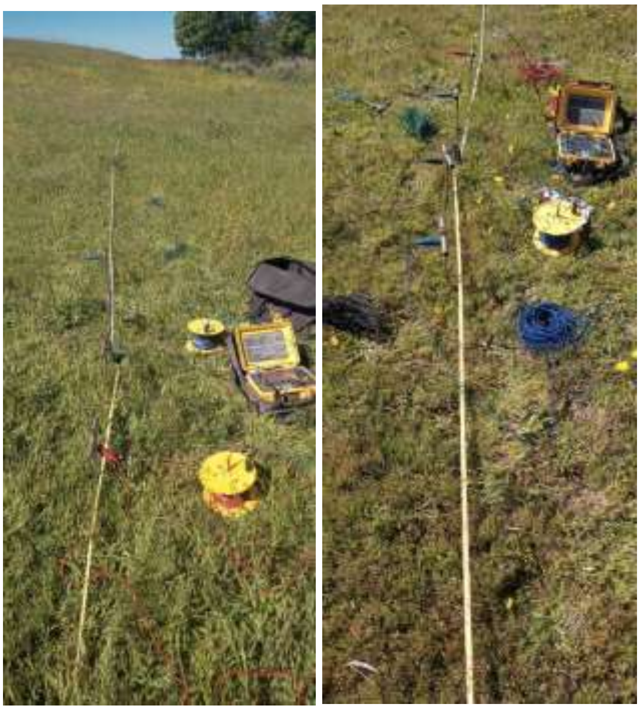

Illustration 6: AEMC 6471 equipment used in VES tests

Illustration 7: VES-04 survey line and equipment setup

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4. CBR test

Illustration 8: Panda2 equipment

Illustration 9: CBR Test

GEOTECHNICAL REPORT LA VENDIMIA PV SOLAR PROJECT, CAUQUENES (CHILE)

Annex 9: Laboratory results

Prepared by:

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TP	TP-01	TP-02	TP-03	TP-04	TP-05	TP-06	TP-07	TP-08	TP-09	TP-10	TP-11	TP-12	TP-13	TP-14	TP-15	TP-14M.I.	TP-15 M.I.
Depth (m)	1.50	0.80	0.90	0.60	1.80	1.90	0.70	1.40	0.60	2.00	0.60	0.60	1.10	1.50	2.50	1.00	0.60
Moisture (%)	14.6	7.6	11.7	10.8	16.6	18.5	9.5	14.9	10.9	14.9	6.2	9.3	13.0	16.3	11.2		
Gravel (%)	23.7	47.7	0.7	0.2	0.0	0.2	0.0	0.0	0.0	4.1	0.90	6.70	0.00	0.60	1.30		
Sand (%)	44.3	10.4	31.9	26.5	23.9	26.7	15.7	30.6	34.4	37.1	38.70	48.80	43.40	61.80	46.20		
Fines (%)	16.80	14.70	61.30	73.00	74.00	68.50	77.70	60.00	50.50	26.70	55.30	17.40	47.60	31.20	30.30		
Liquid Limit (LL)	33.0	53.0	25.0	27.0	28.0	35.0	23.0	32.0	33.0	29.0	25.0	0.0	23.0	24.0	28.0		
Plasticity Index (PI)	13.0	36.0	15.0	14.0	15.0	20.0	15.0	25.0	17.0	13.0	13.0	0.0	12.0	12.0	12.0		
Consistency Index	1.4	1.3	0.9	1.2	0.8	0.8	0.9	0.7	1.3	1.1	1.4		0.8	0.6	1.4		
Sulphates (ppm)	206.00		178.00	171.00		171.00		153.00		182.00		189.00		197.00			
Sol Salts (%)	0.26		0.08	0.06		0.04		0.06		0.18		0.13		0.21			
Chlorides	45.00		26.00	29.00		29.00		23.00		36.00		32.00		34.00			
Redox Potential (mV)	178.00		189.00	181.00		185.00		162.00		206.00		187.00		193.00			
Organic Matter (%)	2.65		1.96	2.12		2.34		2.75		3.07		2.81		2.79			
pH	6.9		6.7	6.8		7.0		6.9		7.0		7.1		6.9			
Baumann-Gully Acidity (ml/kg)	21.5		18.8							23.7							
Initial Void Ratio (e0)																0.64	0.51
Compress. Index (Cc)																0.007	0.007
Coef. Of Consol. (CV)																0.334	0.017
Resistance compresion (qu) (kPa)																	23.0
Cohesion (Cu) (kPa)																	11.0
Colapso a 200 (Ie) (kPa)																0.54	1.58
USCS Classification	SC Clayey SAND	GC Clayey GRAVEL	CL Low Plasticity CLAY	CL Low Plasticity CLAY	CL Low Plasticity CLAY	CL Low Plasticity CLAY	CL Low Plasticity CLAY	CL Low Plasticity CLAY	CL Low Plasticity CLAY	SC Clayey SAND	CL Low Plasticity CLAY	SM Silty SAND	SC Clayey SAND	SC Clayey SAND	SC Clayey SAND		

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INFORME DE RESULTADOS DE ENSAYOS

1. ANTECEDENTES SOLICITANTE: GMS Internacional -	**EXPEDIENTE: EXT_ 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio** MUESTRA Nº: 6033 INFORME Nº: Lab.GCh-581-21 FECHA INFORME: 23.11.2021
PROYECTO/OBRA: LA VENDIMIA , Cauquenes, Region del Maule	

2. DATOS MUESTRA

Descripción:
Procedencia/Referencia: TP-01
Datos complementarios: Desde 1.5 hasta 1.6 m.
Tipo de muestreo: Calicatas

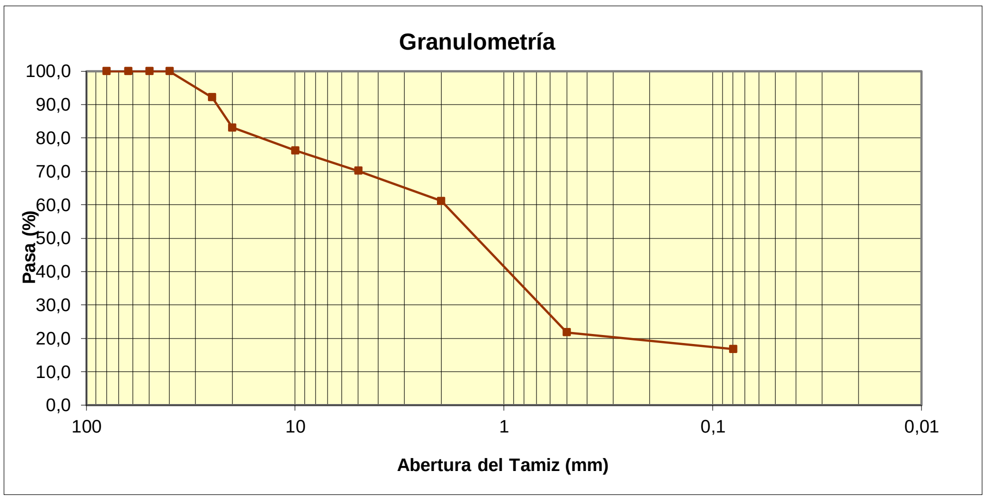
Método de muestreo: NCh 164 Of.2009
Muestreado por: Cliente
Fecha muestreo/recepción: 13.10.2021

3. REGISTRO MUESTRA

Fecha registro: 19.10.2021
Observaciones: -

4. RESULTADOS DE ENSAYOS

GRANULOMETRIA DE SUELOS. MCV8_8.102.1_2017	
Tamiz (mm)	Pasa (%)
80	100,0
63	100,0
50	100,0
40	100,0
25	92,2
20	83,1
10	76,3
5	70,2
2	61,1
0,5	21,8
0,08	16,8



DISTRIBUCIÓN GRANULOMETRICA			
Cantos		De 75 a 300 mm.	0,0
Gravas	gruesas	De 19 a 75 mm.	16,9
	finas	De 4,75 a 19 mm.	12,9
Arenas	gruesas	De 2 a 4,75 mm.	9,1
	medias	De 0,425 a 2 mm.	39,3
	finas	De 0,075 a 0,425 mm.	5,0
Limos y arcillas		Menos de 0,075 mm.	16,8

LIMITES DE ATTERBERG (NCh 1517/1-2.)	
Límite líquido	33
Límite plástico	20
Índice de plasticidad	13

HUMEDAD POR SECADO EN ESTUFA (NCh1515)	
HUMEDAD %	14,6

* **Nota**: Porcentaje de sobre tamaño (Solo indicativo), según manual de carretera, inciso 5.0 "Procedimiento de ensaye". MCV8.102.1_2017.

Clasificación AASHTO
A-2-6 (0)
Grava y arena limo o arcillas
Clasificación USCS
SC: Arena arcillosa

PESO UNITARIO AASHTO T 233-02 (2015)	
Densidad Húmeda g/cm3	1,615
Densidad Seca g/cm3	1,412
Humedad %	14,63

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INFORME DE RESULTADOS DE ENSAYOS

1. ANTECEDENTES SOLICITANTE:
GMS Internacional
-

PROYECTO/OBRA:
LA VENDIMIA , Cauquenes, Region del Maule

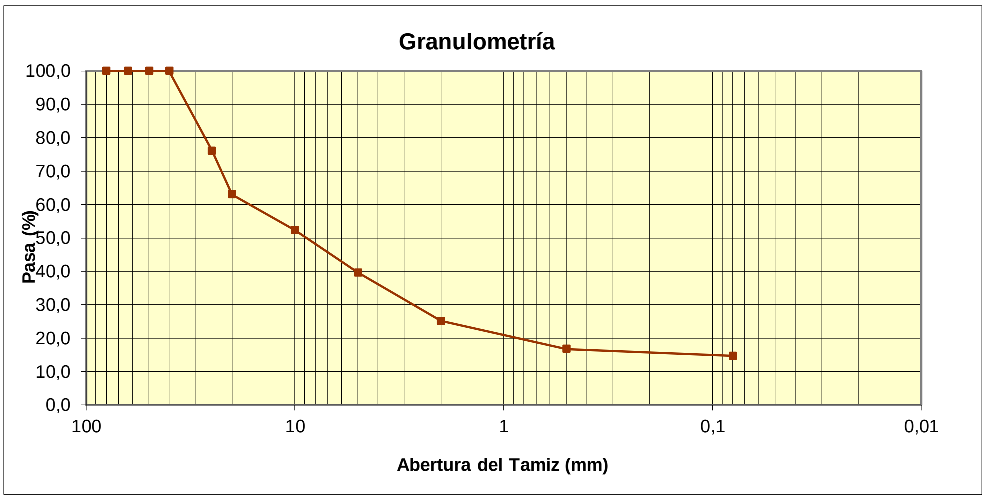
EXPEDIENTE: EXT_ 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio
MUESTRA Nº: 6034
INFORME Nº: Lab.GCh-581-21
FECHA INFORME: 23.11.2021

2. DATOS MUESTRA
Descripción:
Procedencia/Referencia: TP-02
Datos complementarios: Desde 0.8 hasta 0.9 m.
Tipo de muestreo: Calicatas
Método de muestreo: NCh 164 Of.2009
Muestreado por: Cliente
Fecha muestreo/recepción: 13.10.2021

3. REGISTRO MUESTRA
Fecha registro: 19.10.2021
Observaciones: -

4. RESULTADOS DE ENSAYOS

GRANULOMETRIA DE SUELOS. MCV8_8.102.1_2017	
Tamiz (mm)	Pasa (%)
80	100,0
63	100,0
50	100,0
40	100,0
25	76,1
20	63,0
10	52,3
5	39,6
2	25,1
0,5	16,7
0,08	14,7



DISTRIBUCIÓN GRANULOMETRICA			
Cantos		De 75 a 300 mm.	0,0
Gravas	gruesas	De 19 a 75 mm.	37,0
	finas	De 4,75 a 19 mm.	23,4
Arenas	gruesas	De 2 a 4,75 mm.	14,5
	medias	De 0,425 a 2 mm.	8,4
	finas	De 0,075 a 0,425 mm.	2,0
Limos y arcillas		Menos de 0,075 mm.	14,7

LIMITES DE ATTERBERG (NCh 1517/1-2.)	
Límite líquido	53
Límite plástico	17
Índice de plasticidad	36

HUMEDAD POR SECADO EN ESTUFA (NCh1515)	
HUMEDAD %	7,6

*** Nota**: Porcentaje de sobre tamaño (Solo indicativo), según manual de carretera, inciso 5.0 "Procedimiento de ensaye". MCV8.102.1_2017.

Clasificación AASHTO
A-2-7 (0)
Grava y arena limo o arcillas
Clasificación USCS
GC: Grava arcillosa

PESO UNITARIO AASHTO T 233-02 (2015)	
Densidad Húmeda g/cm3	1,721
Densidad Seca g/cm3	1,599
Humedad %	7,61

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INFORME DE RESULTADOS DE ENSAYOS

1. ANTECEDENTES SOLICITANTE: GMS Internacional -	**EXPEDIENTE: EXT_ 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio** MUESTRA Nº: 6035
PROYECTO/OBRA: LA VENDIMIA , Cauquenes, Region del Maule	INFORME Nº: Lab.GCh-581-21 FECHA INFORME: 23.11.2021

2. DATOS MUESTRA

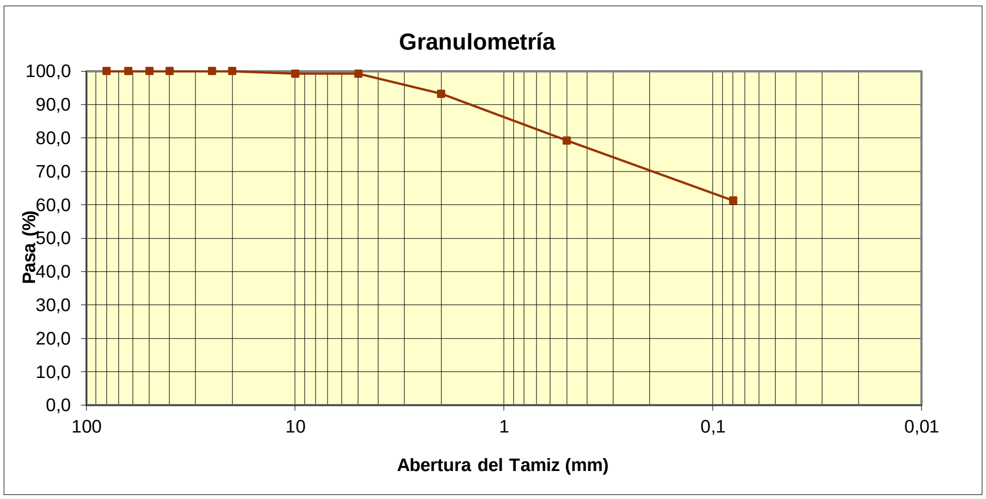
Descripción:	Método de muestreo: NCh 164 Of.2009
Procedencia/Referencia: TP-03	Muestreado por: Cliente
Datos complementarios: Desde 0.9 hasta 1.0 m.	Fecha muestreo/recepción: 13.10.2021
Tipo de muestreo: Calicatas	

3. REGISTRO MUESTRA

Fecha registro: 19.10.2021	Observaciones: -

4. RESULTADOS DE ENSAYOS

GRANULOMETRIA DE SUELOS. MCV8_8.102.1_2017	
Tamiz (mm)	Pasa (%)
80	100,0
63	100,0
50	100,0
40	100,0
25	100,0
20	100,0
10	99,3
5	99,3
2	93,2
0,5	79,2
0,08	61,3



DISTRIBUCIÓN GRANULOMETRICA			
Cantos		De 75 a 300 mm.	0,0
Gravas	gruesas	De 19 a 75 mm.	0,0
	finas	De 4,75 a 19 mm.	0,7
Arenas	gruesas	De 2 a 4,75 mm.	6,1
	medias	De 0,425 a 2 mm.	14,0
	finas	De 0,075 a 0,425 mm.	17,9
Limos y arcillas		Menos de 0,075 mm.	61,3

LIMITES DE ATTERBERG (NCh 1517/1-2.)	
Límite líquido	25
Límite plástico	10
Índice de plasticidad	15

HUMEDAD POR SECADO EN ESTUFA (NCh1515)	
HUMEDAD %	11,7

* **Nota**: Porcentaje de sobre tamaño (Solo indicativo), según manual de carretera, inciso 5.0 "Procedimiento de ensaye". MCV8.102.1_2017.

Clasificación AASHTO
A-6 (6)
Suelos arcillosos
Clasificación USCS
CL: Arcilla de baja plasticidad

PESO UNITARIO AASHTO T 233-02 (2015)	
Densidad Húmeda g/cm3	1,671
Densidad Seca g/cm3	1,496
Humedad %	11,71

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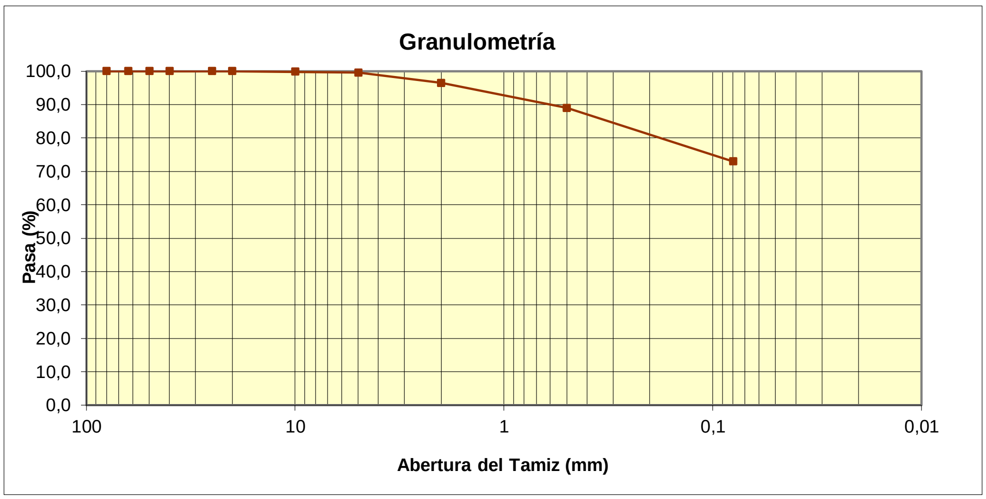
INFORME DE RESULTADOS DE ENSAYOS

1. ANTECEDENTES SOLICITANTE: GMS Internacional -	**EXPEDIENTE: EXT_ 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio** MUESTRA Nº: 6036 INFORME Nº: Lab.GCh-581-21 FECHA INFORME: 23.11.2021
PROYECTO/OBRA: LA VENDIMIA , Cauquenes, Region del Maule	
2. DATOS MUESTRA	
Descripción:	Método de muestreo: NCh 164 Of.2009
Procedencia/Referencia: TP-04	Muestreado por: Cliente
Datos complementarios: Desde 0.6 hasta 0.7 m.	Fecha muestreo/recepción: 13.10.2021
Tipo de muestreo: Calicatas	
3. REGISTRO MUESTRA	
Fecha registro: 19.10.2021	Observaciones: -

4. RESULTADOS DE ENSAYOS

GRANULOMETRIA DE SUELOS. MCV8_8.102.1_2017	
Tamiz (mm)	Pasa (%)
80	100,0
63	100,0
50	100,0
40	100,0
25	100,0
20	100,0
10	99,8
5	99,6
2	96,5
0,5	89,0
0,08	73,0



DISTRIBUCIÓN GRANULOMETRICA			
Cantos		De 75 a 300 mm.	0,0
Gravas	gruesas	De 19 a 75 mm.	0,0
	finas	De 4,75 a 19 mm.	0,4
Arenas	gruesas	De 2 a 4,75 mm.	3,1
	medias	De 0,425 a 2 mm.	7,5
	finas	De 0,075 a 0,425 mm.	16,0
Limos y arcillas		Menos de 0,075 mm.	73,0

LIMITES DE ATTERBERG (NCh 1517/1-2.)	
Límite líquido	27
Límite plástico	13
Índice de plasticidad	14

HUMEDAD POR SECADO EN ESTUFA (NCh1515)	
HUMEDAD %	10,8

* **Nota**: Porcentaje de sobre tamaño (Solo indicativo), según manual de carretera, inciso 5.0 "Procedimiento de ensaye". MCV8.102.1_2017.

Clasificación AASHTO
A-6 (7)
Suelos arcillosos
Clasificación USCS
CL: Arcilla de baja plasticidad

PESO UNITARIO AASHTO T 233-02 (2015)	
Densidad Húmeda g/cm3	1,652
Densidad Seca g/cm3	1,491
Humedad %	10,81

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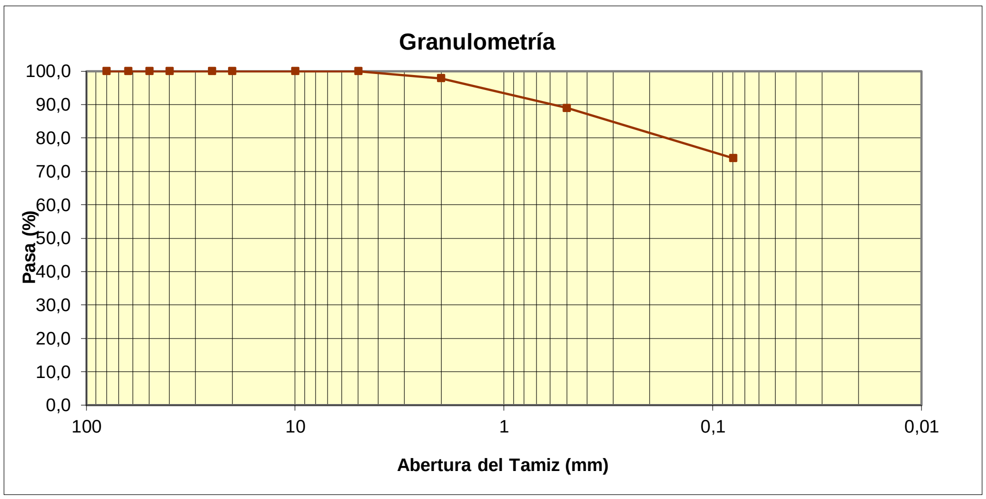
INFORME DE RESULTADOS DE ENSAYOS

1. ANTECEDENTES SOLICITANTE: GMS Internacional -	**EXPEDIENTE: EXT_ 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio** MUESTRA Nº: 6037 INFORME Nº: Lab.GCh-581-21 FECHA INFORME: 23.11.2021
PROYECTO/OBRA: LA VENDIMIA , Cauquenes, Region del Maule	
2. DATOS MUESTRA	
Descripción:	Método de muestreo: NCh 164 Of.2009
Procedencia/Referencia: TP-05	Muestreado por: Cliente
Datos complementarios: Desde 1.8 hasta 1.9 m.	Fecha muestreo/recepción: 13.10.2021
Tipo de muestreo: Calicatas	
3. REGISTRO MUESTRA	
Fecha registro: 19.10.2021	Observaciones: -

4. RESULTADOS DE ENSAYOS

GRANULOMETRIA DE SUELOS. MCV8_8.102.1_2017	
Tamiz (mm)	Pasa (%)
80	100,0
63	100,0
50	100,0
40	100,0
25	100,0
20	100,0
10	100,0
5	100,0
2	97,9
0,5	89,0
0,08	74,0



DISTRIBUCIÓN GRANULOMETRICA			
Cantos		De 75 a 300 mm.	0,0
Gravas	gruesas	De 19 a 75 mm.	0,0
	finas	De 4,75 a 19 mm.	0,0
Arenas	gruesas	De 2 a 4,75 mm.	2,1
	medias	De 0,425 a 2 mm.	8,9
	finas	De 0,075 a 0,425 mm.	15,0
Limos y arcillas		Menos de 0,075 mm.	74,0

LIMITES DE ATTERBERG (NCh 1517/1-2.)	
Límite líquido	28
Límite plástico	13
Índice de plasticidad	15

HUMEDAD POR SECADO EN ESTUFA (NCh1515)	
HUMEDAD %	16,6

* **Nota**: Porcentaje de sobre tamaño (Solo indicativo), según manual de carretera, inciso 5.0 "Procedimiento de ensaye". MCV8.102.1_2017.

Clasificación AASHTO
A-6 (8)
Suelos arcillosos
Clasificación USCS
CL: Arcilla de baja plasticidad

PESO UNITARIO AASHTO T 233-02 (2015)	
Densidad Húmeda g/cm3	1,624
Densidad Seca g/cm3	1,392
Humedad %	16,61

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INFORME DE RESULTADOS DE ENSAYOS

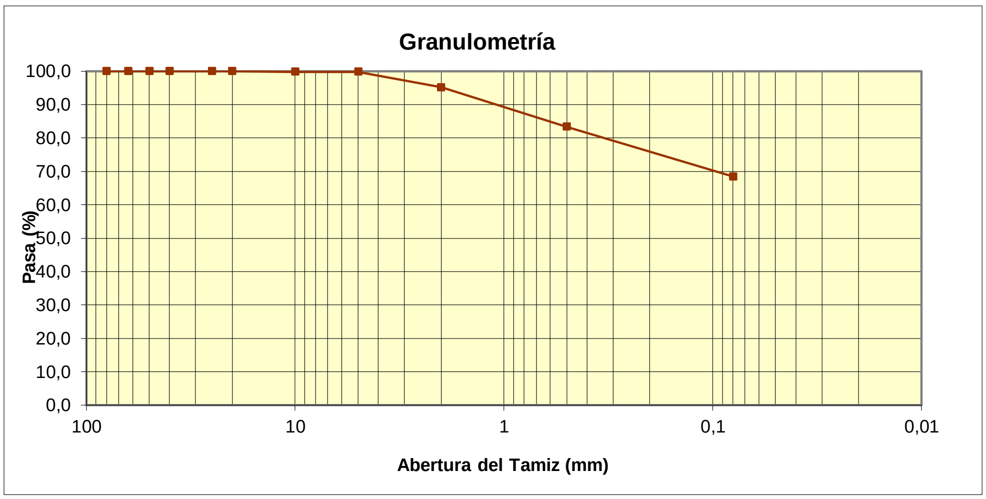
1. ANTECEDENTES SOLICITANTE: GMS Internacional -	**EXPEDIENTE: EXT_ 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio** MUESTRA Nº: 6038 INFORME Nº: Lab.GCh-581-21 FECHA INFORME: 23.11.2021
PROYECTO/OBRA: LA VENDIMIA , Cauquenes, Region del Maule	

2. DATOS MUESTRA
Descripción:
Procedencia/Referencia: TP-06
Datos complementarios: Desde 1.9 hasta 2.0 m.
Tipo de muestreo: Calicatas
Método de muestreo: NCh 164 Of.2009
Muestreado por: Cliente
Fecha muestreo/recepción: 13.10.2021

3. REGISTRO MUESTRA
Fecha registro: 19.10.2021
Observaciones: -

4. RESULTADOS DE ENSAYOS

GRANULOMETRIA DE SUELOS. MCV8_8.102.1_2017	
Tamiz (mm)	Pasa (%)
80	100,0
63	100,0
50	100,0
40	100,0
25	100,0
20	100,0
10	99,8
5	99,8
2	95,2
0,5	83,4
0,08	68,5



DISTRIBUCIÓN GRANULOMETRICA			
Cantos		De 75 a 300 mm.	0,0
Gravas	gruesas	De 19 a 75 mm.	0,0
	finas	De 4,75 a 19 mm.	0,2
Arenas	gruesas	De 2 a 4,75 mm.	4,6
	medias	De 0,425 a 2 mm.	11,8
	finas	De 0,075 a 0,425 mm.	14,9
Limos y arcillas		Menos de 0,075 mm.	68,5

LIMITES DE ATTERBERG (NCh 1517/1-2.)	
Límite líquido	35
Límite plástico	15
Índice de plasticidad	20

HUMEDAD POR SECADO EN ESTUFA (NCh1515)	
HUMEDAD %	18,5

* **Nota**: Porcentaje de sobre tamaño (Solo indicativo), según manual de carretera, inciso 5.0 "Procedimiento de ensaye". MCV8.102.1_2017.

Clasificación AASHTO
A-6 (11)
Suelos arcillosos
Clasificación USCS
CL: Arcilla de baja plasticidad

PESO UNITARIO AASHTO T 233-02 (2015)	
Densidad Húmeda g/cm3	1,678
Densidad Seca g/cm3	1,416
Humedad %	18,53

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INFORME DE RESULTADOS DE ENSAYOS

1. ANTECEDENTES SOLICITANTE: GMS Internacional -	**EXPEDIENTE: EXT_ 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio** MUESTRA Nº: 6039 INFORME Nº: Lab.GCh-581-21 FECHA INFORME: 23.11.2021
PROYECTO/OBRA: LA VENDIMIA , Cauquenes, Region del Maule	

2. DATOS MUESTRA

Descripción:
Procedencia/Referencia: TP-07
Datos complementarios: Desde 0.7 hasta 0.8 m.
Tipo de muestreo: Calicatas

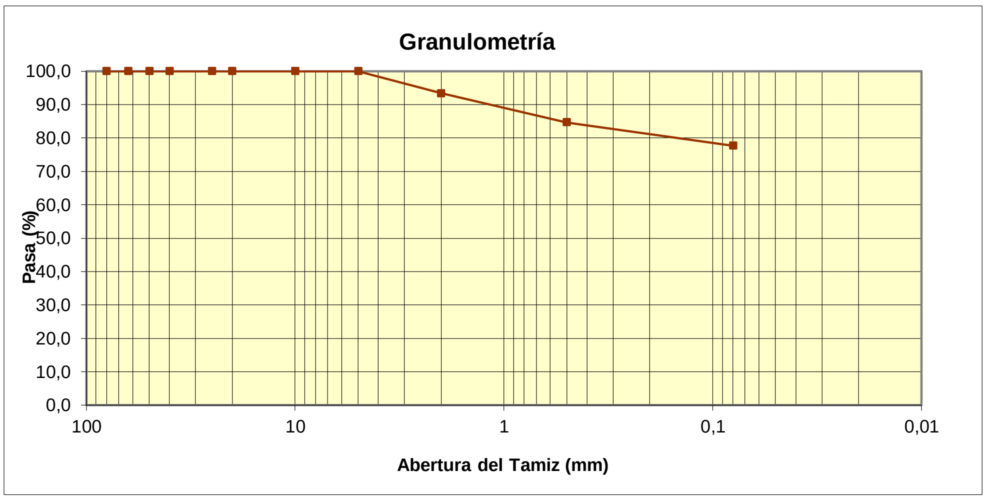
Método de muestreo: NCh 164 Of.2009
Muestreado por: Cliente
Fecha muestreo/recepción: 13.10.2021

3. REGISTRO MUESTRA

Fecha registro: 19.10.2021
Observaciones: -

4. RESULTADOS DE ENSAYOS

GRANULOMETRIA DE SUELOS. MCV8_8.102.1_2017	
Tamiz (mm)	Pasa (%)
80	100,0
63	100,0
50	100,0
40	100,0
25	100,0
20	100,0
10	100,0
5	100,0
2	93,4
0,5	84,7
0,08	77,7



DISTRIBUCIÓN GRANULOMETRICA			
Cantos		De 75 a 300 mm.	0,0
Gravas	gruesas	De 19 a 75 mm.	0,0
	finas	De 4,75 a 19 mm.	0,0
Arenas	gruesas	De 2 a 4,75 mm.	6,6
	medias	De 0,425 a 2 mm.	8,7
	finas	De 0,075 a 0,425 mm.	7,0
Limos y arcillas		Menos de 0,075 mm.	77,7

LIMITES DE ATTERBERG (NCh 1517/1-2.)	
Límite líquido	23
Límite plástico	8
Índice de plasticidad	15

HUMEDAD POR SECADO EN ESTUFA (NCh1515)	
HUMEDAD %	9,5

* **Nota**: Porcentaje de sobre tamaño (Solo indicativo), según manual de carretera, inciso 5.0 "Procedimiento de ensaye". MCV8.102.1_2017.

Clasificación AASHTO
A-6 (8)
Suelos arcillosos
Clasificación USCS
CL: Arcilla de baja plasticidad

PESO UNITARIO AASHTO T 233-02 (2015)	
Densidad Húmeda g/cm3	1,644
Densidad Seca g/cm3	1,502
Humedad %	9,52

COPIA DE ESTE INFORME ENVIADA A: GMS Internacional

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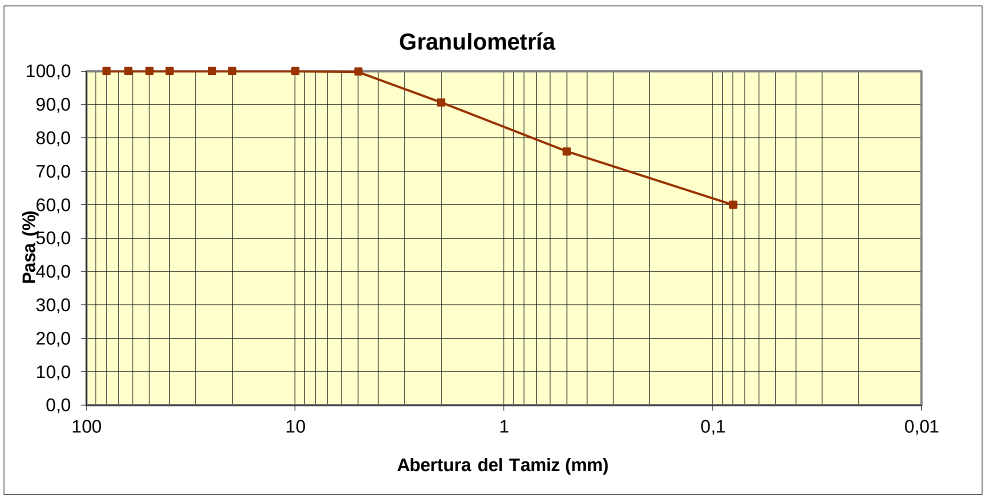
INFORME DE RESULTADOS DE ENSAYOS

1. ANTECEDENTES SOLICITANTE: GMS Internacional -	**EXPEDIENTE: EXT_ 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio** MUESTRA Nº: 6040 INFORME Nº: Lab.GCh-581-21 FECHA INFORME: 23.11.2021
PROYECTO/OBRA: LA VENDIMIA , Cauquenes, Region del Maule	
2. DATOS MUESTRA	
Descripción:	Método de muestreo: NCh 164 Of.2009
Procedencia/Referencia: TP-08	Muestreado por: Cliente
Datos complementarios: Desde 1.4 hasta 1.5 m.	Fecha muestreo/recepción: 13.10.2021
Tipo de muestreo: Calicatas	
3. REGISTRO MUESTRA	
Fecha registro: 19.10.2021	Observaciones: -

4. RESULTADOS DE ENSAYOS

GRANULOMETRIA DE SUELOS. MCV8_8.102.1_2017	
Tamiz (mm)	Pasa (%)
80	100,0
63	100,0
50	100,0
40	100,0
25	100,0
20	100,0
10	100,0
5	99,8
2	90,6
0,5	76,0
0,08	60,0



DISTRIBUCIÓN GRANULOMETRICA			
Cantos		De 75 a 300 mm.	0,0
Gravas	gruesas	De 19 a 75 mm.	0,0
	finas	De 4,75 a 19 mm.	0,2
Arenas	gruesas	De 2 a 4,75 mm.	9,2
	medias	De 0,425 a 2 mm.	14,6
	finas	De 0,075 a 0,425 mm.	16,0
Limos y arcillas		Menos de 0,075 mm.	60,0

LIMITES DE ATTERBERG (NCh 1517/1-2.)	
Límite líquido	32
Límite plástico	7
Índice de plasticidad	25

HUMEDAD POR SECADO EN ESTUFA (NCh1515)	
HUMEDAD %	14,9

*** Nota**: Porcentaje de sobre tamaño (Solo indicativo), según manual de carretera, inciso 5.0 "Procedimiento de ensaye". MCV8.102.1_2017.

Clasificación AASHTO
A-6 (11)
Suelos arcillosos
Clasificación USCS
CL: Arcilla de baja plasticidad

PESO UNITARIO AASHTO T 233-02 (2015)	
Densidad Húmeda g/cm3	1,643
Densidad Seca g/cm3	1,430
Humedad %	14,93

COPIA DE ESTE INFORME ENVIADA A: GMS Internacional

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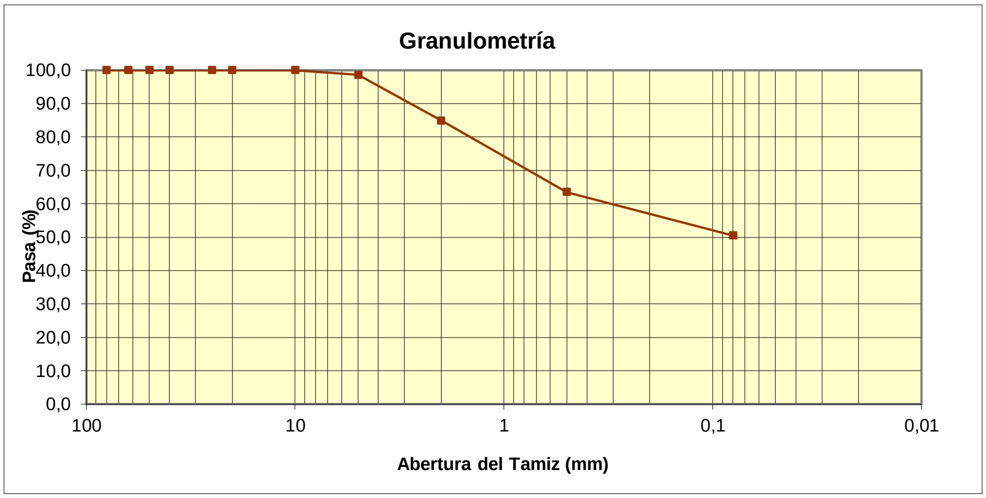
INFORME DE RESULTADOS DE ENSAYOS

1. ANTECEDENTES SOLICITANTE: GMS Internacional -	**EXPEDIENTE: EXT_ 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio** MUESTRA Nº: 6041 INFORME Nº: Lab.GCh-581-21 FECHA INFORME: 23.11.2021
PROYECTO/OBRA: LA VENDIMIA , Cauquenes, Region del Maule	
2. DATOS MUESTRA	
Descripción:	Método de muestreo: NCh 164 Of.2009
Procedencia/Referencia: TP-09	Muestreado por: Cliente
Datos complementarios: Desde 0.6 hasta 0.7 m.	Fecha muestreo/recepción: 13.10.2021
Tipo de muestreo: Calicatas	
3. REGISTRO MUESTRA	
Fecha registro: 19.10.2021	Observaciones: -

4. RESULTADOS DE ENSAYOS

GRANULOMETRIA DE SUELOS. MCV8_8.102.1_2017	
Tamiz (mm)	Pasa (%)
80	100,0
63	100,0
50	100,0
40	100,0
25	100,0
20	100,0
10	100,0
5	98,6
2	84,9
0,5	63,5
0,08	50,5



DISTRIBUCIÓN GRANULOMETRICA			
Cantos		De 75 a 300 mm.	0,0
Gravas	gruesas	De 19 a 75 mm.	0,0
	finas	De 4,75 a 19 mm.	1,4
Arenas	gruesas	De 2 a 4,75 mm.	13,7
	medias	De 0,425 a 2 mm.	21,4
	finas	De 0,075 a 0,425 mm.	13,0
Limos y arcillas		Menos de 0,075 mm.	50,5

LIMITES DE ATTERBERG (NCh 1517/1-2.)	
Límite líquido	33
Límite plástico	16
Índice de plasticidad	17

HUMEDAD POR SECADO EN ESTUFA (NCh1515)	
HUMEDAD %	10,9

* **Nota**: Porcentaje de sobre tamaño (Solo indicativo), según manual de carretera, inciso 5.0 "Procedimiento de ensaye". MCV8.102.1_2017.

Clasificación AASHTO
A-6 (5)
Suelos arcillosos
Clasificación USCS
CL: Arcilla de baja plasticidad

PESO UNITARIO AASHTO T 233-02 (2015)	
Densidad Húmeda g/cm3	1,697
Densidad Seca g/cm3	1,529
Humedad %	10,93

COPIA DE ESTE INFORME ENVIADA A: GMS Internacional

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INFORME DE RESULTADOS DE ENSAYOS

1. ANTECEDENTES SOLICITANTE: GMS Internacional -	**EXPEDIENTE: EXT_ 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio** MUESTRA Nº: 6042 INFORME Nº: Lab.GCh-581-21 FECHA INFORME: 23.11.2021
PROYECTO/OBRA: LA VENDIMIA , Cauquenes, Region del Maule	

2. DATOS MUESTRA

Descripción:
Procedencia/Referencia: TP-10
Datos complementarios: Desde 2.0 hasta 2.1 m.
Tipo de muestreo: Calicatas

Método de muestreo: NCh 164 Of.2009
Muestreado por: Cliente
Fecha muestreo/recepción: 13.10.2021

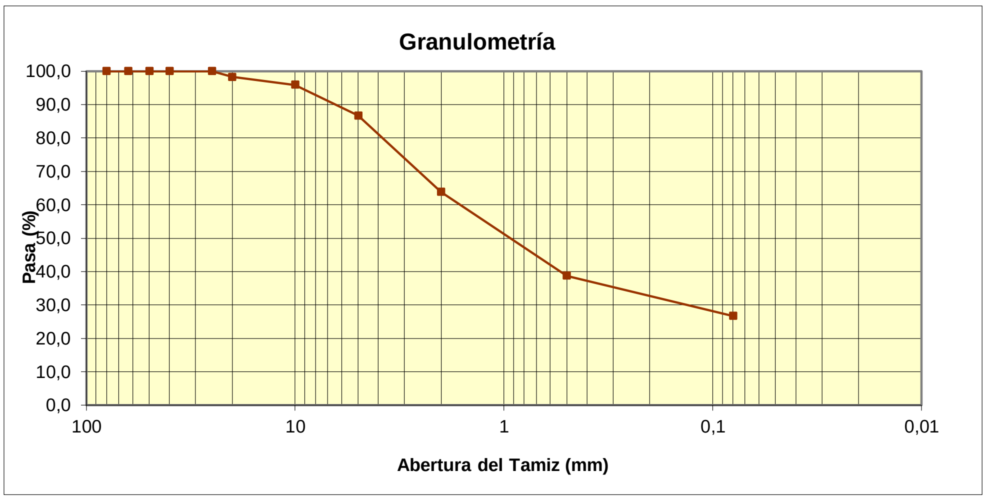
3. REGISTRO MUESTRA

Fecha registro: 19.10.2021

Observaciones: -

4. RESULTADOS DE ENSAYOS

GRANULOMETRIA DE SUELOS. MCV8_8.102.1_2017	
Tamiz (mm)	Pasa (%)
80	100,0
63	100,0
50	100,0
40	100,0
25	100,0
20	98,3
10	95,9
5	86,7
2	63,8
0,5	38,7
0,08	26,7



DISTRIBUCIÓN GRANULOMETRICA			
Cantos		De 75 a 300 mm.	0,0
Gravas	gruesas	De 19 a 75 mm.	1,7
	finas	De 4,75 a 19 mm.	11,6
Arenas	gruesas	De 2 a 4,75 mm.	22,9
	medias	De 0,425 a 2 mm.	25,1
	finas	De 0,075 a 0,425 mm.	12,0
Limos y arcillas		Menos de 0,075 mm.	26,7

LIMITES DE ATTERBERG (NCh 1517/1-2.)	
Límite líquido	29
Límite plástico	16
Índice de plasticidad	13

HUMEDAD POR SECADO EN ESTUFA (NCh1515)	
HUMEDAD %	14,8

* **Nota**: Porcentaje de sobre tamaño (Solo indicativo), según manual de carretera, inciso 5.0 "Procedimiento de ensaye". MCV8.102.1_2017.

Clasificación AASHTO
A-2-6 (0)
Grava y arena limo o arcillas
Clasificación USCS
SC: Arena arcillosa

PESO UNITARIO AASHTO T 233-02 (2015)	
Densidad Húmeda g/cm3	1,614
Densidad Seca g/cm3	1,406
Humedad %	14,85

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Vº Bº JEFE LABORATORIO:
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Vº Bº GERENTE TÉCNICO:
Ricardo Hernández

INFORME DE RESULTADOS DE ENSAYOS

1. ANTECEDENTES SOLICITANTE:
GMS Internacional
-

PROYECTO/OBRA:
LA VENDIMIA , Cauquenes, Region del Maule

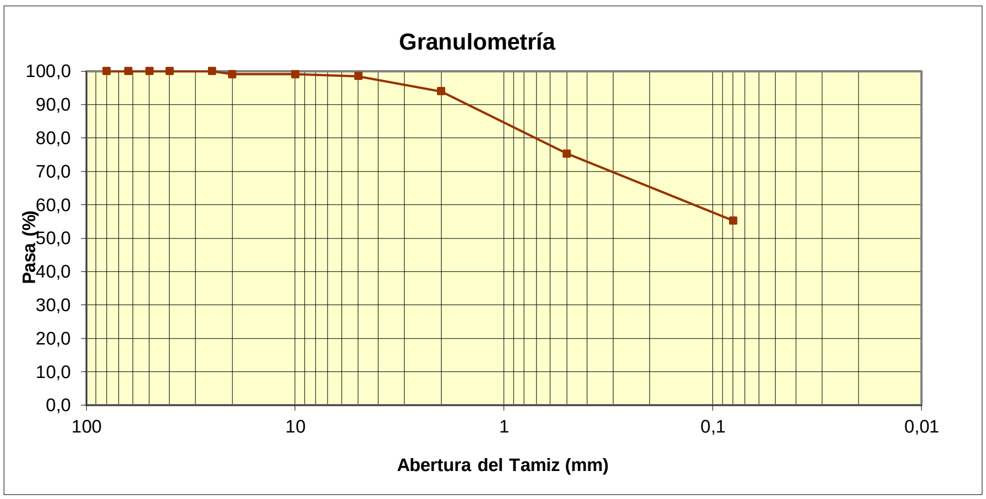
EXPEDIENTE: EXT_ 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio
MUESTRA Nº: 6043
INFORME Nº: Lab.GCh-581-21
FECHA INFORME: 23.11.2021

2. DATOS MUESTRA
Descripción:
Procedencia/Referencia: TP-11
Datos complementarios: Desde 0.6 hasta 0.7 m.
Tipo de muestreo: Calicatas
Método de muestreo: NCh 164 Of.2009
Muestreado por: Cliente
Fecha muestreo/recepción: 13.10.2021

3. REGISTRO MUESTRA
Fecha registro: 19.10.2021
Observaciones: -

4. RESULTADOS DE ENSAYOS

GRANULOMETRIA DE SUELOS. MCV8_8.102.1_2017	
Tamiz (mm)	Pasa (%)
80	100,0
63	100,0
50	100,0
40	100,0
25	100,0
20	99,1
10	99,1
5	98,5
2	94,0
0,5	75,3
0,08	55,3



DISTRIBUCIÓN GRANULOMETRICA			
Cantos		De 75 a 300 mm.	0,0
Gravas	gruesas	De 19 a 75 mm.	0,9
	finas	De 4,75 a 19 mm.	0,6
Arenas	gruesas	De 2 a 4,75 mm.	4,5
	medias	De 0,425 a 2 mm.	18,7
	finas	De 0,075 a 0,425 mm.	20,0
Limos y arcillas		Menos de 0,075 mm.	55,3

LIMITES DE ATTERBERG (NCh 1517/1-2.)	
Límite líquido	25
Límite plástico	12
Índice de plasticidad	13

HUMEDAD POR SECADO EN ESTUFA (NCh1515)	
HUMEDAD %	6,2

* **Nota**: Porcentaje de sobre tamaño (Solo indicativo), según manual de carretera, inciso 5.0 "Procedimiento de ensaye". MCV8.102.1_2017.

Clasificación AASHTO
A-6 (4)
Suelos arcillosos
Clasificación USCS
CL: Arcilla de baja plasticidad

PESO UNITARIO AASHTO T 233-02 (2015)	
Densidad Húmeda g/cm3	1,694
Densidad Seca g/cm3	1,595
Humedad %	6,23

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INFORME DE RESULTADOS DE ENSAYOS

1. ANTECEDENTES SOLICITANTE: GMS Internacional -	**EXPEDIENTE: EXT_ 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio** MUESTRA Nº: 6044 INFORME Nº: Lab.GCh-581-21 FECHA INFORME: 23.11.2021
PROYECTO/OBRA: LA VENDIMIA , Cauquenes, Region del Maule	

2. DATOS MUESTRA

Descripción:
Procedencia/Referencia: TP-12
Datos complementarios: Desde 0.6 hasta 0.7 m.
Tipo de muestreo: Calicatas

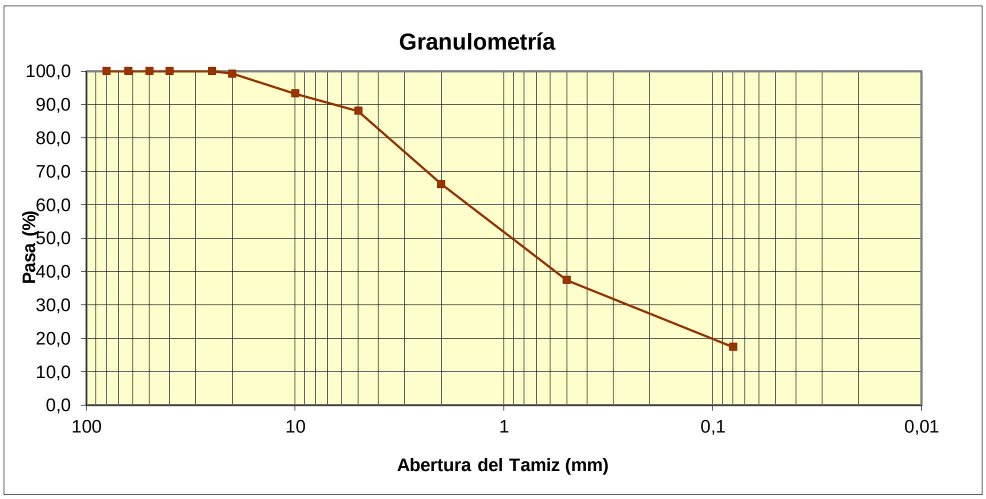
Método de muestreo: NCh 164 Of.2009
Muestreado por: Cliente
Fecha muestreo/recepción: 13.10.2021

3. REGISTRO MUESTRA

Fecha registro: 19.10.2021
Observaciones: -

4. RESULTADOS DE ENSAYOS

GRANULOMETRIA DE SUELOS. MCV8_8.102.1_2017	
Tamiz (mm)	Pasa (%)
80	100,0
63	100,0
50	100,0
40	100,0
25	100,0
20	99,3
10	93,3
5	88,1
2	66,2
0,5	37,4
0,08	17,4



DISTRIBUCIÓN GRANULOMETRICA			
Cantos		De 75 a 300 mm.	0,0
Gravas	gruesas	De 19 a 75 mm.	0,7
	finas	De 4,75 a 19 mm.	11,2
Arenas	gruesas	De 2 a 4,75 mm.	21,9
	medias	De 0,425 a 2 mm.	28,8
	finas	De 0,075 a 0,425 mm.	20,0
Limos y arcillas		Menos de 0,075 mm.	17,4

LIMITES DE ATTERBERG (NCh 1517/1-2.)	
Límite líquido	-
Límite plástico	-
Índice de plasticidad	NP

HUMEDAD POR SECADO EN ESTUFA (NCh1515)	
HUMEDAD %	9,3

* **Nota**: Porcentaje de sobre tamaño (Solo indicativo), según manual de carretera, inciso 5.0 "Procedimiento de ensaye". MCV8.102.1_2017.

Clasificación AASHTO
A-1b (0)
Cantos, grava y arena
Clasificación USCS
SM: Arena limosa

PESO UNITARIO AASHTO T 233-02 (2015)	
Densidad Húmeda g/cm3	1,625
Densidad Seca g/cm3	1,487
Humedad %	9,32

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INFORME DE RESULTADOS DE ENSAYOS

1. ANTECEDENTES SOLICITANTE: GMS Internacional -	**EXPEDIENTE: EXT_ 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio** MUESTRA Nº: 6045 INFORME Nº: Lab.GCh-581-21 FECHA INFORME: 23.11.2021
PROYECTO/OBRA: LA VENDIMIA , Cauquenes, Region del Maule	

2. DATOS MUESTRA

Descripción:
Procedencia/Referencia: TP-13
Datos complementarios: Desde 1.1 hasta 1.2 m.
Tipo de muestreo: Calicatas

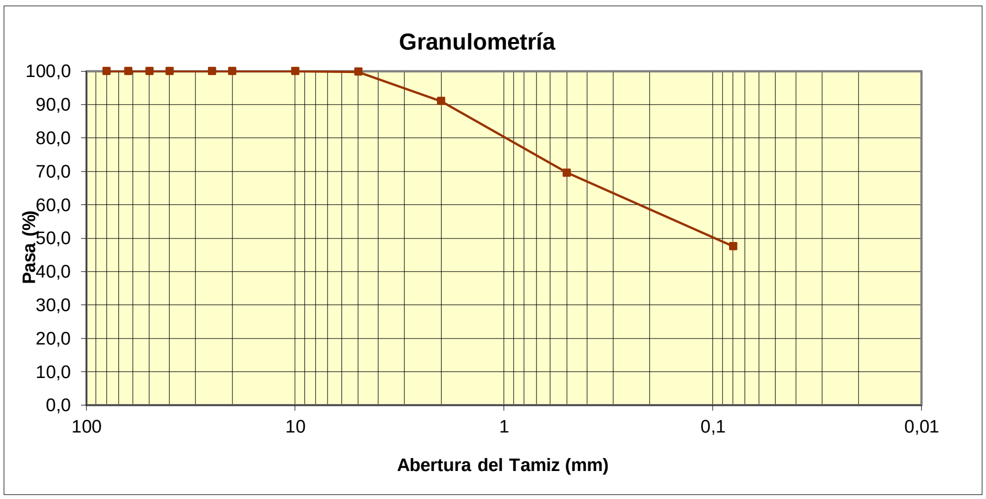
Método de muestreo: NCh 164 Of.2009
Muestreado por: Cliente
Fecha muestreo/recepción: 13.10.2021

3. REGISTRO MUESTRA

Fecha registro: 19.10.2021
Observaciones: -

4. RESULTADOS DE ENSAYOS

GRANULOMETRIA DE SUELOS. MCV8_8.102.1_2017	
Tamiz (mm)	Pasa (%)
80	100,0
63	100,0
50	100,0
40	100,0
25	100,0
20	100,0
10	100,0
5	99,8
2	91,0
0,5	69,6
0,08	47,6



DISTRIBUCIÓN GRANULOMETRICA			
Cantos		De 75 a 300 mm.	0,0
Gravas	gruesas	De 19 a 75 mm.	0,0
	finas	De 4,75 a 19 mm.	0,2
Arenas	gruesas	De 2 a 4,75 mm.	8,8
	medias	De 0,425 a 2 mm.	21,4
	finas	De 0,075 a 0,425 mm.	22,0
Limos y arcillas		Menos de 0,075 mm.	47,6

LIMITES DE ATTERBERG (NCh 1517/1-2.)	
Límite líquido	23
Límite plástico	11
Índice de plasticidad	12

HUMEDAD POR SECADO EN ESTUFA (NCh1515)	
HUMEDAD %	13,0

* **Nota**: Porcentaje de sobre tamaño (Solo indicativo), según manual de carretera, inciso 5.0 "Procedimiento de ensaye". MCV8.102.1_2017.

Clasificación AASHTO
A-6 (2)
Suelos arcillosos
Clasificación USCS
SC: Arena arcillosa

PESO UNITARIO AASHTO T 233-02 (2015)	
Densidad Húmeda g/cm3	1,590
Densidad Seca g/cm3	1,407
Humedad %	13,01

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Vº Bº JEFE LABORATORIO:
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INFORME DE RESULTADOS DE ENSAYOS

1. ANTECEDENTES SOLICITANTE: GMS Internacional -	**EXPEDIENTE: EXT_ 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio** MUESTRA Nº: 6046 INFORME Nº: Lab.GCh-581-21 FECHA INFORME: 23.11.2021
PROYECTO/OBRA: LA VENDIMIA , Cauquenes, Region del Maule	

2. DATOS MUESTRA

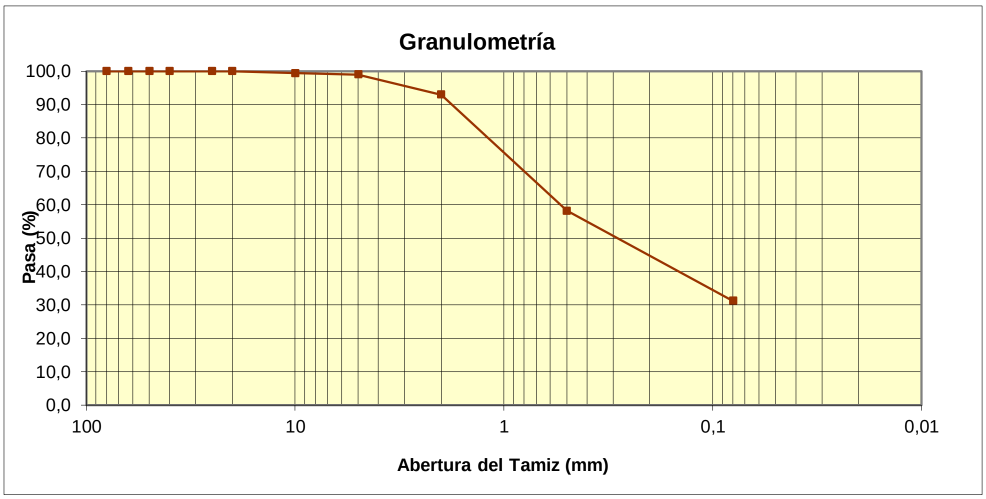
Descripción:	Método de muestreo: NCh 164 Of.2009
Procedencia/Referencia: TP-14	Muestreado por: Cliente
Datos complementarios: Desde 1.5 hasta 1.6 m.	Fecha muestreo/recepción: 13.10.2021
Tipo de muestreo: Calicatas	

3. REGISTRO MUESTRA

Fecha registro: 19.10.2021	Observaciones: -

4. RESULTADOS DE ENSAYOS

GRANULOMETRIA DE SUELOS. MCV8_8.102.1_2017	
Tamiz (mm)	Pasa (%)
80	100,0
63	100,0
50	100,0
40	100,0
25	100,0
20	100,0
10	99,4
5	99,0
2	93,0
0,5	58,2
0,08	31,2



DISTRIBUCIÓN GRANULOMETRICA			
Cantos		De 75 a 300 mm.	0,0
Gravas	gruesas	De 19 a 75 mm.	0,0
	finas	De 4,75 a 19 mm.	1,0
Arenas	gruesas	De 2 a 4,75 mm.	6,0
	medias	De 0,425 a 2 mm.	34,8
	finas	De 0,075 a 0,425 mm.	27,0
Limos y arcillas		Menos de 0,075 mm.	31,2

LIMITES DE ATTERBERG (NCh 1517/1-2.)	
Límite líquido	24
Límite plástico	12
Índice de plasticidad	12

HUMEDAD POR SECADO EN ESTUFA (NCh1515)	
HUMEDAD %	16,3

* **Nota**: Porcentaje de sobre tamaño (Solo indicativo), según manual de carretera, inciso 5.0 "Procedimiento de ensaye". MCV8.102.1_2017.

Clasificación AASHTO
A-2-6 (0)
Grava y arena limo o arcillas
Clasificación USCS
SC: Arena arcillosa

PESO UNITARIO AASHTO T 233-02 (2015)	
Densidad Húmeda g/cm3	1,690
Densidad Seca g/cm3	1,453
Humedad %	16,31

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INFORME DE RESULTADOS DE ENSAYOS

1. ANTECEDENTES SOLICITANTE: GMS Internacional -	**EXPEDIENTE: EXT_ 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio** MUESTRA Nº: 6047 INFORME Nº: Lab.GCh-581-21 FECHA INFORME: 23.11.2021
PROYECTO/OBRA: LA VENDIMIA , Cauquenes, Region del Maule	

2. DATOS MUESTRA

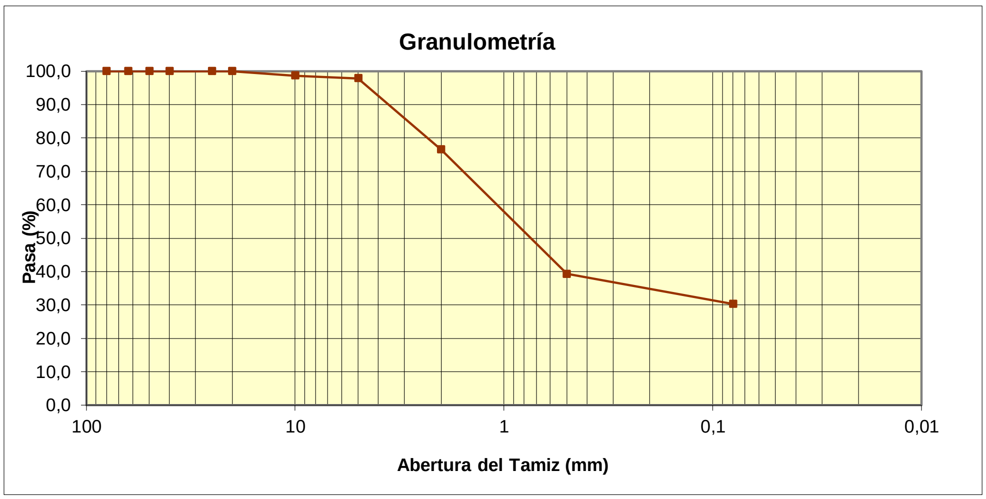
Descripción:	Método de muestreo: NCh 164 Of.2009
Procedencia/Referencia: TP-15	Muestreado por: Cliente
Datos complementarios: Desde 2.5 hasta 2.6 m.	Fecha muestreo/recepción: 13.10.2021
Tipo de muestreo: Calicatas	

3. REGISTRO MUESTRA

Fecha registro: 19.10.2021	Observaciones: -

4. RESULTADOS DE ENSAYOS

GRANULOMETRIA DE SUELOS. MCV8_8.102.1_2017	
Tamiz (mm)	Pasa (%)
80	100,0
63	100,0
50	100,0
40	100,0
25	100,0
20	100,0
10	98,7
5	97,9
2	76,5
0,5	39,3
0,08	30,3



DISTRIBUCIÓN GRANULOMETRICA			
Cantos		De 75 a 300 mm.	0,0
Gravas	gruesas	De 19 a 75 mm.	0,0
	finas	De 4,75 a 19 mm.	2,1
Arenas	gruesas	De 2 a 4,75 mm.	21,4
	medias	De 0,425 a 2 mm.	37,2
	finas	De 0,075 a 0,425 mm.	9,0
Limos y arcillas		Menos de 0,075 mm.	30,3

LIMITES DE ATTERBERG (NCh 1517/1-2.)	
Límite líquido	28
Límite plástico	16
Índice de plasticidad	12

HUMEDAD POR SECADO EN ESTUFA (NCh1515)	
HUMEDAD %	11,2

* **Nota**: Porcentaje de sobre tamaño (Solo indicativo), según manual de carretera, inciso 5.0 "Procedimiento de ensaye". MCV8.102.1_2017.

Clasificación AASHTO
A-2-6 (0)
Grava y arena limo o arcillas
Clasificación USCS
SC: Arena arcillosa

PESO UNITARIO AASHTO T 233-02 (2015)	
Densidad Húmeda g/cm3	1,652
Densidad Seca g/cm3	1,485
Humedad %	11,22

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Ricardo

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INFORME DE RESULTADOS DE ENSAYOS

1. ANTECEDENTES SOLICITANTE: GMS Internacional -	**EXPEDIENTE: EXT_ 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio** MUESTRA Nº: 6028 INFORME Nº: Lab.GCh-581-21 FECHA INFORME: 23.11.2021
PROYECTO/OBRA: LA VENDIMIA , Cauquenes, Region del Maule	

2. DATOS MUESTRA

Descripción:	Método de muestreo: NCh 164 Of.2009
Procedencia/Referencia: TP-02	Muestreado por: Cliente
Datos complementarios: Desde 0.6 hasta 0.9 m.	Fecha muestreo/recepción: 13.10.2021
Tipo de muestreo: Calicatas	

3. REGISTRO MUESTRA

Fecha registro: 19.10.2021	Observaciones: -

4. RESULTADOS DE ENSAYOS

PROCTOR MODIFICADO Nch 1534/2 Of. 1979		
Método empleado		A
Cont. de humedad óptima	[%]	**10,3**
Densidad seca máxima	[g/cm³]	**2,02**
Material retenido en 20 mm	[%]	-
Reemplazo por Probeta	[%]	-

RESISTENCIA A LA PENETRACIÓN (CBR) Nch 1852 Of. 1981				
Probetas por Golpe		56	25	10
Método (A, B, C, D)		D	D	D
Sobrecarga	[Kg]	5.130	5.070	5.025
Muestra sumergida (SI / NO)		SI	SI	SI
Densidades de los moldes (g/cm^3)				
Dens. Seca pre inmersión		2,03	1,92	1,86
Dens. Seca post inmersión		1,91	1,79	1,75
Humedades de los moldes (%)				
Hum. Antes de compactar				
Hum. Después de compactar		10,51	10,79	10,72
Hum. Sup. (25 mm) Post inmersión		29,55	29,53	29,54
Hum. Prom. Post inmersión		26,60	26,33	26,38
Razón de Soporte (CBR)				
Para 0,1" penetración		15,9	13,8	10,1
Para 0,2" penetración		28,9	27,1	21,4
Para 0,3" penetración		38,5	28,4	10,1
Expansión				
Expansión de los moldes	[%]	5,87	6,63	6,44
CBR a 95% D.M.C.S. (CBR a 0,2")		**25,13**		

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INFORME DE RESULTADOS DE ENSAYOS

1. ANTECEDENTES SOLICITANTE: GMS Internacional -	**EXPEDIENTE: EXT_ 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio** MUESTRA Nº: 6029 INFORME Nº: Lab.GCh-581-21 FECHA INFORME: 23.11.2021
PROYECTO/OBRA: LA VENDIMIA , Cauquenes, Region del Maule	

2. DATOS MUESTRA

Descripción:	Método de muestreo: NCh 164 Of.2009
Procedencia/Referencia: TP-07	Muestreado por: Cliente
Datos complementarios: Desde 0.8 hasta 1.1 m.	Fecha muestreo/recepción: 13.10.2021
Tipo de muestreo: Calicatas	

3. REGISTRO MUESTRA

Fecha registro: 19.10.2021	Observaciones: -

4. RESULTADOS DE ENSAYOS

PROCTOR MODIFICADO Nch 1534/2 Of. 1979		
Método empleado		A
Cont. de humedad óptima	[%]	**10,1**
Densidad seca máxima	[g/cm³]	**1,967**
Material retenido en 20 mm	[%]	-
Reemplazo por Probeta	[%]	-

RESISTENCIA A LA PENETRACIÓN (CBR) Nch 1852 Of. 1981				
Probetas por Golpe		56	25	10
Método (A, B, C, D)		D	D	D
Sobrecarga	[Kg]	5.070	5.025	5.055
Muestra sumergida (SI / NO)		SI	SI	SI
Densidades de los moldes (g/cm³)				
Dens. Seca pre inmersión		1,97	1,88	1,80
Dens. Seca post inmersión		1,90	1,75	1,73
Humedades de los moldes (%)				
Hum. Antes de compactar				
Hum. Después de compactar		10,79	10,25	10,14
Hum. Sup. (25 mm) Post inmersión		18,04	18,53	18,50
Hum. Prom. Post inmersión		17,28	17,36	17,25
Razón de Soporte (CBR)				
Para 0,1" penetración		17,5	15,9	8,5
Para 0,2" penetración		18,6	12,8	9,3
Para 0,3" penetración		23,6	18,5	11,5
Expansión				
Expansión de los moldes	[%]	2,65	3,26	3,13
CBR a 95% D.M.C.S. (CBR a 0,2")		**12,75**		

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INFORME DE RESULTADOS DE ENSAYOS

1. ANTECEDENTES SOLICITANTE:
GMS Internacional
-

EXPEDIENTE: EXT_ 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio
MUESTRA Nº: 6030
INFORME Nº: Lab.GCh-581-21
FECHA INFORME: 23.11.2021

PROYECTO/OBRA:
LA VENDIMIA , Cauquenes, Region del Maule

2. DATOS MUESTRA
Descripción:
Procedencia/Referencia: TP-09
Datos complementarios: Desde 0.6 hasta 0.9 m.
Tipo de muestreo: Calicatas
Método de muestreo: NCh 164 Of.2009
Muestreado por: Cliente
Fecha muestreo/recepción: 13.10.2021

3. REGISTRO MUESTRA
Fecha registro: 19.10.2021
Observaciones: -

4. RESULTADOS DE ENSAYOS

PROCTOR MODIFICADO Nch 1534/2 Of. 1979		
Método empleado		C
Cont. de humedad óptima	[%]	**13,0**
Densidad seca máxima	[g/cm³]	**1,817**
Material retenido en 20 mm	[%]	-
Reemplazo por Probeta	[%]	-

RESISTENCIA A LA PENETRACIÓN (CBR) Nch 1852 Of. 1981				
Probetas por Golpe		56	25	10
Método (A, B, C, D)		D	D	D
Sobrecarga	[Kg]	5.065	5.045	5.025
Muestra sumergida (SI / NO)		SI	SI	SI
Densidades de los moldes (g/cm³)				
Dens. Seca pre inmersión		1,82	1,73	1,63
Dens. Seca post inmersión		1,81	1,72	1,61
Humedades de los moldes (%)				
Hum. Antes de compactar				
Hum. Después de compactar		13,32	13,30	13,25
Hum. Sup. (25 mm) Post inmersión		19,28	19,35	19,95
Hum. Prom. Post inmersión		17,04	17,10	17,20
Razón de Soporte (CBR)				
Para 0,1" penetración		14,3	11,1	9,0
Para 0,2" penetración		15,3	12,8	10,3
Para 0,3" penetración		18,0	14,3	11,5
Expansión				
Expansión de los moldes	[%]	0,37	0,38	0,50
CBR a 95% D.M.C.S. (CBR a 0,2")			**12,87**	

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INFORME DE RESULTADOS DE ENSAYOS

1. ANTECEDENTES SOLICITANTE: GMS Internacional -	**EXPEDIENTE: EXT_ 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio** MUESTRA Nº: 6031 INFORME Nº: Lab.GCh-581-21 FECHA INFORME: 23.11.2021
PROYECTO/OBRA: LA VENDIMIA , Cauquenes, Region del Maule	

2. DATOS MUESTRA

Descripción:
Procedencia/Referencia: TP-11
Datos complementarios: Desde 0.8 hasta 1.0 m.
Tipo de muestreo: Calicatas

Método de muestreo: NCh 164 Of.2009
Muestreado por: Cliente
Fecha muestreo/recepción: 13.10.2021

3. REGISTRO MUESTRA

Fecha registro: 19.10.2021
Observaciones: -

4. RESULTADOS DE ENSAYOS

PROCTOR MODIFICADO Nch 1534/2 Of. 1979		
Método empleado		A
Cont. de humedad óptima	[%]	**8,3**
Densidad seca máxima	[g/cm³]	**1,916**
Material retenido en 20 mm	[%]	-
Reemplazo por Probeta	[%]	-

RESISTENCIA A LA PENETRACIÓN (CBR) Nch 1852 Of. 1981			
Probetas por Golpe	56	25	10
Método (A, B, C, D)	D	D	D
Sobrecarga [Kg]	5.040	5.025	5.045
Muestra sumergida (SI / NO)	SI	SI	SI
Densidades de los moldes (g/cm³)			
Dens. Seca pre inmersión	1,92	1,82	1,77
Dens. Seca post inmersión	1,91	1,81	1,76
Humedades de los moldes (%)			
Hum. Antes de compactar			
Hum. Después de compactar	8,36	8,31	8,40
Hum. Sup. (25 mm) Post inmersión	19,73	19,39	19,27
Hum. Prom. Post inmersión	17,55	17,49	17,42
Razón de Soporte (CBR)			
Para 0,1" penetración	14,3	12,7	10,1
Para 0,2" penetración	14,3	11,8	11,0
Para 0,3" penetración	18,0	14,3	11,8
Expansión			
Expansión de los moldes [%]	0,28	0,43	0,34
CBR a 95% D.M.C.S. (CBR a 0,2")	**12,00**		

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INFORME DE RESULTADOS DE ENSAYOS

1. ANTECEDENTES SOLICITANTE: GMS Internacional -	**EXPEDIENTE: EXT_ 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio** MUESTRA Nº: 6032 INFORME Nº: Lab.GCh-581-21 FECHA INFORME: 23.11.2021
PROYECTO/OBRA: LA VENDIMIA , Cauquenes, Region del Maule	

2. DATOS MUESTRA

Descripción:
Procedencia/Referencia: TP-13
Datos complementarios: Desde 0.9 hasta 1.0 m.
Tipo de muestreo: Calicatas

Método de muestreo: NCh 164 Of.2009
Muestreado por: Cliente
Fecha muestreo/recepción: 13.10.2021

3. REGISTRO MUESTRA

Fecha registro: 19.10.2021
Observaciones: -

4. RESULTADOS DE ENSAYOS

PROCTOR MODIFICADO Nch 1534/2 Of. 1979		
Método empleado		C
Cont. de humedad óptima	[%]	**10,0**
Densidad seca máxima	[g/cm³]	**1,943**
Material retenido en 20 mm	[%]	-
Reemplazo por Probeta	[%]	-

RESISTENCIA A LA PENETRACIÓN (CBR) Nch 1852 Of. 1981			
Probetas por Golpe	56	25	10
Método (A, B, C, D)	D	D	D
Sobrecarga [Kg]	5.050	5.005	5.020
Muestra sumergida (SI / NO)	SI	SI	SI
Densidades de los moldes (g/cm³)			
Dens. Seca pre inmersión	1,94	1,84	1,73
Dens. Seca post inmersión	1,91	1,82	1,70
Humedades de los moldes (%)			
Hum. Antes de compactar			
Hum. Después de compactar	10,03	10,14	10,10
Hum. Sup. (25 mm) Post inmersión	21,16	21,91	21,81
Hum. Prom. Post inmersión	19,00	19,22	19,12
Razón de Soporte (CBR)			
Para 0,1" penetración	14,3	13,8	10,6
Para 0,2" penetración	17,1	14,3	12,8
Para 0,3" penetración	20,5	15,7	12,9
Expansión			
Expansión de los moldes [%]	1,24	2,42	2,15
CBR a 95% D.M.C.S. (CBR a 0,2")		**14,87**	

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INFORME DE RESULTADOS DE ENSAYOS

1. ANTECEDENTES SOLICITANTE: GMS Internacional -	**EXPEDIENTE: EXT_ 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio** MUESTRA Nº: 6033 INFORME Nº: Lab.GCh-581-21 FECHA INFORME: 23.11.2021
PROYECTO/OBRA: LA VENDIMIA , Cauquenes, Region del Maule	

2. DATOS MUESTRA

Descripción:
Procedencia/Referencia: TP-01
Datos complementarios: Desde 1.5 hasta 1.6 m.
Tipo de muestreo: Calicatas

Método de muestreo: NCh 164 Of.2009
Muestreado por: Cliente
Fecha muestreo/recepción: 13.10.2021

3. REGISTRO MUESTRA

Fecha registro: 19.10.2021

Observaciones: -

4. RESULTADOS DE ENSAYOS

Determinación del contenido de Cloruros (NCh 1444. Of80)		
Cloruros (Cl)	mg Cl^{-}/Kg Suelo	45
Cloruros (Cl)	%	0,0045

Determinación cuantitativa del contenido de sulfatos solubles (NCh 1444. Of80)		
Sulfatos (SO4)	mg SO_4^{2-}/Kg Suelo	206
Sulfatos (SO4)	%	0,0206

Determinación de sales solubles totales. MCV8. Cap 8.202.14		
Sales Solubles totales	%	0,260

Potencial Oxido-Reducción. Redox ASTM D 1498/2000		
Potencial Oxido-Reducción	mV	178

Determinación del pH. ASTM D4972/95		
Valor pH a 20 C°	%	6,89

Determinación Materia Orgánica		
Materia Organica	%	2,65

Determinación Acidez Baumann Gully. UNE EN 16502:2015		
Acidez Baumann Gully	mL NaOH/Kg Suelo	21,45

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INFORME DE RESULTADOS DE ENSAYOS

1. ANTECEDENTES SOLICITANTE: GMS Internacional -	**EXPEDIENTE: EXT_ 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio** MUESTRA Nº: 6035 INFORME Nº: Lab.GCh-581-21 FECHA INFORME: 23.11.2021
PROYECTO/OBRA: LA VENDIMIA , Cauquenes, Region del Maule	
2. DATOS MUESTRA Descripción: Procedencia/Referencia: TP-03 Datos complementarios: Desde 0.9 hasta 1.0 m. Tipo de muestreo: Calicatas	 Método de muestreo: NCh 164 Of.2009 Muestreado por: Cliente Fecha muestreo/recepción: 13.10.2021
3. REGISTRO MUESTRA Fecha registro: 19.10.2021	 Observaciones: -

4. RESULTADOS DE ENSAYOS

Determinación del contenido de Cloruros (NCh 1444. Of80)		
Cloruros (Cl)	mg Cl^-/Kg Suelo	26
Cloruros (Cl)	%	0,0026

Determinación cuantitativa del contenido de sulfatos solubles (NCh 1444. Of80)		
Sulfatos (SO4)	mg SO_4^{2-}/Kg Suelo	178
Sulfatos (SO4)	%	0,0178

Determinación de sales solubles totales. MCV8. Cap 8.202.14		
Sales Solubles totales	%	0,08

Potencial Oxido-Reducción. Redox ASTM D 1498/2000		
Potencial Oxido-Reducción	mV	189

Determinación del pH. ASTM D4972/95		
Valor pH a 20 C°	%	6,74

Determinación Materia Orgánica		
Materia Organica	%	1,96

Determinación Acidez Baumann Gully. UNE EN 16502:2015		
Acidez Baumann Gully	mL NaOH/Kg Suelo	18,77

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INFORME DE RESULTADOS DE ENSAYOS

1. ANTECEDENTES SOLICITANTE: GMS Internacional -	**EXPEDIENTE: EXT_ 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio** MUESTRA Nº: 6036 INFORME Nº: Lab.GCh-581-21 FECHA INFORME: 23.11.2021
PROYECTO/OBRA: LA VENDIMIA , Cauquenes, Region del Maule	
2. DATOS MUESTRA	
Descripción:	Método de muestreo: NCh 164 Of.2009
Procedencia/Referencia: TP-04	Muestreado por: Cliente
Datos complementarios: Desde 0.6 hasta 0.7 m.	Fecha muestreo/recepción: 13.10.2021
Tipo de muestreo: Calicatas	
3. REGISTRO MUESTRA	
Fecha registro: 19.10.2021	Observaciones: -

4. RESULTADOS DE ENSAYOS

Determinación del contenido de Cloruros (NCh 1444. Of80)		
Cloruros (Cl)	mg Cl^-/Kg Suelo	29
Cloruros (Cl)	%	0,003

Determinación cuantitativa del contenido de sulfatos solubles (NCh 1444. Of80)		
Sulfatos (SO4)	mg SO_4^{2-}/Kg Suelo	171
Sulfatos (SO4)	%	0,017

Determinación de sales solubles totales. MCV8. Cap 8.202.14		
Sales Solubles totales	%	0,06

Potencial Oxido-Reducción. Redox ASTM D 1498/2000		
Potencial Oxido-Reducción	mV	181

Determinación del pH. ASTM D4972/95		
Valor pH a 20 C°	%	6,82

Determinación Materia Orgánica		
Materia Organica	%	2,12

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INFORME DE RESULTADOS DE ENSAYOS

1. ANTECEDENTES SOLICITANTE: GMS Internacional -	**EXPEDIENTE: EXT_ 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio** MUESTRA Nº: 6038 INFORME Nº: Lab.GCh-581-21 FECHA INFORME: 23.11.2021
PROYECTO/OBRA: LA VENDIMIA , Cauquenes, Region del Maule	

2. DATOS MUESTRA

Descripción:
Procedencia/Referencia: TP-06
Datos complementarios: Desde 1.9 hasta 2.0 m.
Tipo de muestreo: Calicatas

Método de muestreo: NCh 164 Of.2009
Muestreado por: Cliente
Fecha muestreo/recepción: 13.10.2021

3. REGISTRO MUESTRA

Fecha registro: 19.10.2021
Observaciones: -

4. RESULTADOS DE ENSAYOS

Determinación del contenido de Cloruros (NCh 1444. Of80)		
Cloruros (Cl)	mg Cl^{-}/Kg Suelo	29
Cloruros (Cl)	%	0,003

Determinación cuantitativa del contenido de sulfatos solubles (NCh 1444. Of80)		
Sulfatos (SO4)	mg SO_4^{2-}/Kg Suelo	171
Sulfatos (SO4)	%	0,017

Determinación de sales solubles totales. MCV8. Cap 8.202.14		
Sales Solubles totales	%	0,041

Potencial Oxido-Reducción. Redox ASTM D 1498/2000		
Potencial Oxido-Reducción	mV	185

Determinación del pH. ASTM D4972/95		
Valor pH a 20 C°	%	6,960

Determinación Materia Orgánica		
Materia Organica	%	2,340

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INFORME DE RESULTADOS DE ENSAYOS

1. ANTECEDENTES SOLICITANTE: GMS Internacional -	**EXPEDIENTE: EXT_ 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio** MUESTRA Nº: 6040 INFORME Nº: Lab.GCh-581-21 FECHA INFORME: 23.11.2021
PROYECTO/OBRA: LA VENDIMIA , Cauquenes, Region del Maule	

2. DATOS MUESTRA

Descripción:
Procedencia/Referencia: TP-08
Datos complementarios: Desde 1.4 hasta 1.5 m.
Tipo de muestreo: Calicatas

Método de muestreo: NCh 164 Of.2009
Muestreado por: Cliente
Fecha muestreo/recepción: 13.10.2021

3. REGISTRO MUESTRA

Fecha registro: 19.10.2021
Observaciones: -

4. RESULTADOS DE ENSAYOS

Determinación del contenido de Cloruros (NCh 1444. Of80)		
Cloruros (Cl)	mg Cl^-/Kg Suelo	23
Cloruros (Cl)	%	0,002

Determinación cuantitativa del contenido de sulfatos solubles (NCh 1444. Of80)		
Sulfatos (SO4)	mg SO_4^{2-}/Kg Suelo	153
Sulfatos (SO4)	%	0,015

Determinación de sales solubles totales. MCV8. Cap 8.202.14		
Sales Solubles totales	%	0,055

Potencial Oxido-Reducción. Redox ASTM D 1498/2000		
Potencial Oxido-Reducción	mV	162

Determinación del pH. ASTM D4972/95		
Valor pH a 20 C°	%	6,870

Determinación Materia Orgánica		
Materia Organica	%	2,750

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Vº Bº JEFE LABORATORIO:
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INFORME DE RESULTADOS DE ENSAYOS

1. ANTECEDENTES SOLICITANTE: GMS Internacional -	**EXPEDIENTE: EXT_ 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio** MUESTRA Nº: 6042 INFORME Nº: Lab.GCh-581-21 FECHA INFORME: 23.11.2021
PROYECTO/OBRA: LA VENDIMIA , Cauquenes, Region del Maule	
2. DATOS MUESTRA Descripción: Procedencia/Referencia: TP-10 Datos complementarios: Desde 2.0 hasta 2.1 m. Tipo de muestreo: Calicatas	Método de muestreo: NCh 164 Of.2009 Muestreado por: Cliente Fecha muestreo/recepción: 13.10.2021
3. REGISTRO MUESTRA Fecha registro: 19.10.2021	Observaciones: -

4. RESULTADOS DE ENSAYOS

Determinación del contenido de Cloruros (NCh 1444. Of80)		
Cloruros (Cl)	mg Cl^-/Kg Suelo	36
Cloruros (Cl)	%	0,004

Determinación cuantitativa del contenido de sulfatos solubles (NCh 1444. Of80)		
Sulfatos (SO4)	mg SO_4^{2-}/Kg Suelo	182
Sulfatos (SO4)	%	0,02

Determinación de sales solubles totales. MCV8. Cap 8.202.14		
Sales Solubles totales	%	0,178

Potencial Oxido-Reducción. Redox ASTM D 1498/2000		
Potencial Oxido-Reducción	mV	206

Determinación del pH. ASTM D4972/95		
Valor pH a 20 C°	%	6,95

Determinación Materia Orgánica		
Materia Organica	%	3,07

Determinación Acidez Baumann Gully. UNE EN 16502:2015		
Acidez Baumann Gully	mL NaOH/Kg Suelo	23,69

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INFORME DE RESULTADOS DE ENSAYOS

1. ANTECEDENTES SOLICITANTE: GMS Internacional -	**EXPEDIENTE: EXT_ 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio** MUESTRA Nº: 6044 INFORME Nº: Lab.GCh-581-21 FECHA INFORME: 23.11.2021
PROYECTO/OBRA: LA VENDIMIA , Cauquenes, Region del Maule	
2. DATOS MUESTRA Descripción: Procedencia/Referencia: TP-12 Datos complementarios: Desde 0.6 hasta 0.7 m. Tipo de muestreo: Calicatas	Método de muestreo: NCh 164 Of.2009 Muestreado por: Cliente Fecha muestreo/recepción: 13.10.2021
3. REGISTRO MUESTRA Fecha registro: 19.10.2021	Observaciones: -

4. RESULTADOS DE ENSAYOS

Determinación del contenido de Cloruros (NCh 1444. Of80)		
Cloruros (Cl)	mg Cl^{-}/Kg Suelo	32
Cloruros (Cl)	%	0,0032

Determinación cuantitativa del contenido de sulfatos solubles (NCh 1444. Of80)		
Sulfatos (SO4)	mg SO_4^{2-}/Kg Suelo	189
Sulfatos (SO4)	%	0,0189

Determinación de sales solubles totales. MCV8. Cap 8.202.14		
Sales Solubles totales	%	0,13

Potencial Oxido-Reducción. Redox ASTM D 1498/2000		
Potencial Oxido-Reducción	mV	187

Determinación del pH. ASTM D4972/95		
Valor pH a 20 C°	%	7,05

Determinación Materia Orgánica		
Materia Organica	%	2,81

COPIA DE ESTE INFORME ENVIADA A: GMS Internacional

Vº Bº JEFE LABORATORIO:
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Vº Bº GERENTE TÉCNICO:
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INFORME DE RESULTADOS DE ENSAYOS

1. ANTECEDENTES SOLICITANTE: GMS Internacional -	**EXPEDIENTE: EXT_ 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio** MUESTRA Nº: 6046 INFORME Nº: Lab.GCh-581-21 FECHA INFORME: 23.11.2021
PROYECTO/OBRA: LA VENDIMIA , Cauquenes, Region del Maule	

2. DATOS MUESTRA

Descripción:
Procedencia/Referencia: TP-14
Datos complementarios: Desde 1.5 hasta 1.6 m.
Tipo de muestreo: Calicatas

Método de muestreo: NCh 164 Of.2009
Muestreado por: Cliente
Fecha muestreo/recepción: 13.10.2021

3. REGISTRO MUESTRA

Fecha registro: 19.10.2021
Observaciones: -

4. RESULTADOS DE ENSAYOS

Determinación del contenido de Cloruros (NCh 1444. Of80)		
Cloruros (Cl)	mg Cl^-/Kg Suelo	34
Cloruros (Cl)	%	0,0034

Determinación cuantitativa del contenido de sulfatos solubles (NCh 1444. Of80)		
Sulfatos (SO4)	mg SO_4^{2-}/Kg Suelo	197
Sulfatos (SO4)	%	0,0197

Determinación de sales solubles totales. MCV8. Cap 8.202.14		
Sales Solubles totales	%	0,21

Potencial Oxido-Reducción. Redox ASTM D 1498/2000		
Potencial Oxido-Reducción	mV	193

Determinación del pH. ASTM D4972/95		
Valor pH a 20 C°	%	6,91

Determinación Materia Orgánica		
Materia Organica	%	2,79

COPIA DE ESTE INFORME ENVIADA A: GMS Internacional

Vº Bº JEFE LABORATORIO:
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INFORME DE RESULTADOS DE ENSAYOS

1. ANTECEDENTES SOLICITANTE: GMS Internacional -	**EXPEDIENTE: EXT_ 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio** MUESTRA Nº: 6052 INFORME Nº: Lab.GCh-580-21 FECHA INFORME: 10.11.2021
PROYECTO/OBRA: LA VENDIMIA , Cauquenes, Region del Maule	

2. DATOS MUESTRA

Descripción:	Método de muestreo: NCh 164 Of.2009
Procedencia/Referencia: MI-TP-14	Muestreado por: Cliente
Datos complementarios: Desde 1,0 m hasta 1,1 m.	Fecha muestreo/recepción: 13.10.2021
Tipo de muestreo: Calicatas	

3. REGISTRO MUESTRA

Fecha registro: 19.10.2021	Observaciones: -

4. RESULTADOS DE ENSAYOS

CONSOLIDACIÓN UNIDIMENSIONAL DE SUELOS. ASTM D2435

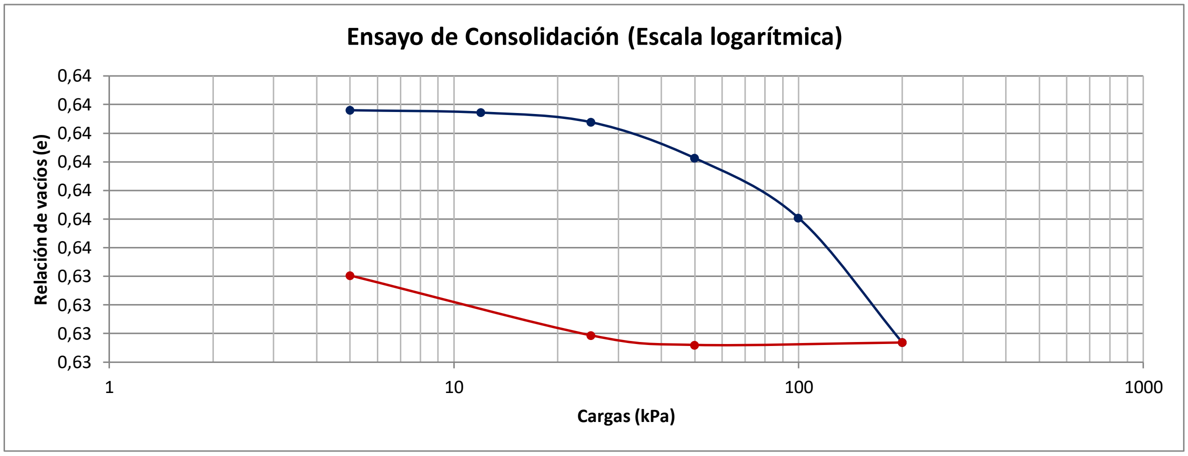
1. DATOS ENSAYO

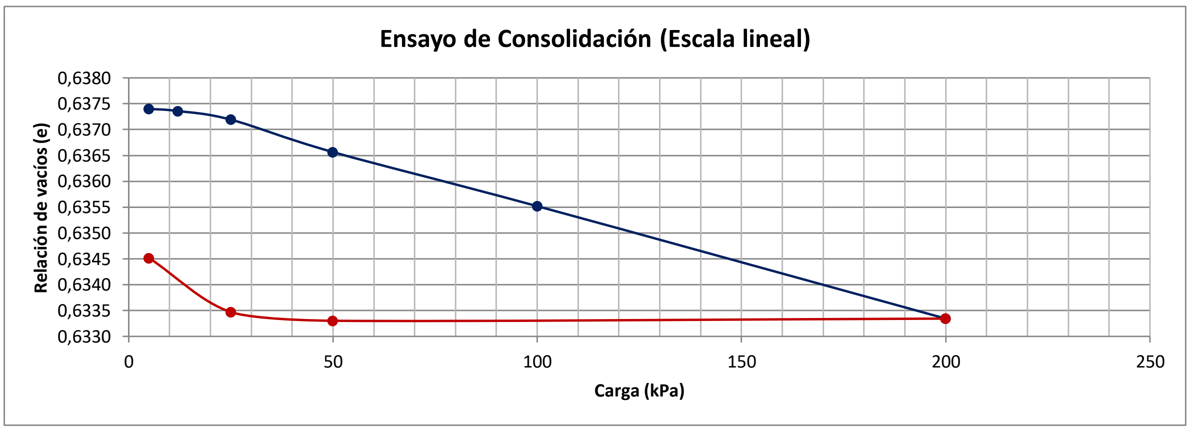
Preparación de Probetas	Tallada Inalterada	x	Peso Especifico (g/cm^3)	2,639
	Remoldeada	-	Densidad aparente seca (g/cm^3)	1,612
Dimensiones y parametros del molde	Diametro: d (cm)	79,60	Área de Probeta (cm^2)	49,76
	Altura h (cm)	39,15	Volumen de Probeta (cm^3)	194,83
	Masa molde	522,2	Humedad (%)	15,10

2. PARÁMETROS CALCULADOS

PARÁMETROS		CONDICIONES INICIALES	CONDICIONES FINALES
Peso Húmedo + Mp	grs	883,6	889
Peso Húmedo	grs	361,4	366,80
Peso seco	grs	313,98	306,10
Altura	(cm)	39,15	39,08
Volumen	cm3	194,83	194,47
Humedad	%	15,10	19,83
Densidad aparente seca	g/cm3	1,612	1,57
Relación de vacios (e_i)		0,64	0,68
Saturación (S_i)	%	62,52	77,34
Altura de sólidos	(cm)	2,39	2,33

	Carga						Descarga		
Carga [kgf/cm2]	0,05	0,12	0,25	0,5	1	2	0,5	0,25	0,05
Carga [kPa]	5	12	25	50	100	200	50	25	5
Def [mm]	-0,02	-0,03	-0,07	-0,22	-0,47	-0,99	-1	-0,96	-0,71
Rel Vacíos	0,6374	0,6374	0,6372	0,6366	0,6355	0,63	0,63	0,63	0,63





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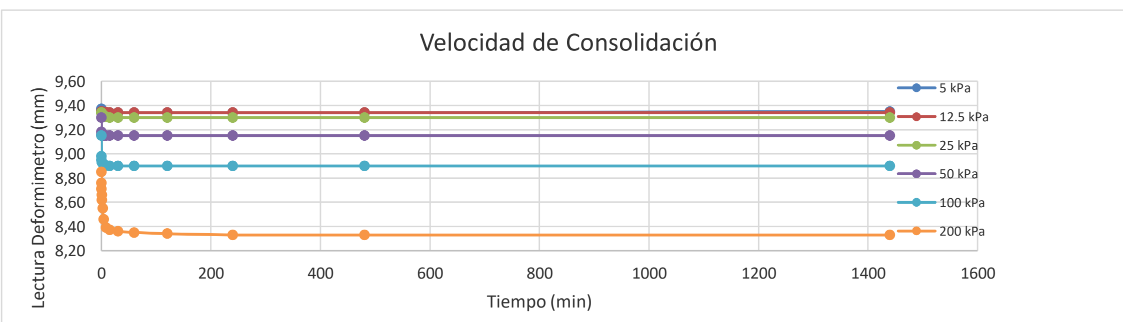
1. ANTECEDENTES SOLICITANTE:	EXPEDIENTE: EXT_ 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio
GMS Internacional **PROYECTO/OBRA:** LA VENDIMIA , Cauquenes, Region del Maule	MUESTRA Nº: 6052 INFORME Nº: Lab.GCh-580-21 FECHA INFORME: 10.11.2021
2. DATOS MUESTRA	
Descripción: Procedencia/Referencia: MI-TP-14 Datos complementarios: Desde 1,0 m hasta 1,1 m. Tipo de muestreo: Calicatas	Método de muestreo: NCh 164 Of.2009 Muestreado por: Cliente Fecha muestreo/recepción: 13.10.2021
3. REGISTRO MUESTRA	
Fecha registro: 19.10.2021	Observaciones: -

Lectura Deformimetro [mm]									
Tiempo	Carga						Descarga		
	5	12,5	25	50	100	200	50	25	5
(min)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)
0	9,37	9,35	9,34	9,30	9,15	8,85	8,33	8,32	8,36
0,1	9,37	9,35	9,34	9,18	8,98	8,76	8,33	8,32	8,39
0,25	9,37	9,35	9,34	9,16	8,95	8,71	8,33	8,32	8,41
0,5	9,36	9,35	9,34	9,15	8,94	8,66	8,33	8,32	8,42
1	9,36	9,35	9,33	9,15	8,93	8,62	8,33	8,32	8,48
2	9,35	9,35	9,33	9,15	8,92	8,55	8,33	8,32	8,51
4	9,35	9,34	9,32	9,15	8,91	8,46	8,32	8,32	8,55
8	9,34	9,34	9,31	9,15	8,91	8,39	8,32	8,33	8,56
15	9,34	9,34	9,30	9,15	8,90	8,37	8,32	8,34	8,57
30	9,34	9,34	9,30	9,15	8,90	8,36	8,32	8,35	8,59
60	9,34	9,34	9,30	9,15	8,90	8,35	8,32	8,36	8,61
120	9,34	9,34	9,30	9,15	8,90	8,34	8,32	8,36	8,61
240	9,34	9,34	9,30	9,15	8,90	8,33	8,32	8,36	8,61
480	9,34	9,34	9,30	9,15	8,90	8,33	8,32	8,36	8,61
1440	9,35	9,34	9,30	9,15	8,90	8,33	8,32	8,36	8,61



Carga	hv-Dh/hs	Δh	h	H	t90^1/2	t(90)	Cv	Cc
Kg/cm^2	e						Cm^2/seg	
0,05	0,637	0,00	3,91	1,96	0,27	0,08	-	-
0,12	0,637	0,00	3,91	1,96	0,03	0,00	54,087	0,000
0,25	0,637	-0,01	3,91	1,96	0,45	0,20	0,270	0,001
0,5	0,637	-0,02	3,89	1,95	0,30	0,09	0,597	0,002
1	0,636	-0,05	3,87	1,94	1,10	1,20	0,044	0,003
2	0,633	-0,10	3,82	1,92	0,39	0,16	0,334	0,007

INFORME DE RESULTADOS DE ENSAYOS

1. ANTECEDENTES SOLICITANTE: GMS Internacional -	**EXPEDIENTE: EXT_ 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio** MUESTRA Nº: 6053 INFORME Nº: Lab.GCh-580-21 FECHA INFORME: 10.11.2021
PROYECTO/OBRA: LA VENDIMIA , Cauquenes, Region del Maule	

2. DATOS MUESTRA

Descripción:	Método de muestreo: NCh 164 Of.2009
Procedencia/Referencia: MI-TP-15	Muestreado por: Cliente
Datos complementarios: Desde 0,6 m hasta 0,7 m.	Fecha muestreo/recepción: 13.10.2021
Tipo de muestreo: Calicatas	

3. REGISTRO MUESTRA

Fecha registro: 19.10.2021	Observaciones: -

4. RESULTADOS DE ENSAYOS

CONSOLIDACIÓN UNIDIMENSIONAL DE SUELOS. ASTM D2435

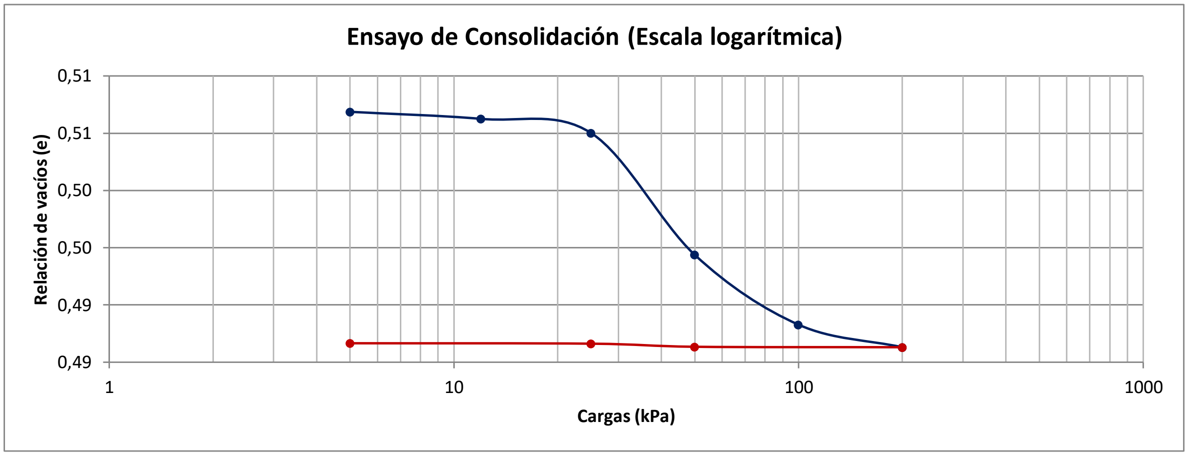
1. DATOS ENSAYO

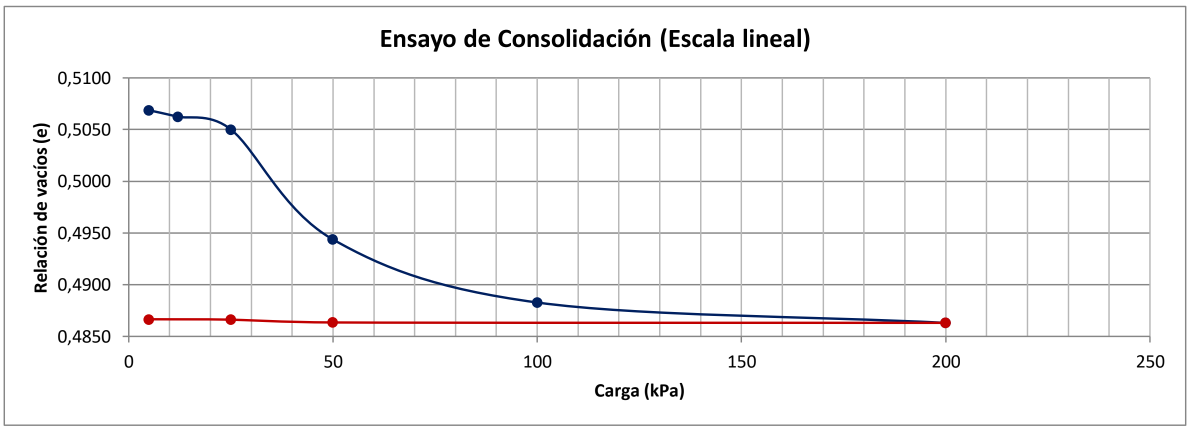
Preparación de Probetas	Tallada Inalterada	-	Peso Especifico (g/cm^3)	2,639
	Remoldeada	x	Densidad aparente seca (g/cm^3)	1,750
Dimensiones y parametros del molde	Diametro: d (cm)	79,50	Área de Probeta (cm^2)	49,64
	Altura h (cm)	39,10	Volumen de Probeta (cm^3)	194,09
	Masa molde	522,2	Humedad (%)	13,70

2. PARÁMETROS CALCULADOS

PARÁMETROS		CONDICIONES INICIALES	CONDICIONES FINALES
Peso Húmedo + Mp	grs	908,4	913,5
Peso Húmedo	grs	386,2	391,30
Peso seco	grs	339,65	333,52
Altura	(cm)	39,1	38,55
Volumen	cm3	194,09	191,34
Humedad	%	13,70	17,32
Densidad aparente seca	g/cm3	1,750	1,74
Relación de vacios (e_i)		0,51	0,51
Saturación (S_i)	%	71,19	88,95
Altura de sólidos	(cm)	2,59	2,55

	Carga						Descarga		
Carga [kgf/cm2]	0,05	0,12	0,25	0,5	1	2	0,5	0,25	0,05
Carga [kPa]	5	12	25	50	100	200	50	25	5
Def [mm]	-0,3	-0,46	-0,78	-3,54	-5,12	-5,63	-5,62	-5,55	-5,54
Rel Vacíos	0,5069	0,5063	0,5050	0,4944	0,4883	0,49	0,49	0,49	0,49





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Vº Bº JEFE LABORATORIO:
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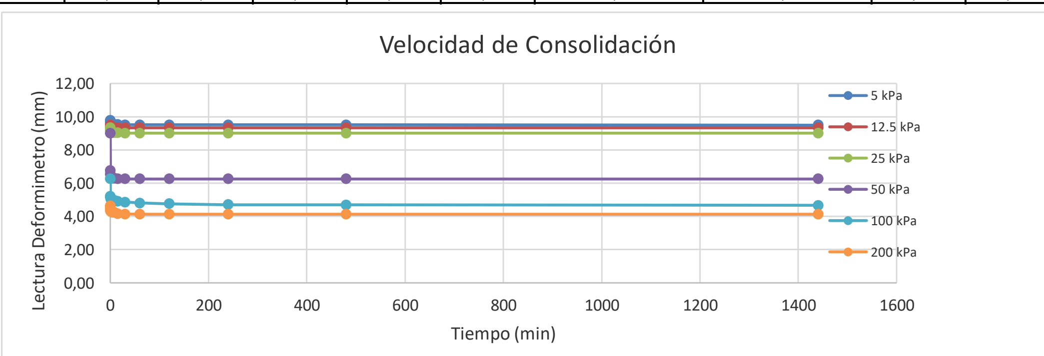
1. ANTECEDENTES SOLICITANTE:	**EXPEDIENTE: EXT_ 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio**
GMS Internacional	MUESTRA Nº: 6053
PROYECTO/OBRA:	INFORME Nº: Lab.GCh-580-21
LA VENDIMIA , Cauquenes, Region del Maule	FECHA INFORME: 10.11.2021

2. DATOS MUESTRA	
Descripción:	Método de muestreo: NCh 164 Of.2009
Procedencia/Referencia: MI-TP-15	Muestreado por: Cliente
Datos complementarios: Desde 0,6 m hasta 0,7 m.	Fecha muestreo/recepción: 13.10.2021
Tipo de muestreo: Calicatas	
3. REGISTRO MUESTRA	
Fecha registro: 19.10.2021	Observaciones: -

Lectura Deformimetro [mm]

Tiempo	Carga						Descarga		
	5	12,5	25	50	100	200	50	25	5
(min)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)
0	9,79	9,49	9,33	9,01	6,25	4,64	4,13	4,14	4,21
0,1	9,75	9,45	9,25	6,75	5,20	4,50	4,13	4,16	4,22
0,25	9,68	9,42	9,20	6,55	5,16	4,34	4,13	4,17	4,22
0,5	9,62	9,40	9,15	6,35	5,09	4,33	4,13	4,18	4,22
1	9,59	9,38	9,10	6,32	5,05	4,31	4,13	4,19	4,22
2	9,58	9,36	9,05	6,30	5,01	4,28	4,13	4,19	4,22
4	9,56	9,35	9,04	6,28	5,00	4,25	4,14	4,19	4,22
8	9,54	9,33	9,03	6,28	4,95	4,23	4,14	4,20	4,22
15	9,53	9,33	9,03	6,26	4,91	4,17	4,14	4,20	4,22
30	9,51	9,33	9,01	6,26	4,86	4,14	4,14	4,20	4,22
60	9,51	9,33	9,01	6,25	4,80	4,13	4,14	4,20	4,22
120	9,51	9,33	9,01	6,25	4,76	4,13	4,14	4,21	4,22
240	9,51	9,33	9,01	6,25	4,70	4,13	4,14	4,21	4,22
480	9,51	9,33	9,01	6,25	4,69	4,13	4,14	4,21	4,22
1440	9,49	9,33	9,01	6,25	4,67	4,13	4,14	4,21	4,22



Carga	hv-Dh/hs	Δh	h	H	t90^1/2	t(90)	Cv	Cc
Kg/cm^2	e						Cm^2/seg	
0,05	0,507	-0,03	3,88	1,94	0,35	0,12	-	-
0,12	0,506	-0,05	3,86	1,94	0,27	0,07	0,736	0,002
0,25	0,505	-0,08	3,83	1,92	0,25	0,06	0,830	0,004
0,5	0,494	-0,35	3,56	1,85	1,35	1,82	0,026	0,035
1	0,488	-0,51	3,40	1,74	0,96	0,92	0,046	0,020
2	0,486	-0,56	3,35	1,69	1,56	2,43	0,017	0,007

INFORME DE RESULTADOS DE ENSAYOS

1. ANTECEDENTES SOLICITANTE: GMS Internacional -	**EXPEDIENTE: 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio** MUESTRA Nº: 6052
PROYECTO/OBRA: LA VENDIMIA , Cauquenes, Region del Maule	INFORME Nº: Lab.GCh-581-20 FECHA INFORME: 10.11.2021
2. DATOS MUESTRA Descripción: Procedencia/Referencia: MI-TP-14 Tipo de muestreo: Calicatas Profundidad: Desde 1,2 m. hasta 1,5 m.	 Método de muestreo: NCh 164 Of.2009 Muestreado por: Cliente Fecha muestreo/recepción: 13.10.2021
3. REGISTRO MUESTRA Fecha registro: 19.10.2021	Observaciones:

DETERMINACIÓN DEL COLAPSO POTENCIAL DE SUELOS. ASTM D5333

A. DATOS DEL ENSAYO

Diametro	**(cm)**	7,94
Altura (ho)	**(cm)**	3,89

B. PARAMETROS FISICOS

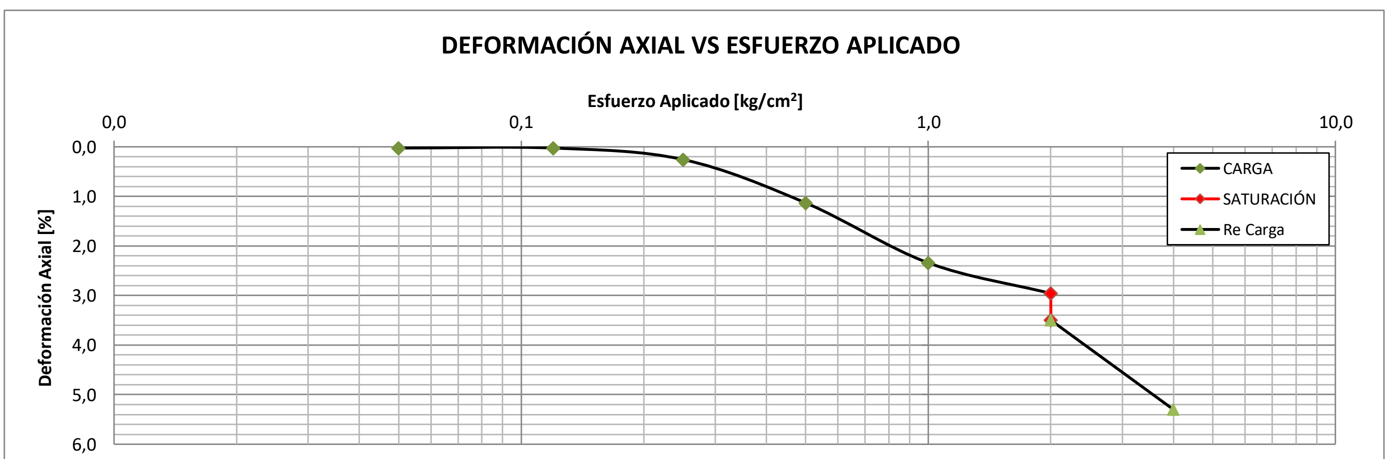
		INICIAL	**FINAL**
Densidad aparente humeda	**(g/cm3)**	1,869	2,024
Densidad aparente seca	**(g/cm3)**	1,635	1,690
Humedad	**(%)**	14,33	19,738

C. DEFORMACIÓN POR INCREMENTO DE PRESIÓN

		Natural	**Carga**					**Saturación**	**Carga**
Cargas	**[kgf/cm2]**	0,05	0,12	0,25	0,50	1,00	2,00	2,00	4,00
Var. Altura	**[mm]**	0,01	0,00	0,09	0,34	0,47	0,24	0,21	0,70
Variación Acum.	**[mm]**	0,01	0,01	0,10	0,44	0,91	1,15	1,36	2,06
Altura de la muestra	**[mm]**	38,87	38,87	38,78	38,44	37,97	37,73	37,52	36,82
Deformación axial	**[%]**	0,03	0,03	0,26	1,13	2,34	2,96	3,50	5,30

D. RESULTADOS DEL ENSAYO

Primera carga de asentamiento (d0)	**[mm]**	9,74
Def. pre-saturación (di)	**[mm]**	8,61
Def. post-saturación (df)	**[mm]**	8,40
Colapso a 200 kPa (Ie)	**(%)**	**0,54**



Vº Bº JEFE LABORATORIO: Josué Acevedo

Vº Bº GERENTE TÉCNICO: Ricardo Hernández

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INFORME DE RESULTADOS DE ENSAYOS

1. ANTECEDENTES SOLICITANTE: GMS Internacional -	**EXPEDIENTE: 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio** MUESTRA Nº: 6053
PROYECTO/OBRA: LA VENDIMIA , Cauquenes, Region del Maule	INFORME Nº: Lab.GCh-581-20 FECHA INFORME: 10.11.2021
2. DATOS MUESTRA Descripción: Procedencia/Referencia: MI-TP-15 Tipo de muestreo: Calicatas Profundidad: Desde 1,2 m. hasta 1,5 m.	 Método de muestreo: NCh 164 Of.2009 Muestreado por: Cliente Fecha muestreo/recepción: 13.10.2021
3. REGISTRO MUESTRA Fecha registro: 19.10.2021	Observaciones:

DETERMINACIÓN DEL COLAPSO POTENCIAL DE SUELOS. ASTM D5333

A. DATOS DEL ENSAYO

Diametro	**(cm)**	7,96
Altura (ho)	**(cm)**	3,92

B. PARAMETROS FISICOS

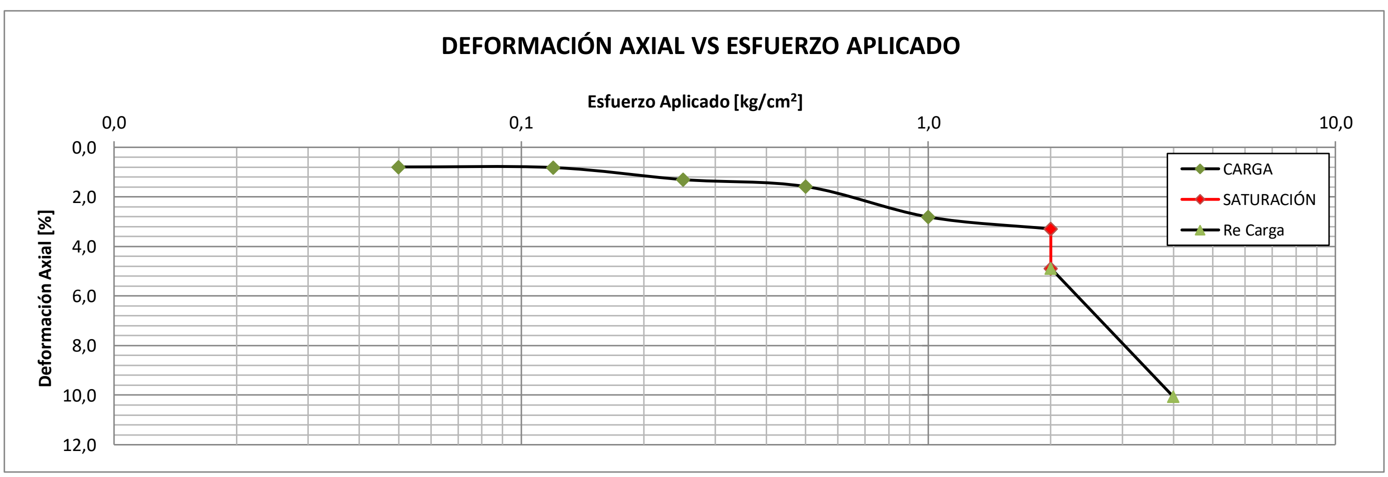
		INICIAL	**FINAL**
Densidad aparente humeda	**(g/cm3)**	1,978	-3,233
Densidad aparente seca	**(g/cm3)**	1,741	0,885
Humedad	**(%)**	13,65	-465,147

C. DEFORMACIÓN POR INCREMENTO DE PRESIÓN

		Natural	**Carga**					**Saturación**	**Carga**
Cargas	**[kgf/cm2]**	0,05	0,12	0,25	0,50	1,00	2,00	2,00	4,00
Var. Altura	**[mm]**	0,31	0,01	0,19	0,11	0,48	0,19	0,62	2,03
Variación Acum.	**[mm]**	0,31	0,32	0,51	0,62	1,10	1,29	1,91	3,94
Altura de la muestra	**[mm]**	38,84	38,83	38,64	38,53	38,05	37,86	37,24	35,21
Deformación axial	**[%]**	0,79	0,82	1,30	1,58	2,81	3,30	4,88	10,06

D. RESULTADOS DEL ENSAYO

Primera carga de asentamiento (d0)	**[mm]**	9,51
Def. pre-saturación (di)	**[mm]**	7,90
Def. post-saturación (df)	**[mm]**	7,28
Colapso a 200 kPa (Ie)	**(%)**	**1,58**



Vº Bº JEFE LABORATORIO:

Vº Bº GERENTE TÉCNICO:

COPIA DE ESTE INFORME ENVIADA A: GMS Internacional

Josué Acevedo

Ricardo Hernández

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INFORME DE RESULTADOS DE ENSAYOS

1. ANTECEDENTES SOLICITANTE: GMS Internacional - **PROYECTO/OBRA:** LA VENDIMIA , Cauquenes, Region del Maule	**EXPEDIENTE: EXT_ 129_ GMS_ LA VENDIMIA _ Ensayos de laboratorio** MUESTRA Nº: 6053 INFORME Nº: Lab.GCh-580-20 FECHA INFORME: 23.11.2021
2. DATOS MUESTRA Descripción: Procedencia/Referencia: MI-TP-15 Tipo de muestreo: Calicatas	 Método de muestreo: NCh 164 Of.2009 Muestreado por: Cliente Fecha muestreo/recepción: 13.10.2021
3. REGISTRO MUESTRA Fecha registro: 19.10.2021	Observaciones:

Ensayo de Compresión Simple - ASTM D2166;2006

A. DATOS DE TERRENO

Densidad Natural Humedad	**(g/cm3)**	1,77
Densidad Natural Seca	**(g/cm3)**	1,75
Humedad Natural	**(%)**	13,70
Densidad de Particulas Solidas		2,639

La determinación de la humedad natural se efectuo después de la falla a la pobreta completa

B. PARAMETROS FISICOS

		Probeta Natural	Probeta Remoldeada
Altura de la probeta	**(mm)**	100,1	100,0
Diametro de la probeta	**(mm)**	51,5	50,0
Relación Altura/Diametro		1,94	2,00
Indice de Vacio		0,503	0,371
"qu"	**(kPa)**	23	34
Resistencia al Corte	**(kPa)**	11	17
Tasa de deformación promedio	**(%/min)**	0,478	0,504
Grado de saturación	**(%)**	71,65	37,06
Sensibilidad		0,632	

C. Esquema de Falla de la Probeta

COPIA DE ESTE INFORME ENVIADA A: GMS Internacional

Vº Bº JEFE LABORATORIO:

Josué Acevedo

Vº Bº GERENTE TÉCNICO:

Ricardo Hernández

ATMOSPHERIC CORROSION ASSESSMENT, LA VENDIMIA, MAULE REGION, CHILE

Project ID:	IG1827115d
Client:	Trina Solar
Consultant:	GMS Internacional, SL

Edition	Date	Version	Revision Purpose	Written	Reviewed	Approved
1ª	01/10/2021	0	First version of the report	R. Rayo	JP Singer	JP Singer

ATMOSPHERIC CORROSION ASSESSMENT,

LA VENDIMIA, MAULE REGION, CHILE

Prepared by:

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October 01st, 2021

Trina Solar Holding

Nueva Tajamar 555, of 1501,
Las Condes, Santiago de Chile
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Attn: Julie Baudry

Email: julie.baudry@trinasolar.com

Re: Atmospheric Corrosion Assessment, La Vendimia, Maule Region, Chile

GMS Internacional SL. has completed the Atmospheric Corrosion Assessment for the project referenced above.

These services were performed in general accordance with the scope resolved with the client "*P21_235_GMS_TRINA SOLAR_Vendimia_GHT_v1_BoQ".*

This report presents the scope and results of the atmospheric corrosion analysis based on international standards and bibliographic data of the site. The final recommendations regarding the estimated coating thickness required by the Client are provided in this report.

We would like to express our gratitude in advance for the opportunity to be of service to Trina Solar on this project.

Please do not hesitate to contact us should you have any further questions regarding this report, or if we may be of further assistance.

GMS Internacional, SL

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FIGURES

TABLES

1. INTRODUCTION

1.1. Project background

GMS Internacional, SL (the Consultant) has been hired by Trina Solar (the Client) to carry out an Atmospheric Corrosion Assessment on the La Vendimia PV solar project.

The construction will involve the use of steel and concrete which are subjected to corrosion both associated with ground aggressiveness and with airborne, atmospheric corrosion. The present report, therefore, summarizes the corrosion assessment performed for the solar plant foundation, using the design guidelines described below.

1.2. Scope of work

The atmospheric corrosion assessment aims to estimate the expected corrosion level on La Vendimia PV solar project's steel infrastructure, according to the international standards ISO 9223 (1992), ISO 9223 (2012), it also aims to set general principles of design, in accordance with ISO 14713-1 (2009) and ISO 9224 (2012) standards.

2. LOCATION AND SITE DESCRIPTION

2.1. *Site location*

The project is in Cauquenes Province, in Maule Region of Chile.

The project area borders the following municipalities: to the northwest with Cauquenes commune, to the northeast with Cauquenes River.

The La Vendimia PV solar project area is approximately 25.3 ha in size and is located approximately 3 km to the southwest of Cauquenes commune. It is characterized by a relatively flat topography previously used for agricultural purposes.

	Site Location	**Project:** IG1827115d **Date:** 01/10/2021	**Figure 1:** Site Location of "La Vendimia" Project.	

2.2. *Site description*

According to the geological map of Chile the study is located at Pleistocene-Holocene age deposits, which are basically alluvial, colluvial and mass removal deposits intercalated with volcanic deposits (SERNAGEOMIN, 2010).

The project site is approximately 139 meters above sea level and 37 km from the Pacific coast.

3. ATMOSPHERIC CORROSION ASSESSMENT

3.1. *Atmospheric corrosion*

The atmospheric corrosion of metals occurs through an electrochemical mechanism. The electrolyte consists of an extremely thin moisture film or aqueous film which occurs when metallic materials are noticeably wet.

Under this electrolyte film, most of the metals exposed in the atmosphere are corroded by the cathodic process of oxygen reduction. Only in case of a high degree of acid contamination, the hydrogen ion discharge reaction matters.

The following section summarizes the assessment of the expected atmospheric corrosion within the project plot according to various standards: ISO 9223 (1992); ISO 9223 (2012); ISO 14713-1 (2009).

The impact assessment of atmospheric corrosion on steel according to these standards requires the use of several parameters that were not directly available. In light of this, the atmospheric corrosion assessment was carried out based on representative bibliographic data from the area.

3.1.1. *Atmospheric corrosion level according to ISO 9223 (1992)*

This guideline is used to determinate the atmospheric corrosion level by either defining the corrosion effects based on standard specimens or in terms of the most significant atmospheric factors that influence corrosion.

No samples were available for the present analysis; therefore, the evaluation of atmospheric corrosivity according to this standard was carried out by evaluating the most significant factors influencing atmospheric corrosivity, such as the time of wetness and pollution levels.

As discussed above, the key factors in the atmospheric corrosion of metals and alloys according to ISO 9223 (1992) are the time of wetness, pollution by sulphur dioxide (SO_2), and airborne salinity.

3.1.1.1. *Time of wetness*

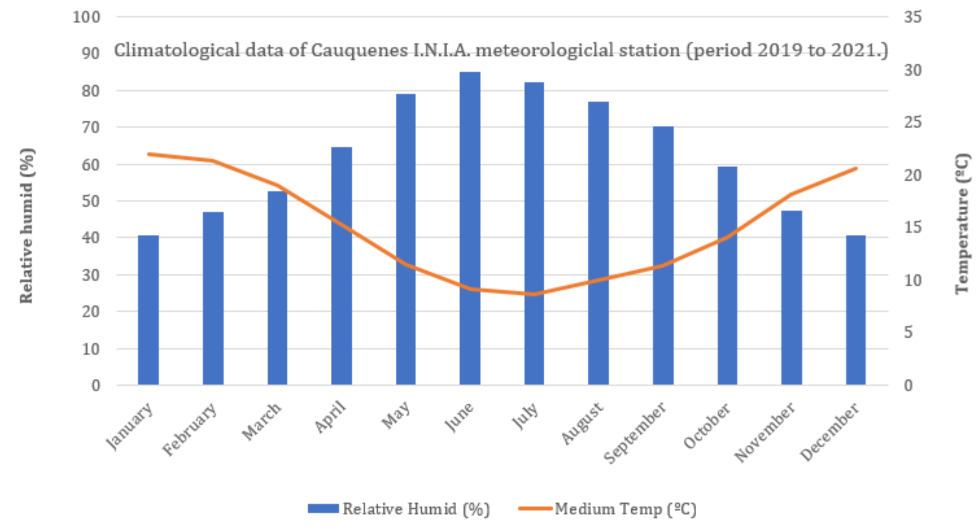
The time of wetness refers to the period during which a metallic surface is covered by adsorptive and/or liquid films of electrolyte that may cause atmospheric corrosion. The time in which relative humidity is greater than 80% at a temperature greater than 0°C is used to estimate the calculated time of wetness (τ) of corroding surfaces. .

In the absence of availability of normal meteorological data from the study area, the meteorological data were taken from the database of Dirección General de Aguas, government of Chile and Dirección Meteorologica de Chile, of the meteorological stations closest to the project area "Cauquenes I.N.I.A. 350021 " located 4 km from the project area and “Tutuven embalse, 07337002-7” located 13 km from the project area. In the case of temperature and relative humidity, the available data is limited to 3 years of meteorological information (from 2019 - 2021). on the other hand, the available precipitation values are for a period of 10 years (from 2010-2019).

Table 1. Meteorological data of the study area, info from (Dirección General de Aguas - Ministerio de Obras Públicas, 2021) and (Dirección Meteorológica de Chile, 2021).

Climatological values			
Month	**CAUQUENES I.N.I.A. STATION Altitud (msnm): 162 Latitud S: 35° 57' 22'' Longitud W: 72° 17' 24'' DIRECCION General de Aeronáutica Civil – Dirección meteorológica de Chile, 2021.**	**TUTUVEN EMBALSE STATION Altitud (msnm): 179 Latitud S: 35° 53' 47'' Longitud W: 72° 22' 48'' DIRECCION GENERAL DE AGUAS – MINISTERIO DE OBRAS PUBLICAS, 2021.**	**CAUQUENES I.N.I.A. STATION Altitud (msnm): 162 Latitud S: 35° 57' 22'' Longitud W: 72° 17' 24'' DIRECCION General de Aeronáutica Civil – Dirección meteorológica de Chile, 2021.**
	Medium Temperature (°C)	Rain (mm/year)	Relative Humid (%)
	Monthly (Period: 2019-2021)	Monthly (Period: 2010-2019)	Monthly (Period: 2019-2021)
January	21,97	2,00	40,70
February	21,37	11,12	46,90
March	18,93	6,85	52,57
April	15,27	29,80	64,67
May	11,50	93,73	79,10
June	9,07	169,37	84,93
July	8,67	138,23	82,30
August	10,00	111,00	76,97
September	11,30	47,56	70,27
October	14,00	48,32	59,20
November	18,15	15,85	47,35
December	20,55	9,97	40,65
Annual average	**15,06**	**56,98**	**62,13**
Accumulated:		**684**	

The Relative humid and Temperature values at Cauquenes region are shown in the next page in **Figure 2** .



	Project: IG1827115d **Date:** 01/10/2021	**Figure 2.** Climatic data for Cauquenes I.N.I.A meteorological station. (Dirección Meteorológica de Chile, 2021)	

As shown in **Figure 2** and **Table 1** the **medium temperature average is 15.06°C** and annual **relative humidity** is around **62.13%,** while relative humidity greater than 80% occurs more than 34% of the year during May-August period, however, this humid condition could reach 40% of the year. According to the time of wetness, the classification is presented in ISO 9223 (1992), the site is represented by category **τ4**.

Table 2. Classification of time of wetness according to ISO 9223 (1992)

Category	Time of wetness		Example of occurrence
	h/a	%	
τ1	τ ≤ 10	τ ≤ 0.1	Internal microclimates with climatic control.
τ2	10 < τ ≤ 250	0.1 < τ ≤ 3	Internal microclimates without climatic control except for internal non-air-conditioned spaces in damp climates.
τ3	250 < τ ≤ 2500	3 < τ ≤ 30	Outdoor atmospheres in dry, cold climates and part of temperate climates; properly ventilated sheds in temperate climates.
τ4	2500 < τ ≤ 5500	30 < τ ≤ 60	Outdoor atmospheres in all climates (except for the dry and cold climates; ventilated sheds in humid conditions; unventilated sheds in temperate climates.
τ5	5500 < τ	60 < τ	Part of damp climates; unventilated sheds in humid conditions.

3.1.1.2. *Pollution by sulphur dioxide (SO_2)*

Sulphur dioxide deposition rate and concentration are calculated from continuous measurements during at least one year and are expressed as the annual average. The classification of pollution by sulphur dioxide for standard outdoor atmospheres is given in **Table 3.**

Table 3. Classification of pollution by sulphur-containing substances.

Category	Deposition rate of SO_2 mg/(m^2*d)	Concentration of SO_2 µg/m^3
P_0	Pd ≤ 10	P_c ≤ 12
P_1	10 < Pd ≤ 35	12 < P_c ≤ 40
P_2	35 < Pd ≤ 80	40 < P_c ≤ 90
P_3	80 < Pd ≤ 200	90 < P_c ≤ 250

According to the RETC (Pollutants Emissions and Transference Registry, Chile) 99% of SO2 emissions in Chile come from point sources and the annual emissions of SO_2 in Cauquenes City in 2018 were a total of **0.0015 tons per year**, the total emissions come from small commercial establishments and do not represent significant emissions of SO_2.

In 2018, a document was published entitled *Atmospheric corrosion map of Chile* (Vera et al. 2018) where a nationwide map of corrosion and environment aggressiveness is presented. This study is based on data from measurement stations located at some of the largest cities of Chile, among them, Coronel is the closest one to the present atmospheric corrosion assessment site. Coronel city is located at 135 km south from the study site; it is a nearer from pacific coast than Cauquenes city and with a more developed industry. Coronel is located in Bio Bio region, according to RETC, this region is a great source of SO2 due to the thermoelectric plants and the industry in the region, According to (Vera et al., 2018) **the SO_2 deposition rate for Coronel is approximately 35 mg/m^2 day**, as shown in **Figure 3**. however, this value is high compared to the emissions reported by RETC in 2018, therefore, the level of sulphur dioxide deposition is considered as **P_1**, assuming that the rural area in which the study area is located presents an industrial activity lower than the area closest to the Coronel station, therefore, it is expected that the concentrations of $S0_2$ would be lower to 35 mg/m2 day.

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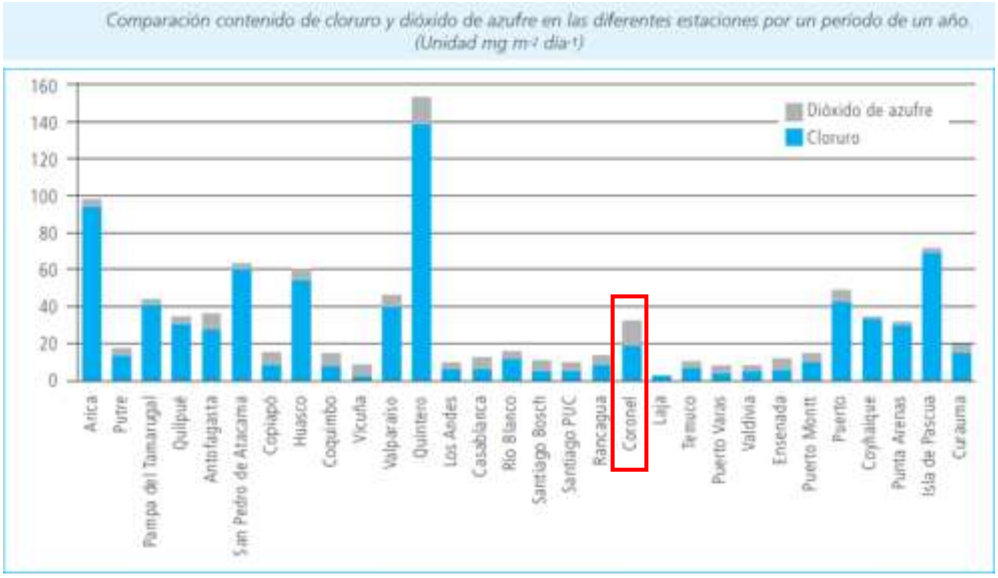

Project: IG1827115d

Date: 01/10/2020

Figure 3. Chloride and sulphur dioxide comparison in the different stations [cities] for one-year period (mg/m²day).

3.1.1.3. *Pollution by airborne salinity represented by chloride (Cl^-)*

The classification of pollution by airborne salinity (chloride) for standard outdoor atmospheres is given in **Table 4.**

The classification of pollution by chlorides according to ISO 9223 (1992) refers to the outdoor atmosphere which is polluted by airborne salinity in marine environments. The deposition rate of chlorides shows a strong negative landward gradient. Likewise, in general, according to Chico et al., the level of chlorides is extremely high on the coastline, and it subsequently decreases to values below 10 mg/(m^2day) at 10 km inland. Finally, according to Vera et al., the potential atmospheric corrosion at the Coronel location could be classified as a medium chloride deposition rate with a salinity deposition rate of **20 mg/(m^2day), S_1**, due to the reported deposition rate of the closest studied city Coronel.

Table 4. Classification of pollution by airborne salinity.

Category	Deposition rate of chloride mg/(m^2day)
S_0	$S \leq 3$
S_1	$3 < S \leq 60$
S_2	$60 < S \leq 300$
S_3	$300 < S \leq 1500$

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3.1.1.4. *Standard ISO 9223 (1992) conclusions*

The pollution and time of wetness categories are used to determine the corrosivity of individual metals. Corrosivity categories corresponding to the classified time of wetness and pollution categories are given in **Table 5,** where categories for individual metals are indicated according to the obtained results.

Table 5. Estimated corrosivity categories of the atmosphere. Corrosivity is expressed by the numeric part of the corrosivity code (i.e., 1 instead of C_1)

Carbon steel															
	τ_1			**τ_2**			**τ_3**			**τ_4**			**τ_5**		
	S_0-S_1	S_2	S_3	S_0-S_1	S_2	S_3	S_0-S_1	S_2	S_3	S_0-S_1	S_2	S_3	S_0-S_1	S_2	S_3
P_0-P_1	1	1	1 o 2	1	2	3 o 4	2 o 3	3 o 4	4	3	4	5	3 o 4	5	5
P_2	1	1	1 o 2	1 o 2	2 o 3	3 o 4	3 o 4	3 o 4	4 o 5	4	4	5	4 o 5	5	5
P_3	1 o 2	1 o 2	2	2	3	4	4	4 o 5	5	5	5	5	5	5	5
Zinc and Cooper															
	S_0-S_1	S_2	S_3	S_0-S_1	S_2	S_3	S_0-S_1	S_2	S_3	S_0-S_1	S_2	S_3	S_0-S_1	S_2	S_3
P_0-P_1	1	1	1	1	1 o 2	3	3	3	3 o 4	3	4	5	3 o 4	5	5
P_2	1	1	1 o 2	1 o 2	2	3	3	3 o 4	4	3 o 4	4	5	4 o 5	5	5
P_3	1	1 o 2	2	2	3	3 o 4	3	3 o 4	4	4 o 5	5	5	5	5	5
Aluminum															
	S_0-S_1	S_2	S_3	S_0-S_1	S_2	S_3	S_0-S_1	S_2	S_3	S_0-S_1	S_2	S_3	S_0-S_1	S_2	S_3
P_0-P_1	1	2	2	1	2 o 3	4	3	3 o 4	4	3	3 o 4	5	4	5	5
P_2	1	2	2 o 3	1 o 2	3 o 4	4	3	4	4 o 5	3 o 4	4	5	4 o 5	5	5
P_3	1	2 o 3	3	3 o 4	4	4	3 o 4	4 o 5	5	4 o 5	5	5	5	5	5

Numerical values of the first year and for the steady state of standard metals (carbon steel, zinc, copper and aluminium) are given in **Table 6** where the corresponding corrosion rate for individual metals are indicated according to the results obtained**: medium atmospheric corrosion C_3 for Carbon steel, Zinc, Aluminium and Copper.**

Table 6. Estimated corrosion rates.

Corrosivity category	Corrosion rate							
	Carbon steel		Zinc		Copper		Aluminium	
	1st year µm/a	Steady state µm/a	1st year µm/a	Steady state µm/a	1st year µm/a	Steady state µm/a	1st year µm/a	Steady state µm/a
C_1	$r_{corr}\leq 1.3$	$r_{lin}\leq 0.1$	$r_{corr}\leq 0.1$	$r_{lin}\leq 0.05$	$r_{corr}\leq 0.1$	$r_{lin}\leq 0.01$	negligible	negligible
C_2	$1.3<r_{corr}\leq 25$	$0.1<r_{lin}\leq 1.5$	$0.1<r_{corr}\leq 0.7$	$0.05<r_{lin}\leq 0.5$	$0.1<r_{corr}\leq 0.6$	$0.01<r_{lin}\leq 0.1$	--	$0.01<r_{lin}\leq 0.02$
C_3	$25<r_{corr}\leq 50$	$1.5<r_{lin}\leq 5$	$0.7<r_{corr}\leq 2.1$	$0.5<r_{lin}\leq 2$	$0.6<r_{corr}\leq 1.3$	$0.1<r_{lin}\leq 1$	--	$0.02<r_{lin}\leq 0.2$
C4	$50<r_{corr}\leq 80$	$5<r_{lin}\leq 20$	$2.1<r_{corr}\leq 4.2$	$2<r_{lin}\leq 4$	$1.3<r_{corr}\leq 2.8$	$1<r_{lin}\leq 3$	--	--
C5	$80<r_{corr}\leq 200$	$20<r_{lin}\leq 90$	$4.2<r_{corr}\leq 8.4$	$4<r_{lin}\leq 10$	$2.8<r_{corr}\leq 5.8$	$3<r_{lin}\leq 5$	--	--

3.2. *Atmospheric corrosion level according to ISO 9223 (2012)*

This International Standard establishes another classification system for the corrosivity of atmospheric environments. The Standard enables an informative estimation of the corrosivity category to be made, based on knowledge of the local environmental parameters and specifying the key factors in the atmospheric corrosion of metals and alloys, which are the temperature-humidity complex, pollution by sulphur dioxide and airborne salinity.

Numerical values of the first-year corrosion rates for standard metals (carbon steel, zinc, copper, aluminium) are the same as for ISO 9223 (1992), indicated in **Table 6**.

ISO 9223 (2012) is a more recent revision of the standard previously analysed; variations included in this standard focus on the description of typical atmospheric environments for each corrosivity category. **Table 7** shows the description of the environments related to the corrosivity categories. **The project's environment falls into the C_3 category** as shown in the next page.

Table 7. Description of typical atmospheric environments related to the corrosivity categories estimation.

Category	Corrosivity	Typical environments
		Outdoor
C_1	Very low	Dry or cold zone, atmospheric environment with very low pollution and time of wetness, e.g. certain deserts, Central Artic/Antarctica
C_2	Low	Temperate zones, atmospheric environment with low pollution (SO_2<5µg/m^3), e.g. rural areas, small towns. Dry or cold zone, atmospheric environment with short time of wetness, e.g. deserts, subarctic areas.
C_3	Medium	Temperate zones, atmospheric environment with medium pollution (SO_2: 5µg/m^3 to 30µg/m^3) or some effect of chlorides, e.g. urban areas, coastal areas with low deposition of chlorides. Subtropical and tropical zone, atmosphere with low pollution.
C_4	High	Temperate zone atmospheric environment with high pollution (SO_2: 30µg/m^3 to 90µg/m^3) or substantial effect of chlorides, e.g. polluted urban areas, industrial areas, coastal areas without spray of salt water or, exposure to strong effect of de-icing salts. Subtropical and tropical zone, atmosphere with medium pollution.
C_5	Very high	Temperate and subtropical zone, atmospheric environment with very high pollution (SO_2: 90µg/m^3 to 250µg/m^3) and/or significant effect of chlorides, e.g. industrial areas, coastal areas, sheltered positions on coastline.

ISO 9223 (2012) is an equation-based standard to estimate the first-year corrosion loss of structural metals through dose-response functions. Input parameters for the equations are shown in **Table 8**; values obtained, atmospheric corrosion rates, from these calculations are shown in **Table 9, It should be noted that in order to be conservative in the results, a concentration of SO2 of 35 mg/m2 per day is considered, although it is not expected that there will be such high concentrations in the study area.**

Equation for carbon steel:

$$r_{corr}=1.77 \cdot P_d^{0.52} \cdot \exp(0.020 \cdot RH+f_{St})+0.017 \cdot S_d^{0.62} \cdot \exp(0.033 \cdot RH+0.040 \cdot T)$$

$$f_{St}=0.150 \cdot (T-10) \ \ when\ T \leq 10°C;\ otherwise, -0.071 \cdot (T-10)$$

$$N = 128\ ,\ \ R^2 = 0.85$$

Equations for zinc:

$$r_{corr}=0.0129 \cdot P_d^{0.44} \cdot \exp(0.046 \cdot RH+f_{Zn})+0.017 \cdot S_d^{0.57} \cdot \exp(0.008 \cdot RH+0.085 \cdot T)$$

$$f_{Zn}=0.038 \cdot (T-10) \ \ when\ T \leq 10°C;\ otherwise, -0.071 \cdot (T-10)$$

$$N = 114\ ,\ \ R^2 = 0.78$$

Equations for copper:

$$r_{corr}=0.0053 \cdot P_d^{0.26} \cdot \exp(0.059 \cdot RH+f_{Cu})+0.01025 \cdot S_d^{0.27} \cdot \exp(0.036 \cdot RH+0.049 \cdot T)$$

$$f_{Cu}=0.126 \cdot (T-10) \ \ when\ T \leq 10°C;\ otherwise, -0.080 \cdot (T-10)$$

$$N = 121\ ,\ \ R^2 = 0.88$$

Equations for aluminium:

$$r_{corr}=0.004 \cdot P_d^{0.73} \cdot \exp(0.025 \cdot RH+f_{Al})+0.0018 \cdot S_d^{0.60} \cdot \exp(0.020 \cdot RH+0.094 \cdot T)$$

$$f_{Al}=0.009 \cdot (T-10) \ \ when\ T \leq 10°C;\ otherwise, -0.043 \cdot (T-10)$$

$$N = 113\,,\ \ R^2 = 0.65$$

Where:

r_{corr} corrosion rate (μm/yr)

T annual average of temperature (°C)

RH annual average of relative humidity (%)

P_d annual average of deposed $S0_2$ [mg/(m^2·d)]

S_d annual average of deposed Cl [mg/(m^2·d)]

Table 8. Input parameters for ISO 9223 (1992) equations.

T (°C)	15.06
R H (%)	62.13
P_d [mg/(m^2*d)]	35
S_d [mg/(m^2*d)]	10

Table 9. Atmospheric corrosion rates result.

	Carbon steel	**Zinc**	**Copper**	**Aluminium**
First-year corrosion loss of structural metals (rcorr) (μm/y)	35.674	1.135	0.722	0.316

The **Table 10** on the next page, shows the categories of corrosion rates, accordance with previous results.

Table 10. Estimated corrosion rates according to ISO 9223 (2012).

Corrosivity category	Corrosion rates of metals r_{corr}				
	Unit	Carbon Steel	Zinc	Copper	Aluminium
C1	g/m²a) µm/a	$r_{corr} \le 10$ $r_{corr} \le 1.3$	$r_{corr} \le 0.7$ $r_{corr} \le 0.1$	$r_{corr} \le 0.9$ $r_{corr} \le 0.1$	negligible --
C2	g/m²a) µm/a	$10 < r_{corr} \le 200$ $1.3 < r_{corr} \le 25$	$0.7 < r_{corr} \le 5$ $0.1 < r_{corr} \le 0.7$	$0.9 < r_{corr} \le 5$ $0.1 < r_{corr} \le 0.6$	$r_{corr} \le 0.6$ --
C3	g/m²a) µm/a	$200 < r_{corr} \le 400$ **$25 < r_{corr} \le 50$**	$5 < r_{corr} \le 15$ **$0.7 < r_{corr} \le 2.1$**	$5 < r_{corr} \le 12$ **$0.6 < r_{corr} \le 1.3$**	$0.6 < r_{corr} \le 2$ --
C4	g/m²a) µm/a	$400 < r_{corr} \le 650$ $50 < r_{corr} \le 80$	$15 < r_{corr} \le 30$ $2.1< r_{corr} \le 4.2$	$12 < r_{corr} \le 25$ $1.3< r_{corr} \le 2.8$	**$2 < r_{corr} \le 5$** --
C5	g/m²a) µm/a	$650 < r_{corr} \le 1500$ $80 < r_{corr} \le 200$	$30 < r_{corr} \le 60$ $4.2 < r_{corr} \le 8.4$	$25 < r_{corr} \le 50$ $2.8 < r_{corr} \le 5.6$	$r_{corr} > 10$ --

According to the previous results and **Table 10** categories, the corrosivity rate of the study site is **C_3** for Carbon steel, Zinc and Copper, On the other hand, **the aluminium is classified as C_2** Environment description for this category can be consulted above.

3.2.1. *Atmospheric corrosion level according to ISO 9224 (2012)*

This standard specifies guiding values of corrosion attack for metals and alloys exposed for more than a year to natural outdoor atmospheres. It is intended to be used in conjunction with standard ISO 9223.

3.2.1.1. *Principle*

The corrosion rate of metals and mechanical alloys to natural outdoor atmospheres is not constant with exposure time. For most metals and alloys, it decreases with exposure time due to the accumulation of corrosion products on the exposed metal surface. Generally, it is observed that progress of the attack to metal and engineering alloys is linear when the total damage is represented again in the exposure time in logarithmic coordinates.

Total damage ratio, D, expressed as loss of mass per unit area or depth of penetration is as follows:

$$D = r_{corr} t^b$$

Where,

t time of exposure (years).

r_{corr} corrosion rate of first year.

b is the metal-environment-specific time exponent, usually less than 1.

This equation is normally used to determine corrosion rate for up to 20 years of exposure, although, in some cases where the exposure time is not that much greater than 20 years, its use is also justified.

3.2.1.2. *Corrosion prediction after long exposure*

This procedure should be used when data on the corrosion produced during the first year is available or can be estimated using ISO 9223.

To determinate which *b* values to use according to the metal, the standard proposes the following table:

Table 11. Values of the time exponent *b*.

Metal	B
Carbon steel	0.523
Zinc	0.813
Cooper	0.667
Aluminium	0.728

3.2.1.3. *Results*

According to the standard ISO 9224 and the environmental category obtained through ISO 9223, the results for this project would be as follows.

Table 12. Maximum corrosion per years of exposure (µm/a).

Metal:	**Carbon Steel**	**Zinc**	**Copper**	**Aluminium**
Category according to ISO 9223(2012):	**C3**	**C3**	**C3**	**C3**
Time of exposure to the environment	**Total damage ratio (D)**			
	$D_{CarbonSteel}$	**D_{zinc}**	**D_{copper}**	**$D_{Aluminium}$**
(year)	**(µm)**	**(µm)**	**(µm)**	**(µm)**
1	26,01	0,90	0,65	0,21
2	37,37	1,59	1,04	0,35
5	60,35	3,35	1,91	0,68
10	86,72	5,88	3,04	1,13
15	107,20	8,17	3,98	1,52
20	124,61	10,33	4,82	1,87
25	140,03	12,38	5,60	2,20
30	154,04	14,36	6,32	2,52

According to regulations, **Zinc atmospheric corrosion in 20 years would be 10.33 µm**

Table 13 in the next page shows the corrosion rate for zinc on different time periods.

Table 13. Zinc corrosion rate for different time periods

Coating life (years)	Coating thickness (µm)	Coating thickness (gr/m^2)
10	7.38	52.62
20	12.96	92.44
25	15.54	110.83
30	18.02	128.54

***NOTE**: The conversion of units between microns and gr / m^2 has been carried out theoretically, considering the zinc density of 7.133 g / cm3. It is important to confirm the coating thickness in gr / m2 with the manufacturer since it could vary depending on the type of galvanizing.

3.3. *General principles of design and corrosion resistance*

According to these principles and the prior established atmospheric corrosion category of the study site (**C_3**), the lifetime by coating type is presented in **Table 14**.

To carry out this section, **ISO 14713-1 (2009**) Standard has been followed.

This Standard reports guidelines and recommendation on the appropriate general design principles for zinc-coated elements to protect them from corrosion, and the level corrosion resistance that zinc coverage affords in iron and steel elements exposed to different environments.

The zinc coating application is an effective method to retard or prevent corrosion of steel.

To determine corrosivity categories for this standard, ISO 9223 is used as a reference, it has been determined above that this area is **C3 type.**

According to ISO 14713-1 (2009), the minimum thickness of the following galvanizing systems and the level of resistance obtained are recommended.

Table 14. Lifetime according to galvanization systems related to C_3 corrosivity category.

System	Standard	Minimum thickness µm	ISO 9223 category	
			C3	
			Life min./max. (years)	Durability
Hot-dip galvanization (HDG)	ISO 1461	85	40/>100	Very high
		140	67/>100	Very high
		200	95/>100	Very high
Hot-dip galvanized sheet	EN 10346	20	10/29	High
		42	20/60	Very high
Hot dip galvanized tube	EN 10240	55	26/79	Very high
Mechanical zinc plating	ISO 12683	8	4/11	Medium
		25	12/36	High
Sheradizing	EN 13811	15	7/21	Medium
		30	14/43	High
		45	21/65	High
Electrodeposited sheet	ISO 2081	5	2/7	Low
		25	12/36	High

Table 15 in the next page shows the comparison between typical zinc galvanizing systems and coating thicknesses against the degree of corrosion, in order to evaluate their resistance to the corrosion rate obtained through the ISO9223 (2012) and ISO9224 (2012) standards of 1.135 µm / year.

Table 15. Resistance to atmospheric corrosion rate in accordance with ISO 9223 and ISO 9224 standards in 20 years for different zinc coating systems

Coating system		Standard	Grade or coating thickness (µm)	Resistance to atmospheric corrosion rate in accordance with ISO 9223 and ISO 9224 standards in 20 years.
Hot galvanizing	Discontinuous Hot-dip galvanization (HDG)	ISO 1461	85	OK
			140	OK
			200	OK
	Continuous Hot-dip galvanized sheet	EN 10346	20	OK
			42	OK
Electroplating		ISO 2081	5	NO
			25	OK
Zinc powder coatings	Sherardization	EN 17668	10	NO
			15	NO
			30	OK
			45	OK
			60	OK
			75	OK
	Mechanical zinc plating	ISO 12683	8	NO
			25	OK
Electrolytic zinc plating	Discontinuous	UNE EN 12329	2 to 5	NO
	Continuous	PNE-Pr EN 10152	2.5 to 10	NO
Zinc paints	Thin	ISO 3549	10 to 20	NO
	Normal		40 to 80	OK
	Thick		60 to 120	OK

It is important to note that **surface galvanizing systems**, such as powdered zinc plating, zinc paints, or electrolytic zinc plating do not have an alloy with the base metal unlike hot-dip galvanizing, **so it is not recommended for the use of foundations.**

4. CONCLUSIONS AND RECOMMENDATIONS

Atmospheric corrosion assessment has been carried out within the project plot according to various standards: **ISO 9223 (1992)**; **ISO 9223 (2012)**; **ISO 9224 (2012)**; **ISO 14713-1**. These standards aim to categorize both the study site and the corrosion rates for Carbon steel, Zinc, Copper, Aluminium, accordingly with environmental input data.

The results from **ISO 9223 (1992)** and **ISO 9223 (2012)** standards indicate that the atmospheric corrosion category of the site is **C_3** category and is considered as medium corrosion level.

Assessment of maximum corrosion over a given years of exposure according to **ISO 9224**, and **ISO 9223** category result, indicate **for carbon steel a maximum corrosion of 170.92 µm in 20 years of exposure**, **and for zinc a maximum corrosion of 12.96 µm in the same period.**

According to ISO 9224 standard results, the **ISO 14713-1 (2009)** standard recommends **using a Hot-Dip or Sheradizing Zinc coating of minimum 30 µm thickness to obtain a High to Very High lifetime coating for a period of 20 years.** However, the powdered zinc plating is not recommended to use in PV projects due to method to install by ramming the piles could degrade the coating at installation moment.

The summary of the evaluation of atmospheric corrosion according to ISO 9223 and ISO 9224 standards for time periods of 20, 25 and 30 years are shown in **Table 16** below.

Table 16. Summary of corrosion assessment for different time periods

Standard or Method	Metal	1st year Corrosion rate (rcorr)(µm)	Micron loss per 20 years of atmospheric exposition (µm)	Micron loss per 25 years of atmospheric exposition (µm)	Micron loss per 30 years of atmospheric exposition (µm)
ISO 9223 (2012) and ISO9224 (2012)	Carbon Steel	35.67	170.92	192.08	211.30
ISO 9223 (2012) and ISO9224 (2012)	Copper	0.72	5.33	6.18	6.98
ISO 9223 (2012) and ISO9224 (2012)	Aluminium	0.32	2.80	3.29	3.76
ISO 9223 (2012) and ISO9224 (2012)	Zinc	1.13	12.96	15.54	18.02

The present atmospheric corrosion assessment was carried out based on bibliographic data representative of the site since direct measurements were not available. Due to the large number of variables that affect the degree and intensity of corrosion, some uncertainty is generated regarding the actual speed that corrosion will occur. For this reason, it is recommended the implementation of standards as ISO 9223 (1992) which allows obtaining corrosion rate intervals with conservative procedures.

Alternatively, it is recommended that in situ wire-on-bolt (CLIMAT) tests are carried out within the project site area to compare actual corrosion rates with those in this report.

Notwithstanding, it is the client's prerogative to choose which design rate is finally used for the coating of selected piles.

5. LIMITATIONS AND EXCEPTIONS

I. This Corrosion report has been prepared by GMS Internacional, SL for the exclusive use of Trina Solar and their design team for specific application to the proposed project.

II. The work on the project has been carried out in accordance with reasonable and acceptable engineering practices. No other warranty, either written or implied, is applicable to the present assessment report.

III. The interpretations and recommendations in this report are based solely on the information available at the time this report was prepared.

IV. In the event that the location or design of the structures is altered, the conclusions and recommendations presented herein should not be considered valid unless GMS Internacional, SL has been given the opportunity to review the changes.

V. It is strongly recommended that GMS Internacional, SL be provided with the opportunity for a general review of the final design and specifications in order that recommendations may be properly interpreted and implemented. If GMS Internacional, SL is not accorded the privilege of making this review, we can assume no responsibility for misinterpretation of our recommendations.

VI. Corrosivity analysis results may not be apparent until project construction due to the lack of direct measurements of atmospheric corrosivity at the site. It is suggested that GMS Internacional, SL be contracted to provide continuous soil engineering services and in turn to carry out on-site measurements based on international standards to able to more accurately assess the levels of atmospheric and / or soil corrosivity against different types of metals and coatings before, during or after the foundation construction phases of the work. This would be done with the purpose of observing the behavior of the recommendations and, failing that, suggesting design changes in case the corrosivity conditions differ from those anticipated before construction.

VII. The use of information contained in this report for bidding purposes should be done at the client's option and risk.

VIII. This report including its conclusions, recommendations and findings should be related to the terms and conditions and the scope of works agreed between the Consultant and the Client. Words PRELIMINARY or DRAFT written on any page throughout the report mean that the information contained therein shall NOT be considered for construction design.

IX. Any assessments made in this report are based on specialized literature. Any special conditions appertaining to the site which have not been revealed by literature may therefore have not been taken into account in the report. The assessment may be subject to amendment in the light of additional information becoming available. Any amendments shall be issued after the Client has accepted initial version.

X. Any recommendations and interpretations contained in this report represent the consultant's opinion only. This opinion has been arrived at in accordance with currently accepted industry practices at the time of reporting and based on current legislation in force at that time.

XI. GMS International does not accept any responsibility for the structural calculations of the stainless-steel pile, as well as the thickness and galvanizing method that the client decides to apply.

XII. Should further assessment on corrosion of studs be so required, additional soil samples shall be tested and full corrosivity tests performed. Where the data available from previous site investigation reports, as supplied by the Client, have been used, it has been assumed that the information is correct. No liability can be accepted by the Consultant for inaccuracies within the data supplied.

XIII. The copyright in this report and other plans and documents prepared by the Consultant is owned by him and no such report, plan or document may be reproduced, published, or adapted without his written consent. Complete copies of this report may, however, be made and distributed by the Client as an expedient in dealing with matters related to its commission.

XIV. This annex is prepared and written in the context of the proposals stated in the introduction to this report and should not be used in a differing context. Furthermore, new information, improved practices and legislation may necessitate an alteration to the report in whole or in part after its submission. Therefore, with any change in circumstances or after the expiry of one year from the date of the report, the report should be referred to the Consultant for re-assessment and, if necessary, re-appraisal.

XV. Whatever the materials and structures beyond survey limits (horizontal and vertical) may be, they may have not been taken into consideration for purposes of the corrosivity assessment.

6. ADDITIONAL BIBLIOGRAPHY

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TOPOGRAPHICAL SURVEY REPORT LA VENDIMIA PV SOLAR PROJECT, MAULE REGION, CHILE

Project ID: IG1827115b

Client: Trina Solar

Consultant: GMS International, SL

Document History

Edition	Date	Version	Revision Purpose	Written	Reviewed	Approved
1ª	27/09/2021	0	First version of the report	R. Morán	JP Singer	JP Singer

GENERAL TOPOGRAPHIC SURVEY REPORT LA VENDIMIA PV SOLAR PROJECT, MAULE REGION, CHILE

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September 27th, 2021

Trina Solar Holding

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Attn: Julie Baudry

Email: julie.baudry@trinasolar.com

Re: Topographic Report La Vendimia PV Project, Maule Region, Chile

GMS International, SL has completed the topographic survey report of the La Vendimia PV solar plant. These services were performed in accordance with the scope of work agreed with the client. This report presents the results of the topographical land survey which was conducted for the referenced project.

We greatly appreciate the opportunity to serve Trina Solar on this project. Please do not hesitate to contact us if you have any questions regarding this report.

GMS International, SL

Document		
Fieldwork	**Created and Revised**	**Approved**
Surveying field team	**Project Manager**	**Managing Director**
Edgardo Manuel Godoy Querelle	Ramón Morán	Juan P Singer Col. 4625

CONTENT

Figure

Table

1. INTRODUCTION

GMS Internacional, SL (from now on the consultant) has been appointed by Trina Solar (from now on the client) to carry out a Topographic survey on La Vendimia PV project.

This document includes a technical report showing main activities details as carried out to obtain a general topographic survey with aerophotogrammetric support on La Vendimia PV Project.

The solar PV Project area is approximately 25.3 Ha in size, and it is located in Cauquenes commune, Maule Region of Chile.

Linked to the IGM National Geodetic Network through differential GPS measurements (static mode) and to an orthometric dimension to give heights linked to the EGM 96 gravitational model.

The field works were carried out over the period from August 30th to September 05 th, 2021, with GPS Instruments, Phantom 4 Professional Drone and Post-Processing Software CGO 2.0. **Figure 1** Shows the instrumentals used for topographic survey.

GPS Antenna

Phantom 4 Professional Drone

Post-Processing Software CGO 2.0

Figure 1: Instrumental working methods

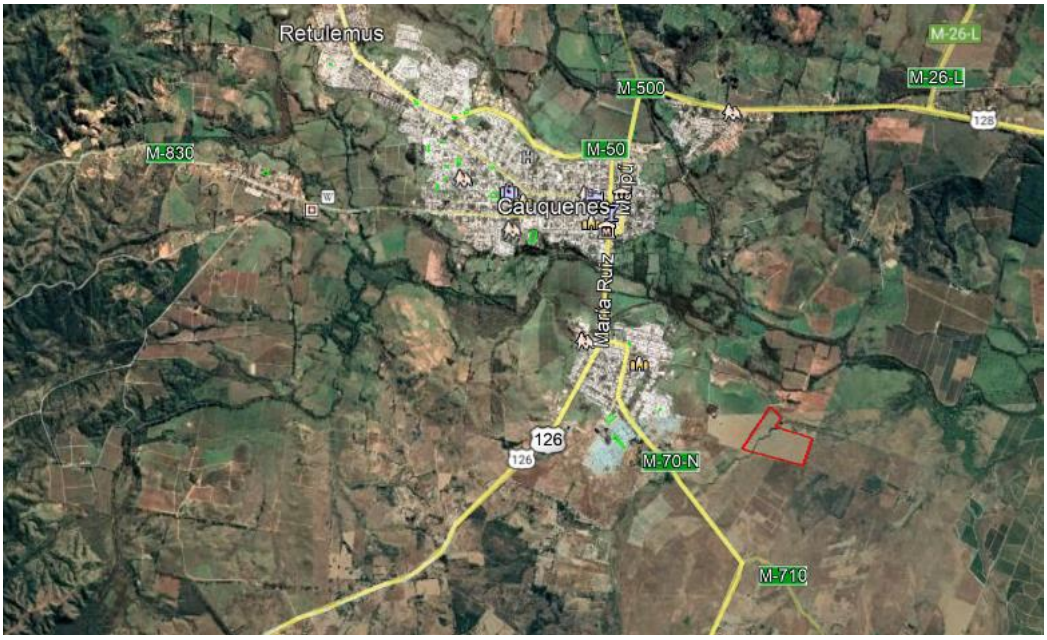

Figure 2: Site location of La VendimiaPV Project

2. GPS MEASUREMENTS AND MONOLITHS

Four PRs (concrete cairns) were built, then differential GPS measurements were taken by means of static mode to obtain the control points coordinates linked to the IGM National Geodesic Network. Based on the Active Station of Bienes Nacionales de Chillán.

IGM. INSTITUTO GEOGRÁFICO MILITAR

CERTIFICADO DE COORDENADAS GEOGRÁFICAS
PLANAS Y ALTURA

22 de abril de 2019
O/T Nº 1-2018

Solicitadas por: MINISTERIO DE BIENES NACIONALES

Datum: SIRGAS
Elipsoide : GRS-80
Unidad : N, E y Altura en metros

Nombre Estación	Coordenadas Geográficas Latitud	Longitud	Coordenadas Planas Norte	Este	Altura Elipsoidal	Zona
BIENES NACIONALES CHILLÁN (BN16)	36° 36' 30,7106"	72° 5' 42,0328"	5944623.208	756826.114	146,657	18

NOTAS: Los valores de coordenadas están referidos a la época 2013.0

EJERCITO DE CHILE INSTITUTO GEOGRÁFICO MILITAR

... PARADA PICHUANTE
Ingeniero Geomensor
Departamento Geodésico

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Figure 3: IGM Point Certificate

Once measurements were obtained, the post-processing was carried out using CGO 2.0 software, to obtain the coordinates of these points, taking as a basis that of the Active Station of Bienes Nacionales de Chillán. Results are shown in **Table 1** on the next page:

POINT	SIRGAS 2013		GEOGRAPHICAL WGS84		ELLIPSOIDAL HEIGHT
	NORTH	EAST	LATITUDE	LONGITUDE	
V-1	6013944.471	743847.053	35°59´18.56260"S	72°17´42.47334"W	158.271
V-2	6013787.669	743696.439	35°59’23.78186”S	72°17’48.30822”W	159.510
V-3	6013566.161	743526.109	35°59’31.11658”S	72°17’54.85832”W	155.008
V-4	6013725.830	744074.900	35°59’25.44601”S	72°17’33.14151”W	152.233

Table 1: Coordinates and heights table of concrete cairns.

Figure 4: V-1 concrete cairn view and location

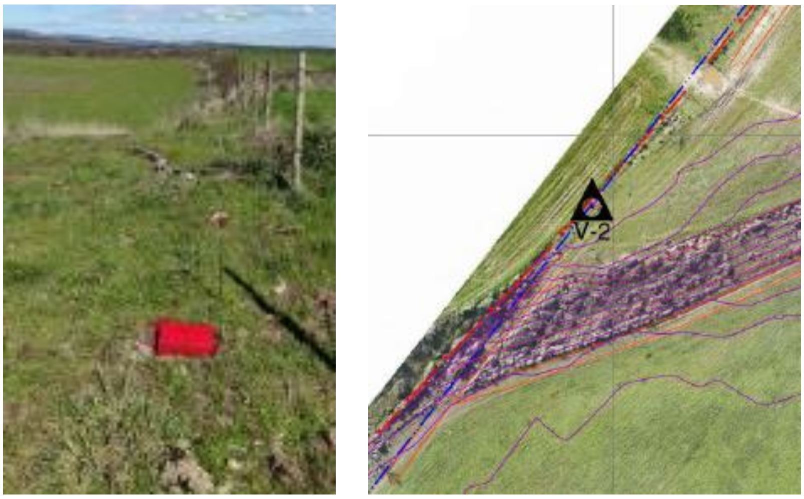

Figure 5: V-2 concrete cairn view and location

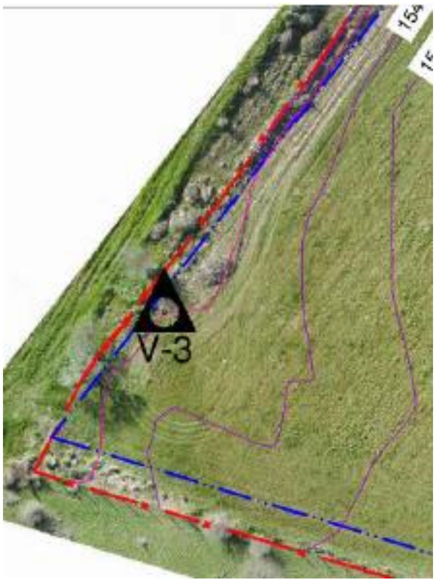

Figure 6: V-3 concrete cairn view and location

Figure 7: V-4 concrete cairn view and location

As a precaution, a PR with a Hilti nail was also installed in the sector of the channel, called PRA1, because the ground is very unstable and there is evidence of tractors passing.

POINT	SIRGAS 2013		ELLIPSOIDAL HEIGHT
	NORTH	EAST	
PRA1	6013774.718	744255.203	154.257

Table 2: Coordinates and height table of PRA1.

3. AEROPHOTOGRAMMETRY

The aerophotogrammetry was carried out using a Phantom 4 Professional Drone, to obtain the high resolution orthophoto, where 14 control points were installed, which were measured with GPS RTK.

Finally, measurements using Total Station and GPS were made of the entire terrain with its details, measuring channels, roads, fill points and all relevant details.

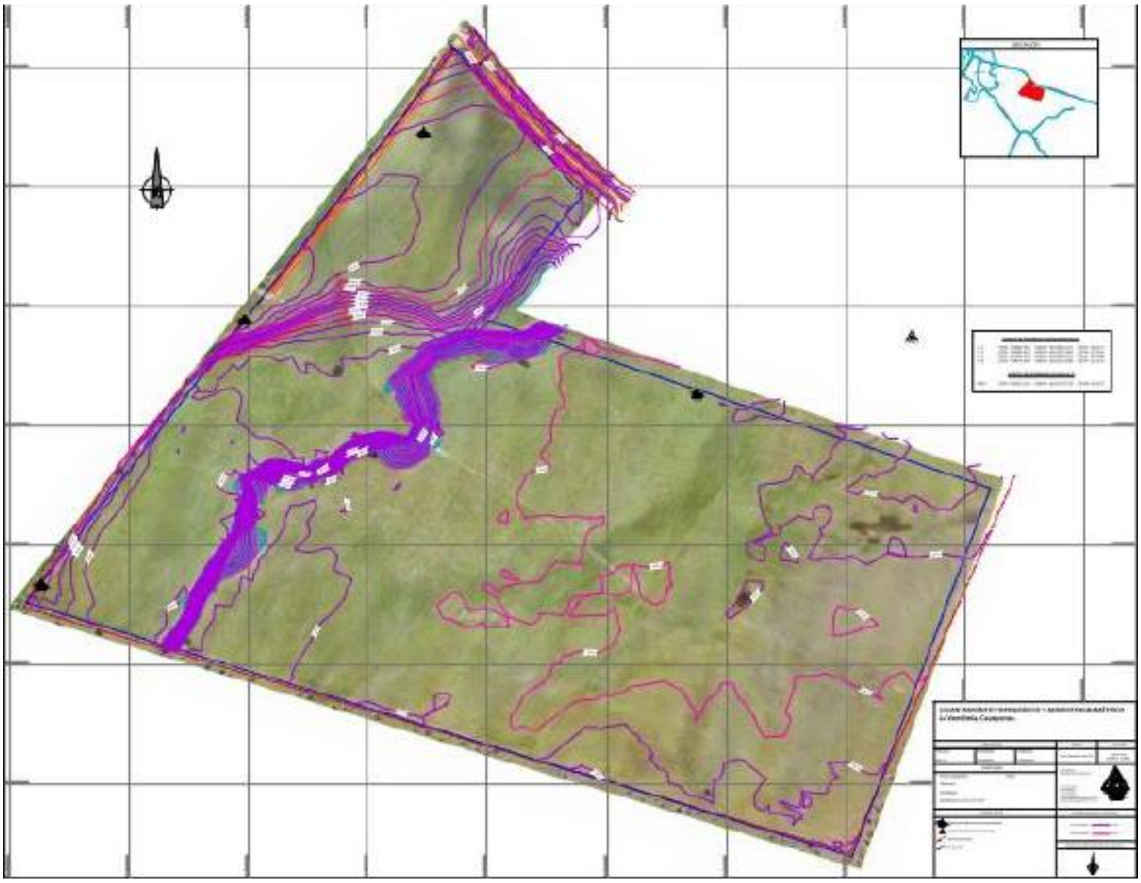

Figure 8: Topographic plan with orthophoto

4. RESULTS

In addition to this report, the following files will be delivered:

- Post-Process files.
- GPS certificates.
- Rinex files.
- KMZ file.
- Points Sheet.
- Plans in dwg and pdf.
- Ortophoto.
- IGM Certificate, Bienes Nacionales de Chillán antenna.

5. LA VENDIMIA LAND PHOTOS








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