BRYPAAL SOLAR POWER (PV) PROJECT NOVEMBER 2017

Soil Specialist Report

Remainder of Portion 4 of the

farm Brypaal No. 134

Prepared for:

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TITLE AND APPROVAL PAGE

Project Name	EIA for the proposed development of a 100 MW PV Solar Facility on the farm Brypaal, Northern Cape Province.
Report Title	Soil Specialist Report
DEA Reference	14/12/16/3/3/2/1019
Report Status	Final

Client	Vintage Energy Pty Ltd
Client Representative	Mr. Jan Du Preez

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Authorisation	Name	Signature	Date
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Dear Ms Faul

EIA for the proposed PV Solar Plant Facility: Kakamas, Northern Cape, South Africa – Soil Specialist Report

I have reviewed your report and find it to be a well written and thorough work and well suited for the purpose of a specialist report to inform an Environmental Impact Assessment.

The purpose of a Soil Specialist Report is to provide the right information in the best way to inform the EIA: from predicting through assessing and evaluating the potential significance of impacts, to recommending management actions (including mitigation, enhancement) and monitoring programmes and reporting.

I am of the opinion that you have met the above-mentioned criteria and will contribute to the thorough assessment of impacts related to the development.

Kind Regards,

P.W. van Deventer [Pr.Sci.Nat.[2]: 400075/08]

Declaration of Consultant's Independence

I Cindy Faul, as the appointed independent specialist hereby declare that I:

- Acted as the independent specialist in this application;
- Regard the information contained in this report as it relates to my specialist input/study to be true and correct;
- Do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the NEMA, the Environmental Impact Assessment Regulations, 2010 and any specific environmental management Act;
- Have disclosed any information that have or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the NEMA, the Environmental Impact Assessment Regulations, 2010 and any specific environmental management Act;
- Am fully aware of the NEMA, the Environmental Impact Assessment Regulations, 2010 and any specific environmental management Act;
- Have provided the competent authority with access to all information at my disposal regarding the application;
- Am aware that a false declaration is an offence in terms of regulation 71 of GN No. R. 543.

Cindy Faul (Hons. Environmental Sciences at NWU)
30 November 2017

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1 Executive summary

Vintage Energy Pty Ltd has appointed Boscia Environmental Solutions as an Independent Environmental Consultant to undertake the Environmental process for the proposed (Photovoltaic) Solar Energy Facility, on remainder of Portion 4 of the farm Brypaal No.134, located approximately 60 km south south-west of Kakamas in the Kai !Garib Local Municipality in the Northern Cape of South Africa. The proposed development area is 320 ha. The soil survey will be conducted on the entire segment of Portion 4 of the farm Brypaal No. 134 situated south-east of the Kenhardt-Loeriesfontein road (Road No. 2972) (total of 1032 ha).

According to the EIA Regulations published in terms of Section 24 (5) of the National Environmental Management Act (NEMA, Act No. 107 of 1998), authorization from the National Department of Environmental Affairs (DEA) is required before development can proceed. For the development of this Solar Energy Facility a soil survey is required to describe the soil characteristics of the site and provide an assessment of the likely impacts associated with the development. Impacts are assessed for the preconstruction, construction and operation phases. In order to reduce the likely impact of the development, a variety of avoidance and mitigation measures associated with the identified impacts are recommended. These recommendations should also be included in the EMPr for the development.

This report discusses the approach, findings and conclusion of a Soil Specialist Report carried out for the proposed development area. The main aim of this investigation is to assess the likelihood of soil and agricultural sensitive areas in the study area, in an effort to identify issues regarding erosion potential, soil stability and dust generation that may arise from the proposed development which should be mitigated accordingly.

The purpose of the Soil Specialist Report is to describe the area that may be affected by the proposed activity, describe the manner in which the environment may be affected by the proposed facility and provide a detailed description of the mitigation measures. With the updated layout assessed, no part of the development would occupy areas that are highly sensitive to erosion or areas of agricultural significance.

Mitigation measures would be necessary to control negative spin of effects associated with the development. Water scarcity is a problem on the site and resources need to be protected. The area is dominated by sandy soils with isolated areas dominated by loamy sandy soils. In the north-western segment of the study area soils tend to be relatively shallow (< 1m) with abundant outcrops, whereas the south-eastern segment is dominated by deeper calcareous soils (< 1.5m).

No environmentally fatal flaws are associated with the associated with the proposed layout and the specialist's opinion is that the development may be authorised.

2 General Information

2.1 Applicant

Vintage Energy Pty Ltd has appointed Boscia Environmental Solutions as an Independent Environmental Consultant to undertake the Environmental process for the proposed (Photovoltaic) Solar Energy Facility, on remainder of Portion 4 of the farm Brypaal No.134, located approximately 60 km south south-west of Kakamas in the Kai !Garib Local Municipality in the Northern Cape of South Africa.

2.2 Development Aspects

The proposed Solar Facility will have a peak power generating capacity of approximately 100 MW, and will consist of the following:

- Module Mounting structures 2 tier;
- String Inverters – 60 KVA;
- PV Modules – 250 WP;
- Meteor stations;
- Power reducer Boxes;
- Power Plant Controllers;
- Cluster Controllers;
- LV Substations;
- MV Substations;
- Access roads (temporary & permanent roads);
- Permanent office/workshop building.

A temporary laydown area was identified [workshops, mobile offices, mobile ablution facilities, material storage area, vehicle parking area, water tanks for drinking, construction and dust suppression) fencing, etc.]. The main activities during the construction phase area:

- Permanent living quarters for operational phase workers (only for residential staff). The rest of the staff will stay in Kakamas;
- Equipment (Trucks & front-end loaders, excavators, cranes, etc.);
- Topsoil/Overburden stockpiles/fill material. Topsoil stripping and stockpiling will be required only for the service roads and sub-station foundations. No concrete slabs or foundations are required for the screw-in pylons;
- Opencast quarries/excavations for cut and fill material. Very limited for roads and sub-station only, the rest of the construction site will follow a non-destructive-surface-topography approach because no foundations are required for the screw-in pylons;

- Water storage facilities (reservoir, tanks, etc.) mainly for construction phase;
- Water Desalination plant (pipelines towards water storage and power plant). Very small, just for standby water supply. The rest of the operational water will be transported from Kakamas or extracted from boreholes. Limited water is required for the washing of the PV-panels because nano-technology will be applied to the surface of the panels, which keeps it virtually clean for very long periods of time and washing of the panels will be required only once a year or even longer intervals;
- Waste handling facilities (for construction & operational phase). Solid, hydrocarbon and liquid waste to be sorted on site and keep in certified appropriate containers and to be removed to certified land fill sites.
- Surface run-off control systems. A non-destructive surface topography will be followed during the construction phase, drainage systems will be avoided, therefore surface runoff structures for instance trenches, canals, etc. will not be implemented and no large scale desalination plants and evaporation ponds will be constructed because of low water requirements for operational phase.
- A 400kV high voltage overhead grid connection of approximately 500 m between the substation at the solar facility and the Aries – Kokerboom 400 KV line.

Total footprint of the 100 MW PV solar farm will be approximately 320 ha. The terms of the land owner agreement for this project provides allowance for a 36 month construction period and foresees the use as a PV Solar facility for up to 25 years. During this period, it is anticipated that the PV modules may be replaced, however the primary plant and electrical infrastructure would be suitable for this intended project life.

2.3 Location

The proposed location is on remainder of Portion 4 of the farm Brypaal No.134, approximately 60 km south south-west of Kakamas in the Kai !Garib Local Municipality in the Northern Cape of South Africa.

2.4 Scope of Report

The following activities are included in the scope of the study:

- A description of the affected area as well as the degree to which the proposed project may affect the environment;
- A description and evaluation of the identified environmental concerns as well as potential impacts;
- A statement based on the evaluation of the concerns/impacts regarding the potential significance of these concerns/impacts;
- A description of the methodology used during this study;

- The identification and classification of the soils according to the South African Classification System (Soil Classification Working Group, 1991);
- Constructing a soil map by using a combination of pedogenic knowledge and predictive mapping techniques;
- Determining the agricultural potential of mapping units based on interpretations of the soil potential, climate, and current land use;
- An evaluation of the significance of direct, indirect, and cumulative impacts in terms of the following criteria:
    - The **nature** of the impact, cause of impact, what will be affected and how it will be affected.
    - The **extent** of the impact (local, regional, national, or international). A value between 1 and 5 must be assigned as appropriate, with 1 being low and 5 being high.
    - Impact **duration**
        - Very short-term (0-1 years) with a score of 1;
        - Short-term (2-5 years) with a score of 2;
        - Medium-term (5-15 years) with a score of 3;
        - Long-term (>15 years) with a score of 4;
        - Permanent, with a score of 5.
    - **Probability**
        - Very improbable (probably will not happen = 1);
        - Improbable (some possibility, but low likelihood = 2);
        - Probable (distinct possibility = 3);
        - Highly probable (most likely = 4);
        - Definite (impact will occur regardless of any prevention measures = 5).
    - **Magnitude** scale
        - Small magnitude with no effect on the environment = 0;
        - Minor magnitude and will not result in an impact on processes = 2;
        - Low magnitude and will cause a slight impact on processes = 4;
        - Moderate magnitude and will result in processes continuing but in a modified way = 6;
        - High magnitude and therefore processes are altered to the extent that they must be ceased temporary = 8;
        - Very high magnitude with complete destruction of patterns and permanent cessation of processes = 10.
    - The **status** can be described as either positive, negative or neutral.
    - The **significance** can be described as **LOW**, **MEDIUM,** or **HIGH**, and are calculated through:

$$S=(E+D+M)P$$

Where:

S = Significance weighting

E = Extent

D = Duration

M = Magnitude

P = Probability

S = <30	LOW	The impact would not have a direct influence on the decision to develop in the area.
S = 30-60	MEDIUM	The impact could influence the decision to develop in the area unless it is effectively mitigated.
S = >60	HIGH	The impact must have an influence on the decision process to develop in the area.

  - The reversibility of the impact.
  - Possibility of irreplaceable loss of resources.
  - The degree of impact mitigation.
- Recommendation regarding practical mitigation measures for potentially significant impacts.

2.5 Legislation

In terms of Subdivision of Agricultural Land Act (Act 70 of 1970), any application for change of land use must be approved by the Minister of Agriculture. Under the Conservation of Agricultural Resources Act (Act 43 of 1983) no degradation of natural land is permitted.

The handling of topsoil, according to the South African Environmental Legislation, is as follows:

- **Conservation of Agricultural Resources Act (Act 43 of 1983)**
  No degradation of the agricultural potential of soil is permitted. The protection of land against soil erosion and the prevention of water logging and salinization of soils by means of suitable soil conservation works to be constructed and maintained.

- **Bill of Rights**
  Environmental rights exist primarily to ensure good health and well-being, and secondarily to protect the environment through reasonable legislation, ensuring the prevention of the degradation of resources.

- **National Environmental Management Act (No. 107 of 1998)**
  This Act prescribes the precautionary principle, the “polluter pays” principle, and the preventive principle. The individual/group responsible for the degradation/pollution of natural resources is required to rehabilitate the polluted source.

- **National Environmental Management Act (No. 107 of 1998), the Environmental Conservation Act (No. 73 of 1989), the Mineral and Petroleum Resources Development Act (No. 28 of 2002) and the Conservation of Agricultural Resources Act (No. 43 of 1983).**
  Protect soils and land capability.

- **National Veld and Forest Fire Bill (of 10 July 1998) and the Fertiliser, Farm Feeds, Agricultural Remedies, and Stock Remedies Act (No. 36 of 1947)**
  To be applicable in some cases.

- **Sub-division of Agricultural Land (SALA) Act (Act 70 of 1970)**
  For the long-term lease, or consensual use of the properties near the project, approval in terms of SALA is required.

3 Introduction

Vintage Energy Pty Ltd has appointed Boscia Environmental Solutions as an Independent Environmental Consultant to undertake the Environmental process for the proposed (Photovoltaic) Solar Energy Facility, on remainder of Portion 4 of the farm Brypaal No.134, located approximately 60 km south south-west of Kakamas in the Kai !Garib Local Municipality in the Northern Cape of South Africa. The proposed development area is 320 ha. The soil survey will be conducted on the entire segment of Portion 4 of the farm Brypaal No. 134, situated south-east of the Kenhardt-Loeriesfontein road (Road No. 2972) (total of 1032 ha).

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It is important to determine the possible impact of development on the soils and agricultural potential, as well as identifying areas of high sensitivity regarding the position of solar panels and associated infrastructure.

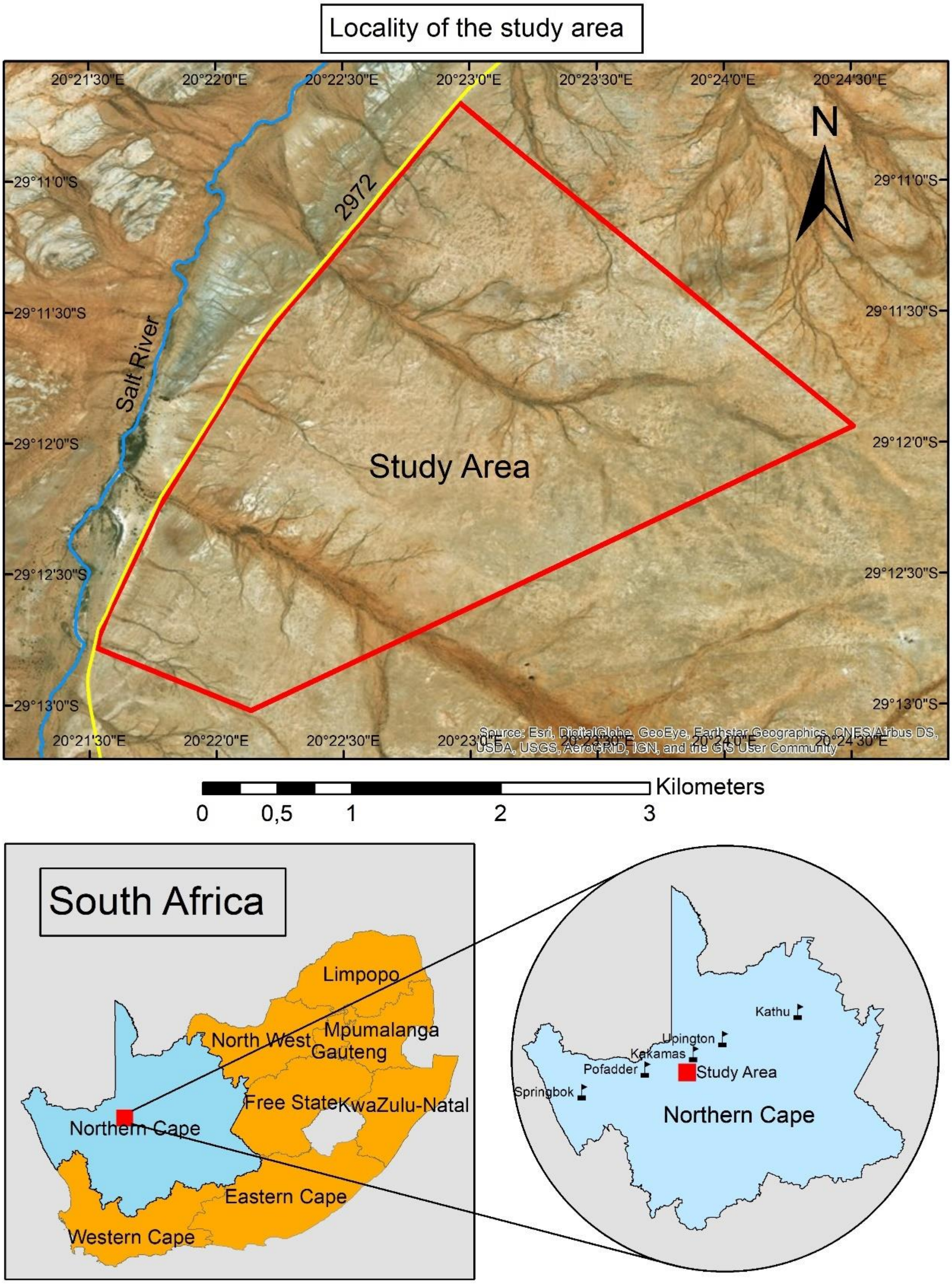


Figure 1: Locality map of the study area (Red line: The boundaries of the area where the soil survey was conducted) (Google Earth, 2016).

These aims will be accomplished with:

- o The identification of soil forms and soil depth (according to the South African taxonomic system);
- o The estimation of soil potential;
- o The discussion of the agricultural potential in terms of soil, water availability and status of land; and
- o The discussion of the potential and actual impact that development will have.

In order to determine the agricultural potential, both soil characteristics and climatic conditions need to be investigated. An important characteristic to consider is rainfall, as it provides an adequate baseline for the viable production of crops and yield of vegetation which form part of the assessment of agricultural potential.

4 Methodology

Prior to the site visit Google Earth (2016) was used to divide the area into characteristic mapping units (Figure 2) according to the principles of parametric terrain evaluation as described in Mitchell (1977). A total of ten mapping units (referred to as mapping unit A – J) were identified based on corresponding characteristics visible on satellite imagery. Each mapping unit consists of various sub-units depending on locality. A minimum of five representative sub-units per mapping unit were identified (except for mapping unit A, F and I). Mapping unit A and I consist of two sub-units each, while only two sub-units from mapping unit F falls within the boundaries of the study area. Therefore, two sub-units were identified for mapping unit A, I and F respectively.

Soil description and classification took place from 8 July 2016 until 1 August 2016. The site was visited again in March 2017 where additional observations were made. Within each representative mapping unit (Figure 3) a soil auger was used to drill holes up to a maximum depth in order to make soil description and classification possible.

The morphological, chemical and physical properties (at field level) of each soil horizon were described according to the guidelines set out by the Agricultural Research Council (Land Type Survey Staff, 1991). (Consult Figure A-1 in Annexure A for explanation of soil description categories, and Figure A-2 in Annexure A to view the standard soil description form). The Binomial System (MacVicar *et al.*, 1977) was used for soil classification, because the original land type surveys were conducted with this system. A re-classification was done using the Taxonomic System (Soil Classification Working Group, 1991) in order to interpret and re-classify the soil data with respect to soil families. Soil was classified according to a hierarchical system incorporating classification categories. The classification categories used in this study for the purpose of soil descriptions include Soil Order, Soil Group, Soil Form and Soil Family.

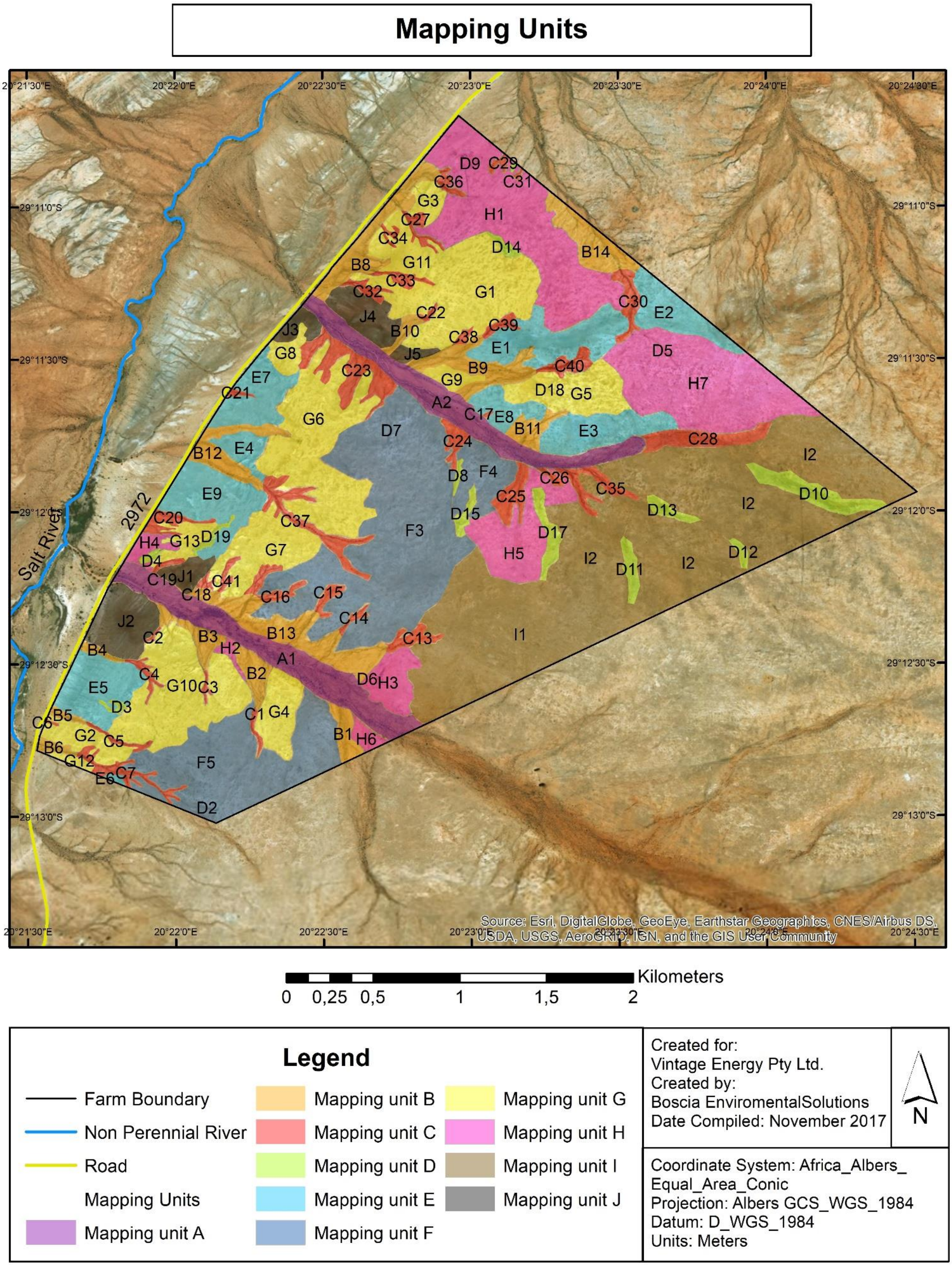


Figure 2: Map of the different mapping units and sub-units identified for the study area (Google Earth, 2016).

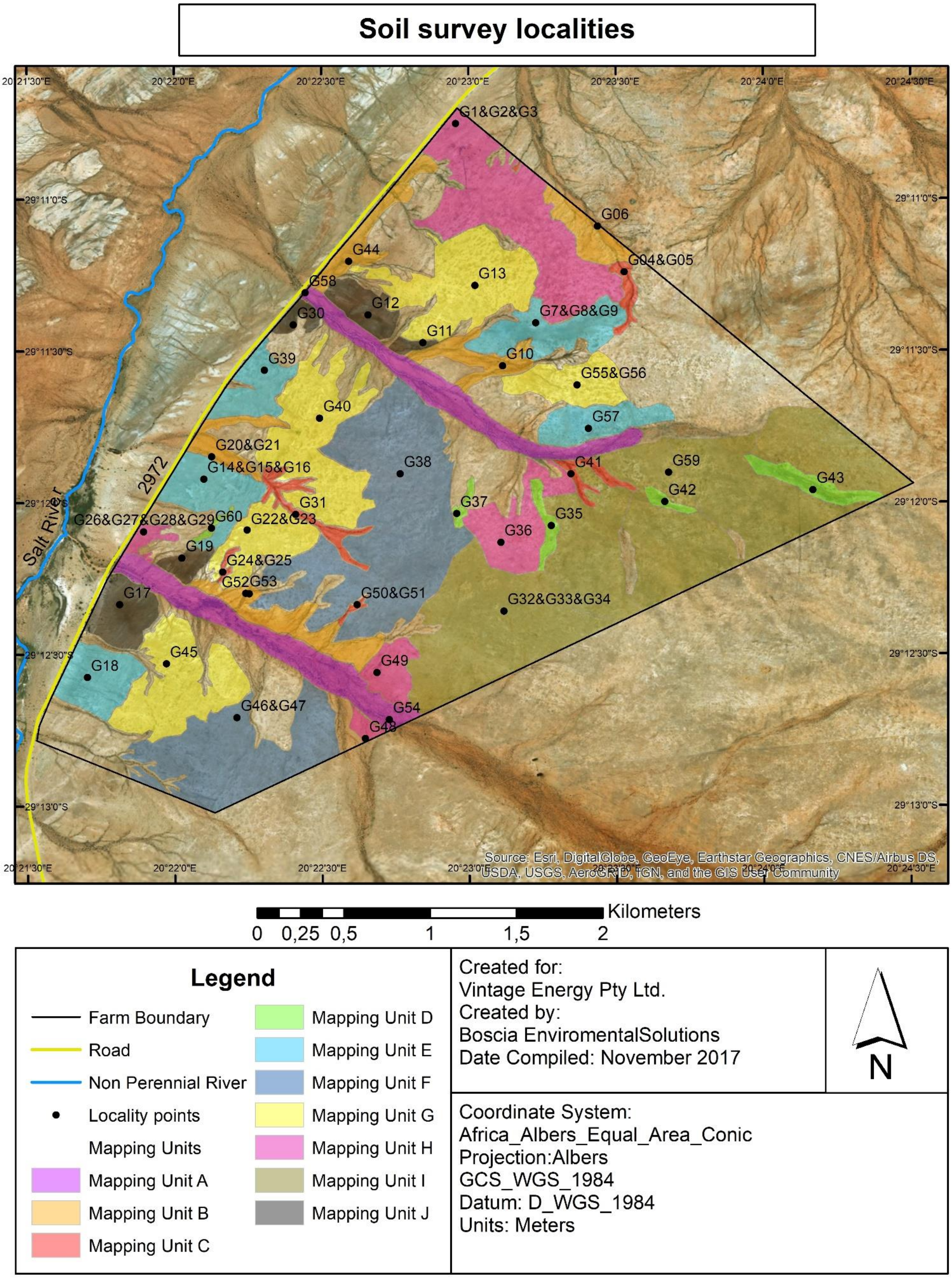


Figure 3: Map indicating the soil survey localities in accordance with the associated mapping units (Google Earth, 2016).

The sample collection localities correspond to the localities where soil descriptions and classifications were conducted (Figure 3). At each locality one sample was collected for every soil horizon. A total of 60 soil samples were collected (samples marked G1 – G60). In order to determine the dispersion and erosion potential of the study area, additional descriptive information was obtained from the geotechnical soil survey (46 samples) (Figure 4).

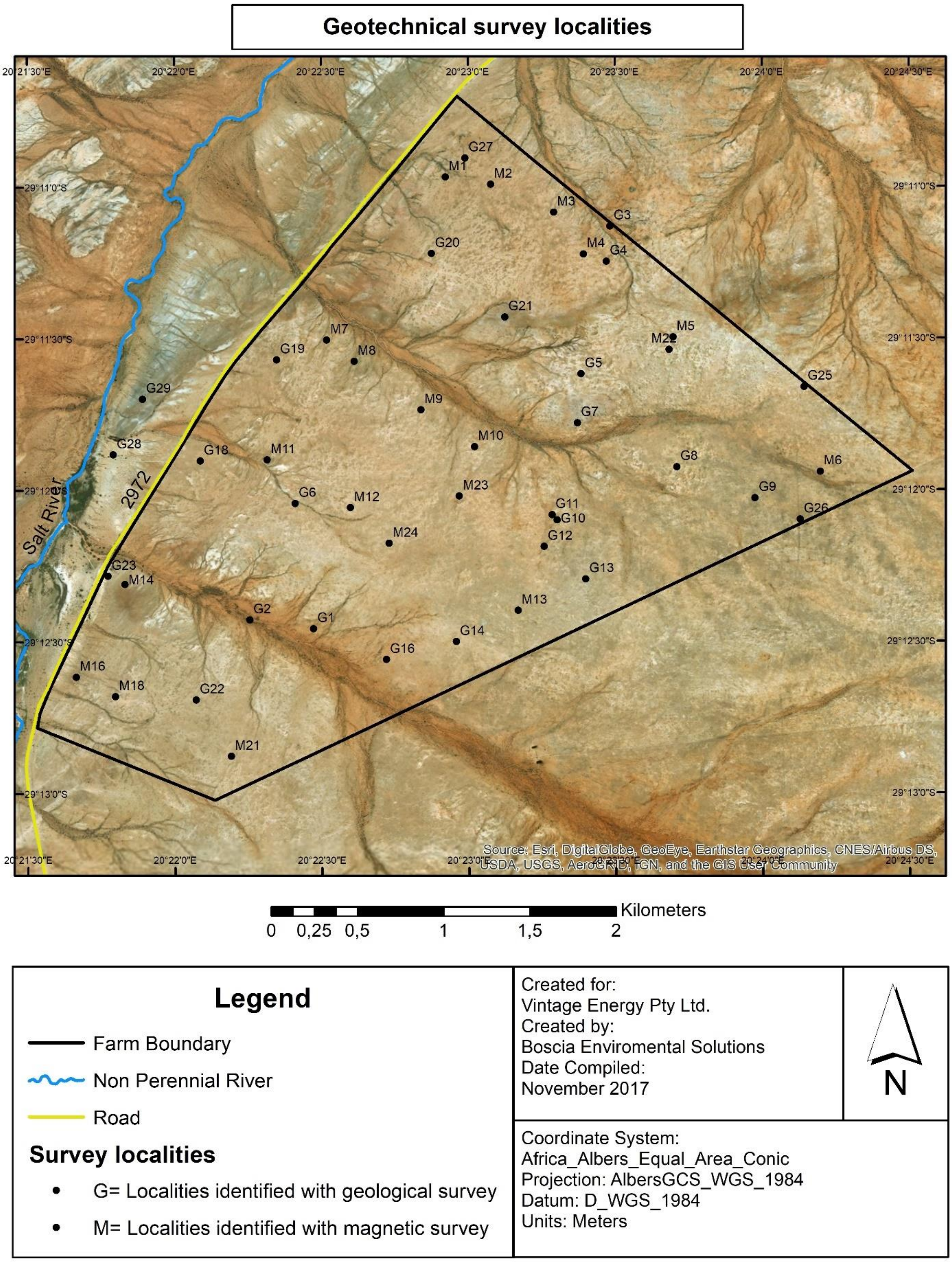


Figure 4: Map indicating the geotechnical survey localities (Google Earth, 2016).

5 Description of the affected environment

5.1 Climate and Rainfall

As illustrated in Figure 5, the study area forms part of the semi-arid Bushmanland region and falls within the very late summer rainfall region (Schulze, 1997). According to meteorological statistics from the South African Weather Services (Weather Bureau, 2016) (Figure 6 – Figure 9) the average annual rainfall for this area, from 1992 up to 2015, was between 140 mm and 250 mm per annum.

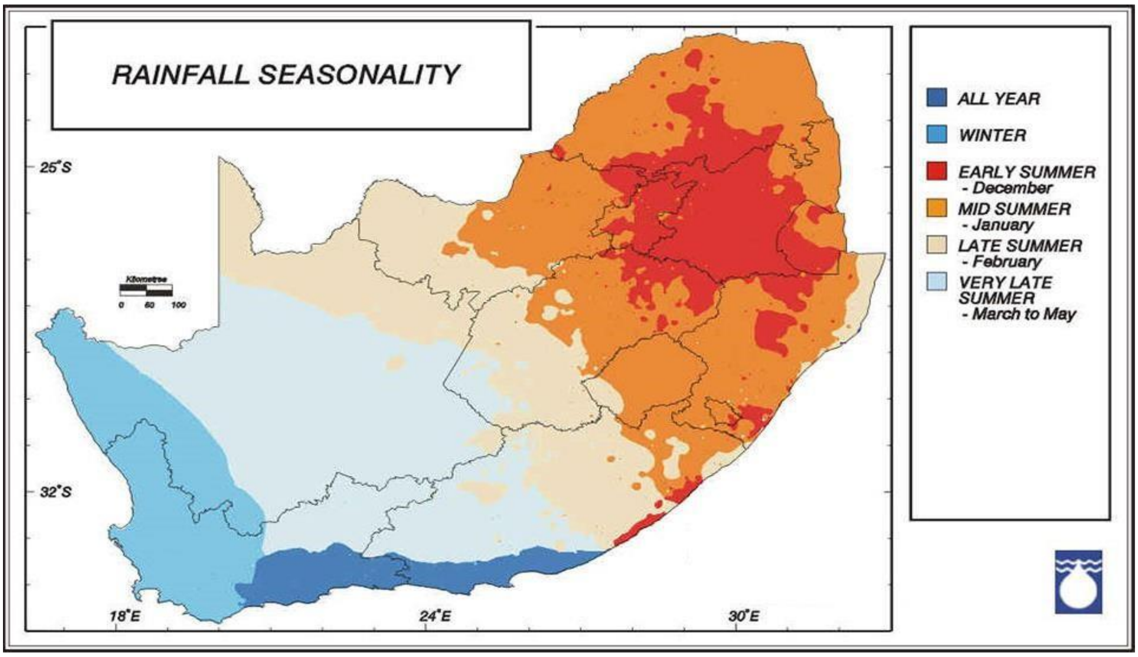


Figure 5: Map indicating the rainfall seasonality in South Africa (Schulze, 1997).

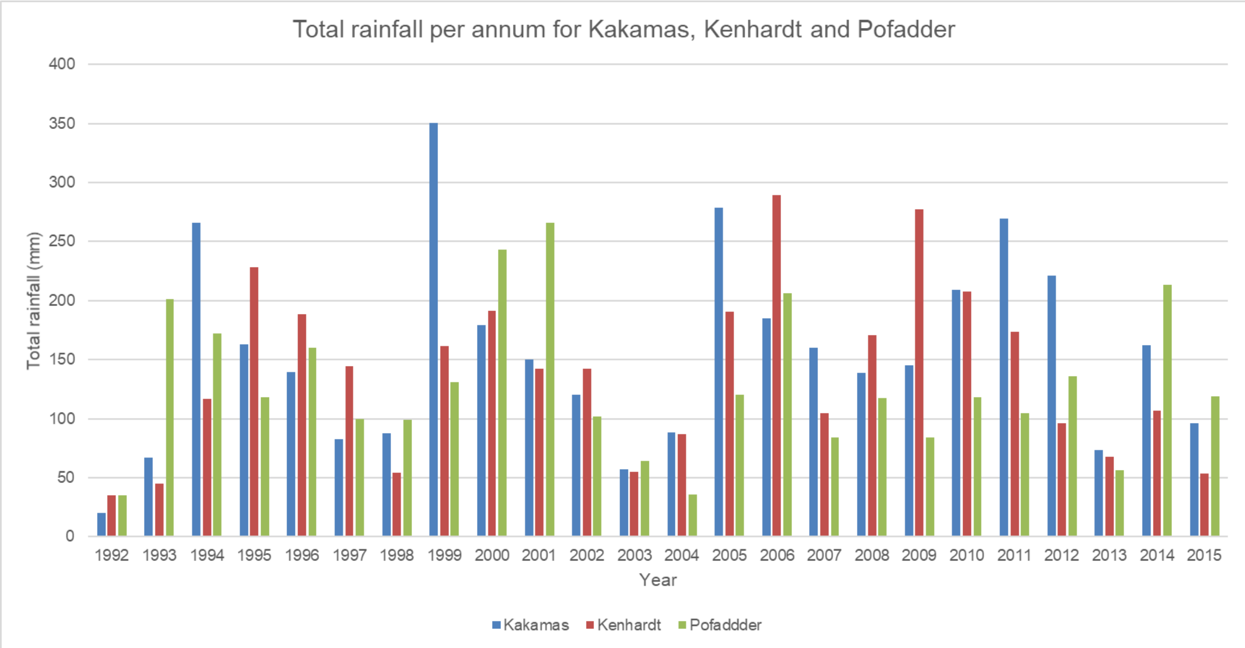


Figure 6: Total rainfall per annum for Kakamas, Kenhardt and Pofadder respectively (Weather Bureau, 2016).

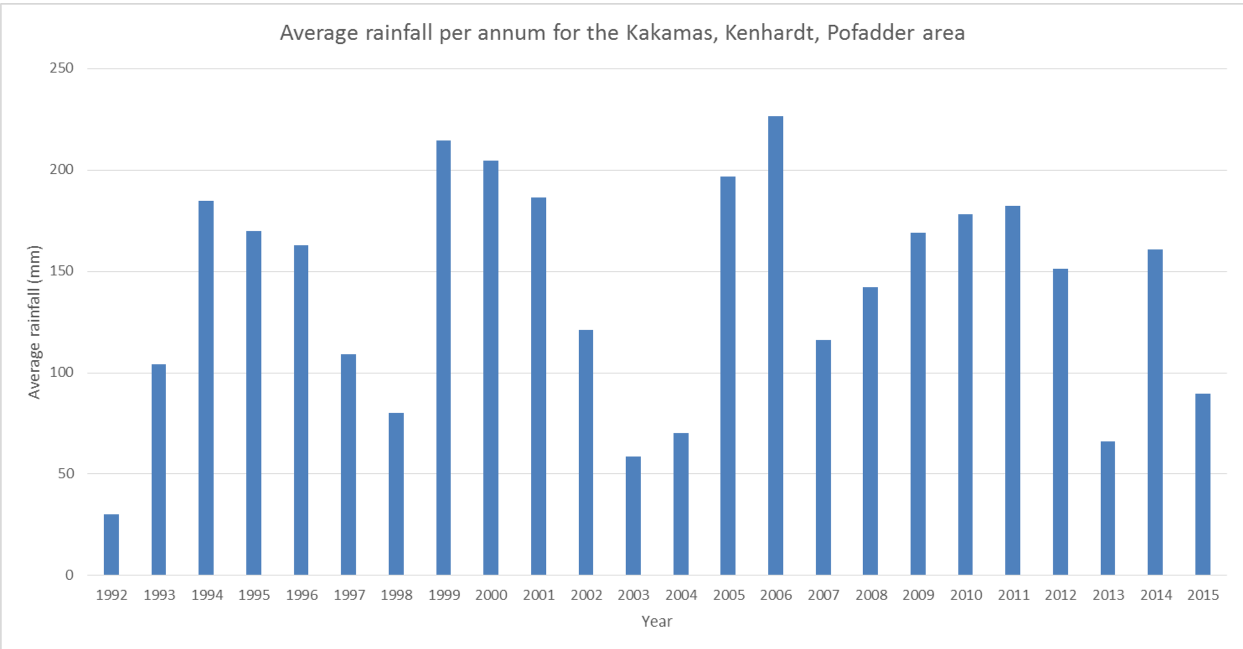


Figure 7: Average rainfall per annum for the Kakamas, Kenhardt and Pofadder area (Weather Bureau, 2016).

Figure 6 and Figure 7 revealed that severe drought conditions were experienced during 1992, 2003, 2004 and 2013. The variation in average temperatures within this area is extreme with maximum temperatures during the summer reaching up to 40.8 °C and minimum temperatures as low as -3 °C. Figure 8 illustrates the daily maximum temperatures (°C) for the Pofadder area while the daily minimum temperatures (°C) (measured at 8 am in the morning) for the same area are illustrated in Figure 9.

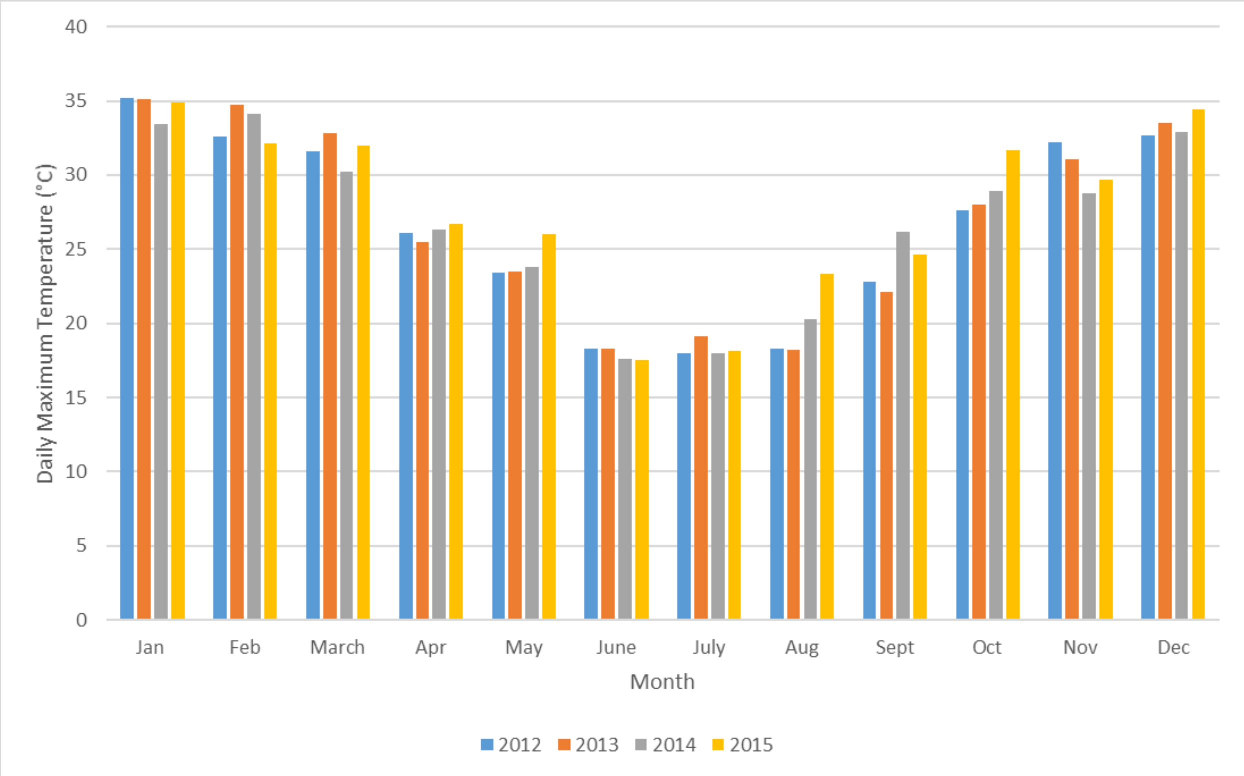


Figure 8: The daily maximum temperatures (°C) for the Pofadder area (Weather Bureau, 2016).

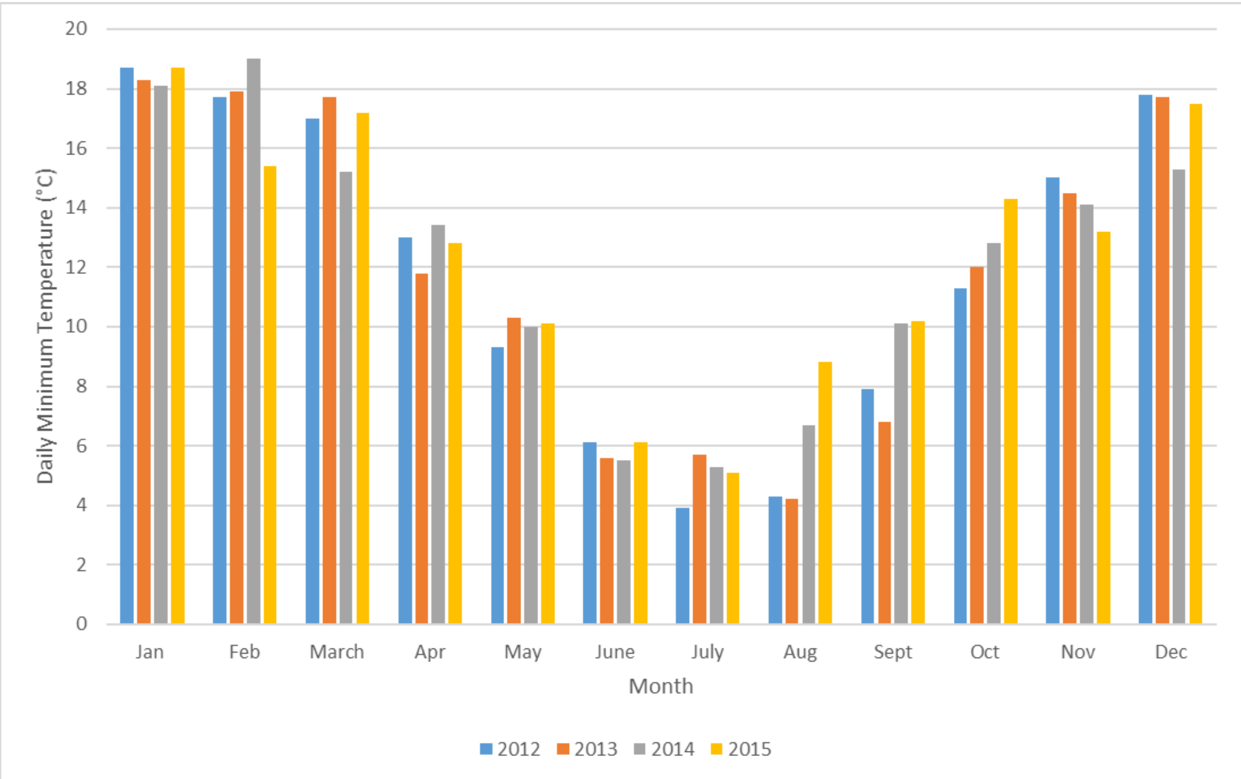


Figure 9: The daily minimum temperatures (°C) for the Pofadder area (Weather Bureau, 2016).

Daily maximum temperatures (Figure 8) range from an average of 35 °C (January) to 17 °C (June) with daily minimum temperatures (Figure 9) ranging from an average of 19 °C (February) to 4 °C (July). According to Mucina and Rutherford (2006) this site forms part of an area with a mean annual evaporation potential of 2771 mm per annum, experiencing between 21 and 30 mean frost days per annum.

5.2 Topography

The overall topography of the site is relatively homogenous and ranges from 857 m to 880 m above mean sea level with the highest part of the landscape to the south-east and the lowest part to the north-west (Figure 10).

The area with the lowest elevation (north-west) lies south-east of the Salt River which is situated north-west of the study area. The Salt River flows to the north-east into the Hartbees River which eventually connects to the Gariep River.

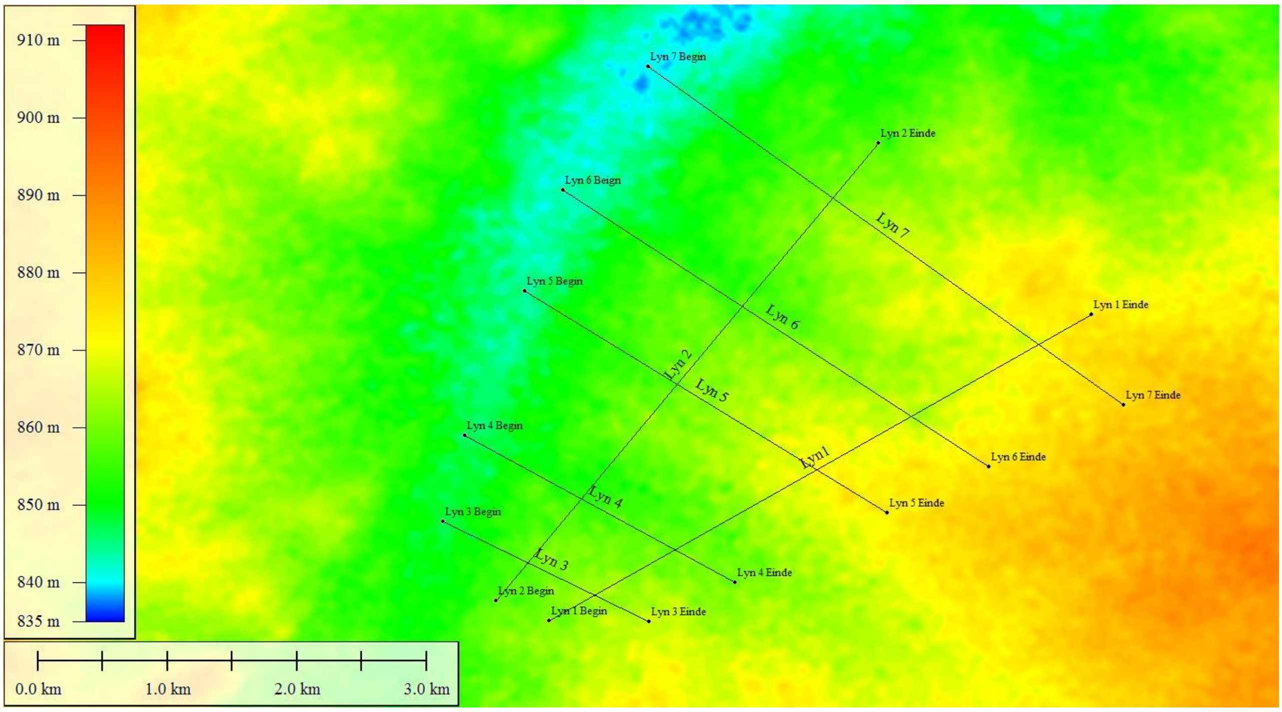


Figure 10: General elevation (above mean sea level) of the study area.

5.3 Geology

Table 1: Lithostratigraphic column of the study area (Bailie *et al.*, 2007; Colliston *et al.*, 2008; Cornell *et al.*, 2009; Cornell *et al.*, 2006; Eglington, 2006; McClung, 2006; Reid *et al.*, 1997; Von M Harmse & Hatting, 2012; Watts, 1980).

Ma	Group	Subgroup	Formation	Intrusive Rocks	Lithological Description	Epoch	Period	Era	Eon	Ma
0 - 0.01	Kalahari Group				Kalahari calcrete, sandy material of mixed origin, lag deposit and gypsic deposits	Holocene	Quaternary	Cenozoic	Phanerozoic	0 – 0.01
0.01 – 1.6					Kalahari calcrete, sandy material of mixed origin, and lag deposit	Pleistocene				0.01 – 1.6
1.6 – 5.0					Kalahari calcrete (soft, hard bank, nodular, tabular)	Pliocene	Tertiary			1.6 – 5.0
~ 1130	Bushmanland Group	Kouboom Subgroup	Vaalkop Formation		Biotite-gneisses.			Mokolian	Proterozoic	900 - 2050
			Driekop Formation		Metagreywacke comprised of grey quartzite.					
			Geelvloer Formation		Biotite-schist hosting calc-silicate and carbonate rich rocks. Emplacement of pegmatites.					
			Broken Hill Quartzite Formation		Typical purplish-red to dark grey glassy quartzite and metaquartzite.					
~1640		Wortel Subgroup	Namies Schist Formation		Calc-silicate gneiss, biotite-rich schist, quartzite and metaquartzite.					
~ 1650				Hoogoor Suite	Pink gneiss					
1700-2050				Achab Gneiss	Migmatitic leucogneiss					

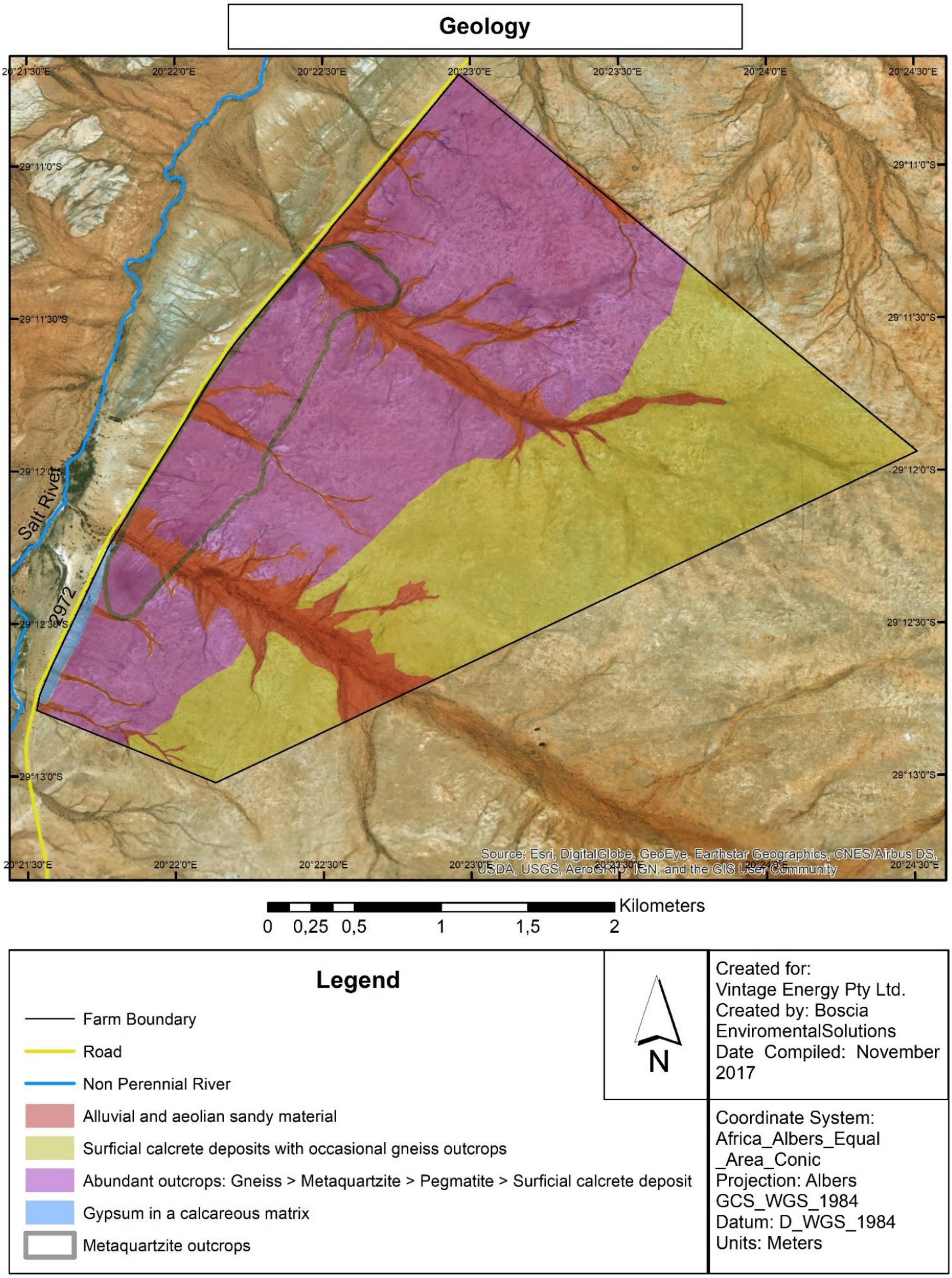


Figure 11: Geology map of the study area (Google Earth, 2016).

The north-western segment of the study area consists of granitoids with the following order of abundancy: Gneiss > metaquartzite > pegmatite > surficial calcrete deposits. Surficial calcrete deposits with occasional gneiss outcrops dominate the south-eastern segment of the study area. The drainage systems consist of alluvial and aeolian sandy material. Gypsic deposits, coexisting with a calcareous mixture, occur in closed proximity to the north-western boundary of the study area.

5.4 Hydrology and geohydrology

The study area is situated within the Lower Orange Management Area, Quaternary Drainage Area D53H. North-east of the site lies the non-perennial Salt River, with drainage lines running off in a north-eastern direction towards the Hartbees River. Due to the gradual decline in altitude (Figure 10), this area contains seasonal and ephemeral drainage lines. Based on vegetation, no wetland conditions occur along the drainage lines on site. There are also no pans on site. In the northern corner of the site there is a small earth dam which cannot be considered as a pan system. Different factors including domestic stock farming with sheep, dirt track crossings and weirs all affect the watercourses of the Salt River. However due to the low rainfall and seasonal nature of the river, there will be no significant impact on the river.

5.5 Existing Land Use

This area is predominantly used for livestock farming. The infrastructure present within the boundaries of the study area is limited to a feeding and water trough, border fences and a gravel pit. There is also a small earth dam (not considered as a pan system) in the northern corner of the site. Parallel to the north-western border of the site (located outside the study area) is the Loeriesfontein-Kakamas road.

5.6 Vegetation

The area under investigation (semi-arid Bushmanland region) forms part of the Nama Karoo Biome (Bezuidenhout, 2009). Based on the classification of Mucina and Rutherford (2006), it was concluded that the study area comprises mainly the Bushmanland Arid Grassland, the Bushmanland Sandy Grassland and the Bushmanland Basin Shrubland. The Bushmanland Arid Grassland is characterised by irregular plains dominated by *Stipagrostis* species. In some regions the vegetation structure is altered by low shrubs of *Salsola species.* The Bushmanland Sandy Grassland is characterised by sandy grassland plains dominated by *Stipagrostis* and *Schmidtia* species. There is also a common occurrence of drought-resistant shrubs, and after rainfall the display of ephemeral spring flora including *Grielum humifusum* and *Gazania lichtensteinii.* The Bushmanland Basin Shrubland is characterised by irregular plains dominated by shrubs including *Rhigozum, Salsola,* *Pentzia* and *Eriocephalus* as well as different *Stipagrostis* grass species. After rainfall *Gazania* and *Leysera* species may also be present (Mucina & Rutherford, 2006).

The vegetation differences on this site reflects the substrate conditions including soil depth, texture, and geology. The areas with coarse material (for instance the deep, sandy soils in the drainage systems) are dominated by shrubby vegetation, while the areas with fine material or abundant geological outcrops (for instance the calcic soils) are dominated by grasses.

The north-western part of the study area consists of abundant outcrops with the following order of abundancy: Gneiss > metaquartzite > pegmatite > surficial calcrete deposits. This area has a large proportion of grasses (to a lesser extent than the south-eastern parts), combined with shrubs and rocky outcrops with no vegetation. The south-eastern part of the study area consists of surficial calcrete deposits with occasional gneiss outcrops, and a dominating grassland. The drainage systems consist of alluvial and aeolian sandy material and are dominated by shrubs.

5.7 Critical Biodiversity Area

For this study area no Critical Biodiversity Areas have been defined and no fine-scale conservation planning has been done. This area does not fall within a National Protected Areas Expansion Strategy Focus Area (NPAES), and therefore is **not** characterised:

- With exceptional biodiversity;
- As significant for the maintenance of ecological processes; or
- As significant to climate change buffering.

According to Mucina and Rutherford (2006) the Bushmanland Arid Grassland, Bushmanland Sandy Grassland as well as the Bushmanland Basin Shrubland are considered as least threatened. According to the Department of Environmental Affairs, there are no proposed renewable energy facilities in the immediate surrounding area. The renewable energy project closest to the proposed Brypaal PV Project, is situated near Kenhardt. Figure 12 illustrates the map, generated by the Department of Environmental Affairs, indicating all registered renewable energy projects.

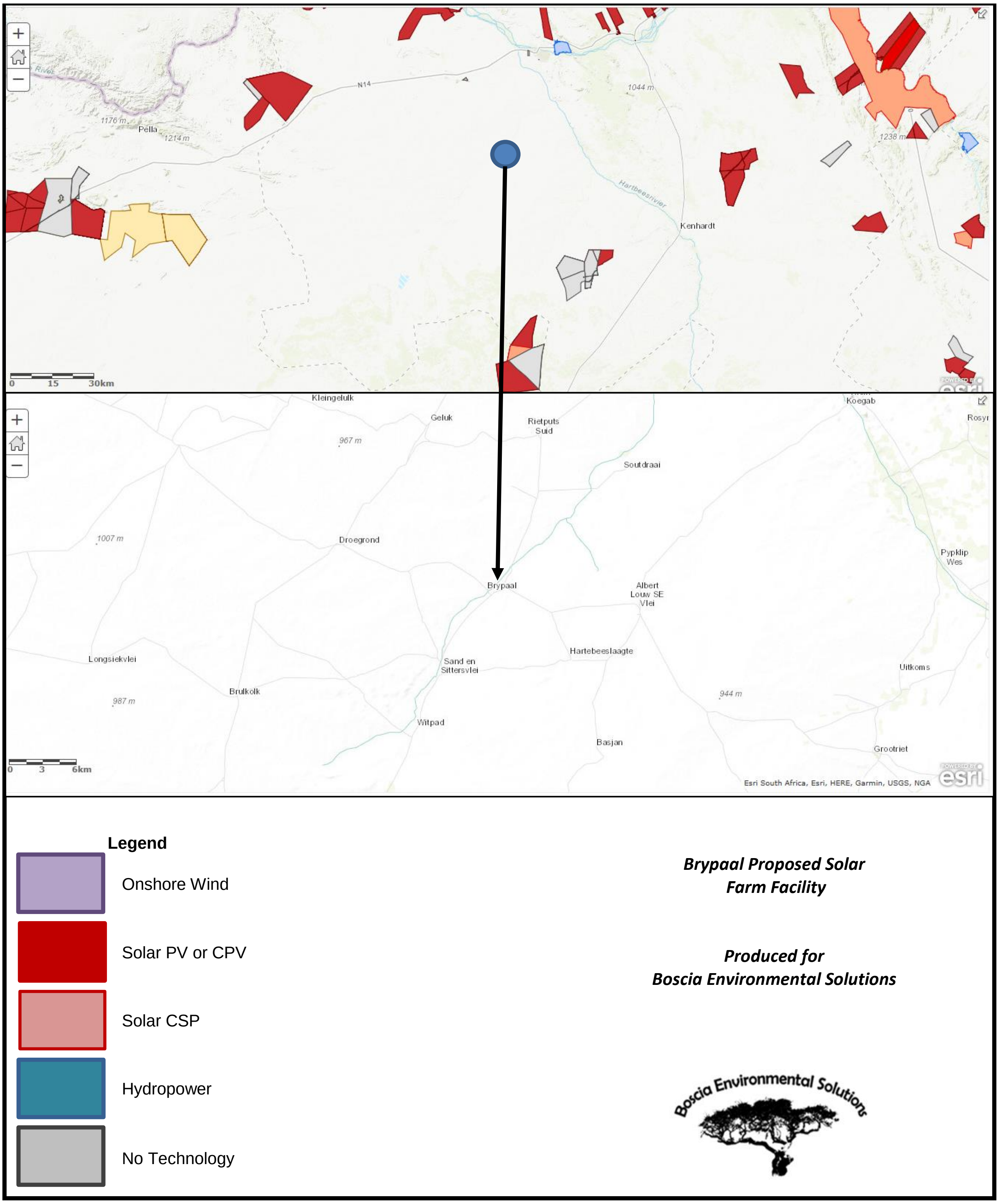


Figure 12: Map of DEA-registered renewable energy projects as seen on 30 November 2017.

6 Results

6.1 Land Type Data

Soil:

A predictive soil mapping approach was followed due to low soil variability and restrictive climatic conditions relating to agricultural potential. Note that since the information obtained from the land type survey is of a reconnaissance nature, only the general dominance of the soils in the landscape can be provided and not the actual area of occurrence within a specific land type. Land type data was obtained from the Agricultural Research Council (Land Type Survey Staff, 2003) and entails the division of land into land types, typical terrain cross sections and dominant soil types for each terrain unit (consult Annexure A Figure A-3 for more information). A land type can be defined as an area with similar climate, topography and soil distribution patterns.

One land type (Ag3) dominates the entire study area. According to the Land Type Survey Staff (2003), 40% of land type Ag3 consists of freely drained, shallow (< 300 mm deep), red, eutrophic, apedal soils with yellow-brown soils comprising less than 10% of this land type. The average depth of all soils is 280.5 mm. Approximately 77% of land type Ag3 consist of soils with a depth of ≤ 300 mm (depth class D1), whereas 12.5% consist of soil with a depth of 901 mm to 1200 mm (depth class D4). The average topsoil clay percentage of land type Ag3 is 10.7%. Around 88.5% of land type Ag3 consist of loamy sand soils (clay class C2) with an average clay percentage of 6.1% to 15% in the topsoil, whilst 1% consist of sandy loam soils (clay class C3) with an average clay percentage of 15.1% to 25% in the topsoil (Land Type Survey Staff, 2003).

The soils of land type Ag3 can be divided into three soil classes. Table 2 illustrates the different soil classes, description of soil classes, soil forms and percentage occupancy of each soil class within land type Ag3.

Table 2: Description of soil classes within land type Ag3 (Land Type Survey Staff, 2003).

Soil Classes	Description	Soil Form	Percentage occupancy
S2	Freely drained, structureless soils.	*Hutton, Clovelly, Griffen, Shortlands, Oakleaf.*	58,3%
S13	Lithic soil (shallow soils on hard weathering rocks).	*Mispah, Glenrosa.*	31,2%
S16	Non-soil land classes	*Pans, rivers, stream beds, erosion structures, marshes, reclaimed land, dunes, gravel, etc.*	0,5%

Approximately 58.3% of land type Ag3 consists of freely drained, structureless soils, whereas 31.2% consist of characteristic lithic soils. A small part (0.5%) of land type Ag3 is occupied by structures like pans, rivers, stream beds, erosion structures, marshes, reclaimed land, dunes and gravel.

Land capability and land use:

Mainly extensive grazing due to climatic constraints. Irrigation land uses are limited due to lack of large volumes of water.

Agricultural potential:

The Agricultural potential is low due to shallow soils, poor water holding capacity and low and erratic rainfall. Dryland crop production is not viable in areas with rainfall lower than 450 mm unless significant groundwater is available (not the case for this specific survey site).

6.2 Site Visit, Soil Survey and Soil Analyses

All soil description data, as well as soil classification per mapping unit are illustrated in Figure 13.

Soil description data and field observations were utilised for soil classification purposes (Land Type Survey Staff, 1991; MacVicar *et al.*, 1977; Soil Classification Working Group, 1991). The classification system of the WRB Reference Soil Group (IUSS Working Group WRB, 2006) as well as that of USDA Soil Taxonomy (Soil Survey Staff, 1999) were used for further classification.

As illustrated in Figure 13 a total of ten soil forms and eleven soil families were identified accordingly. The identified soil forms include Dundee, Oakleaf, Augrabies, Knersvlakte, Oudtshoorn, Addo, Brandvlei, Coega, Etosha and Mispah.

Based on the observations and information obtained (Figure 13) a map was constructed illustrating all soil forms within the study area (Figure 14).

These soil forms were grouped into four individual soil groups known as silicic soils, calcic soils, cumulic soils and lithic soils (Fey, 2010; Brummer, 2015; Fanourakis, 1991; IUSS Working Group WRB, 2006; Schmidhuber, 2015; Von M Harmse & Hatting, 1985). Each soil group is discussed (Table 3 – Table 6) based on description, properties, morphology and genesis.

MAPPING UNIT A

Mapping Unit	Horizon	Texture class	Depth (mm)	Clay %	Sand grade	Dry colour	Moist colour	Mottles		Lime		Structure			Coarse fragments	
								OCC	COL	OCC	Type	GRA	Size	Type	Type	%
A1	A	co	0-600	0-15	co	2,5YR 6/8	2,5YR 5/8	N/A	N/A	N/A	N/A	A	c	SG	G	90
A2	A	co	0-800	0-15	co	2,5YR 6/8	2,5YR 5/8	N/A	N/A	N/A	N/A	A	c	SG	G	90

Mapping Unit	Parent material	Efficient Depth (mm)	Terrain Unit	Depth limiting material
A1	Transported material (Quartz)	600	5	Soil with low consistency.
A2	Transported material (Quartz)	200	5	Soil with low consistency.

Mapping Unit	Sample No.	Coordinates		Initial Weight (g)	Weight after (g)		
		Latitude	Longitude		Coarse (> 2 mm)	Fine (< 2 mm)	Total
A1	G54	29°12'42,9"S	20°22'43,7"E	2714	1166	1519	2685
A2	G58	29°11'18,5"S	20°22'26,7"E	1500	742	750	1492

Mapping Unit	Diagnostic Soil Horizon	Soil Form	Soil Family	WRB Reference Soil Group	USDA Soil Taxonomy
A1	Stratified alluvium	Dundee	Marico 2110	Fluvisols	Inceptisols – Fluventic variants
A2	Stratified alluvium	Dundee	Marico 2110	Fluvisols	Inceptisols – Fluventic variants

Mapping unit A1 – *Photograph taken by Faul C. (2017).*

Figure 13: Soil description and classification (Fey, 2010; IUSS Working Group WRB, 2006; Land Type Survey Staff, 1991; MacVicar *et al.*, 1977; Soil Classification Working Group, 1991; Soil Survey Staff, 1999).

MAPPING UNIT B

Mapping Unit	Horizon	Texture class	Depth (mm)	Clay %	Sand grade	Dry colour	Moist colour	Mottles		Lime		Structure			Coarse fragments	
								OCC	COL	OCC	Type	GRA	Size	Type	Type	%
B8	A	fi	0-400	0-15	fi	5YR 6/8	2,5YR 4/6	N/A	N/A	N/A	N/A	A	f	SG	G	20
B9	A	fi	0-400	0-15	fi	10R 5/8	10YR 5/6	N/A	N/A	s	P	A	f	SG	G	10
B12 – In riverbed	A	co	0-150	0-15	co	2,5YR 7/8	2,5YR 5/8	N/A	N/A	N/A	N/A	A	c	SG	G	20
B12 – On riverbank	A	fi	0-200	0-15	fi	2,5YR 6/8	2,5YR 5/10	N/A	N/A	N/A	N/A	A	f	SG	G	5
B13 – In riverbed	A	co	0-450	0-15	co	5YR 5/8	2,5YR 5/8	N/A	N/A	N/A	N/A	A	c	SG	G + S	80
B13 – On riverbank	A	co	0-420	0-15	co	2,5YR 5/8	5YR 5/8	N/A	N/A	N/A	N/A	A	c	SG	G + S	30
B14	A	co	0-600	0-15	co	5YR 5/8	10YR 5/6	c	Bl	N/A	N/A	A	m	SG	G	20

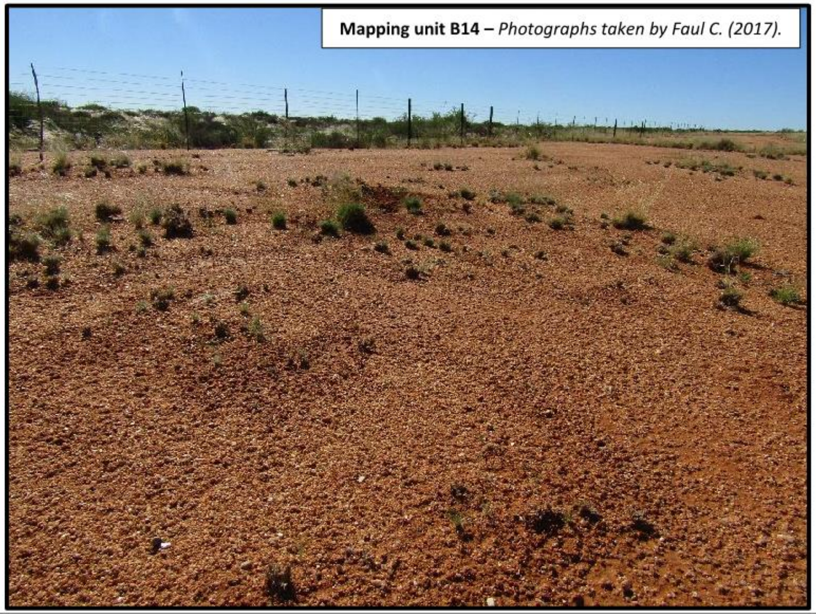
Mapping Unit	Parent material	Efficient Depth (mm)	Terrain Unit	Depth limiting material
B8	Quartz	200	4U	Quartz fragments
B9	Quartz	200	4L	Quartz fragments
B12 - In riverbed	Feldspar; Quartzite-schist	150	5	Calcrete; Feldspar and Quartzite-schist fragments
B12 - On riverbank	Feldspar; Quartzite-schist	200	4U	Calcrete; Feldspar and Quartzite-schist fragments
B13 - In riverbed	Quartz	350	5	Quartz outcrop
B13 - On riverbank	Quartz	300	5	Dorbank
B14	Quartz	50	4U	Dorbank

Mapping unit B14 – *Photographs taken by Faul C. (2017).*

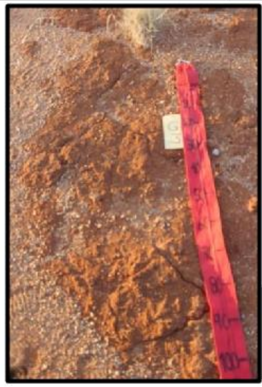
Figure 13 (continued):Soil descriptions and classifications (Fey, 2010; IUSS Working Group WRB, 2006; Land Type Survey Staff, 1991; MacVicar *et al.*, 1977; Soil Classification Working Group, 1991; Soil Survey Staff, 1999).

Mapping Unit	Sample No.	Coordinates		Initial Weight (g)	Weight after (g)		
		Latitude	Longitude		Coarse (> 2 mm)	Fine (< 2 mm)	Total
B8	G44	29°11'12,3"S	20°22'35,6"E	2434	572	1852	2424
B9	G10	29°11'33,0"S	20°23'06,9"E	2609	357	2230	2587
B12 - In riverbed	G20	29°11'50,9"S	20°22'07,6"E	3271	984	2240	3224
B12 - On riverbank	G21	29°11'50,9"S	20°22'07,6"E	2505	217	2280	2497
B13 - In riverbed	G53	29°12'17,9"S	20°22'14,5"E	1756	635	1106	1741
B13 - On riverbank	G52	29°12'18,0"S	20°22'15,2"E	2826	830	1456	2286
B14	G06	29°11'05,4"S	20°23'26,3"E	2110	591	1518	2109

Mapping Unit	Diagnostic Soil Horizon	Soil Form	Soil Family	WRB Reference Soil Group	USDA Soil Taxonomy
B8	Neocutanic	Oakleaf	Caledon 1210	Acrisols Lixisols Arenosols Cambisols	Inceptisols
B9	Neo-carbonate	Augrabies	Khubus 1210	Luvisols Lixisols Arenosols Cambisols	Aridisols Inceptisols
B12 – In riverbed	Stratified alluvium	Dundee	Marico 2110	Fluvisols	Inceptisols Fluviantic variants
B12 – On riverbank	Neocutanic	Oakleaf	Caledon 1210	Acrisols Lixisols Arenosols Cambisols	Inceptisols
B13 – In riverbed	Stratified alluvium	Dundee	Marico 2110	Fluvisols	Inceptisols Fluviantic variants
B13 – On riverbank	Stratified alluvium	Dundee	Marico 2110	Fluvisols	Inceptisols - Fluviantic variants
B14	Dorbank	Knersvlakte	Bitterfontein 1000	Durisols	Typic Haplodurids Entic Durixeralfs Haplic Durixeralfs



Mapping unit B14 – *Photographs taken by Faul C. (2017).*



Mapping unit B14 – *Photographs taken by Faul C. (2017).*

Figure 13 (continued):Soil descriptions and classifications (Fey, 2010; IUSS Working Group WRB, 2006; Land Type Survey Staff, 1991; MacVicar *et al.*, 1977; Soil Classification Working Group, 1991; Soil Survey Staff, 1999).

MAPPING UNIT C

Mapping Unit	Horizon	Texture class	Depth (mm)	Clay %	Sand grade	Dry colour	Moist colour	Mottles		Lime		Structure			Coarse fragments	
								OCC	COL	OCC	Type	GRA	Size	Type	Type	%
C14	A	me	0-400	0-15	me	5YR 6/8	5YR 5/8	N/A	N/A	N/A	N/A	A	m	SG	G	10
	B	me	400-600	0-15	me	7,5YR 7/4	10YR 6/8	N/A	N/A	a	P	A	m	SG	G	15
C30	A	co	0-200	0-15	co	2,5YR 5/8	2,5YR 4/8	N/A	N/A	N/A	N/A	A	c	MA	G	60
	B	co	200-590	0-15	co	5YR 4/6	10YR 5/6	N/A	N/A	N/A	N/A	M	c	CR	G+S	50
C35	A	me	0-170	0-15	me	5YR 5/8	2,5YR 4/8	N/A	N/A	N/A	N/A	A	m	SG	S	30
C37	A	co	0-200	0-15	co	2,5YR 6/8	2YR 5/8	N/A	N/A	N/A	N/A	W	c	SG	G + S	70
C41	A	me	0-300	0-15	me	7,5YR 6/6	5YR 5/8	N/A	N/A	N/A	N/A	A	f	SG	S + G	40
	B	me	300-400	0-15	me	7,5YR 7/6	5YR 68	N/A	N/A	a	P	A	f	SG	G	30

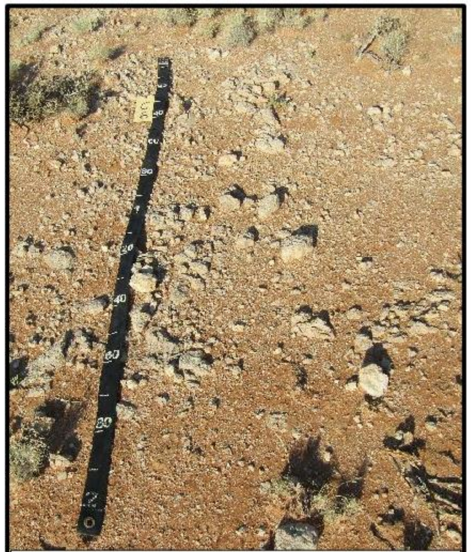
Mapping Unit	Parent material	Efficient Depth (mm)	Terrain Unit	Depth limiting material
C14	Calcrete; Feldspar; Quartz	250	4	Calcrete boulders
C30	Quartz; Feldspar	200	4	Dorbank
C35	Quartz; Feldspar	100	4	Quartz fragments
C37	Quartz; Feldspar	200	4	Quartz and calcrete boulders
C41	Calcrete; Feldspar; Quartz	200	4	Calcrete boulders

Mapping Unit	Sample No.	Coordinates		Initial Weight (g)	Weight after (g)		
		Latitude	Longitude		Coarse (> 2 mm)	Fine (< 2 mm)	Total
C14	G50	29°12'20,2"S	20°22'37,2"E	2430	395	2028	2423
	G51			1184	386	794	1180
C30	G4	29°11'14.46"S	20°23'31.74"E	2253	823	1427	2250
	G5			1353	756	591	1347
C35	G41	29°11'54,4"S	20°23'20,8"E	2616	410	2126	2536
C37	G31	29°12'02,3"S	20°22'24,7"E	3423	1137	2272	3409
C41	G24	29°12'13,7"S	20°22'09,8"E	2046	855	1193	2048
	G25			1027	499	529	1028

Figure 13 (continued):Soil descriptions and classifications (Fey, 2010; IUSS Working Group WRB, 2006; Land Type Survey Staff, 1991; MacVicar *et al.*, 1977; Soil Classification Working Group, 1991; Soil Survey Staff, 1999).

Mapping Unit	Diagnostic Soil Horizon	Soil Form	Soil Family	WRB Reference Soil Group	USDA Soil Taxonomy
C14	Orthic Neocutanic	Oakleaf	Caledon 1210	Acrisols Lixisols Arenosols Cambisols	Inceptisols
C30	Neocutanic Dorbank	Oudtshoorn	Doringbaai 1210	Durisols	Typic Petrocambids Cambidic Haplodurids
C35	Neocutanic	Oakleaf	Caledon 1210	Acrisols Lixisols Arenosols Cambisols	Inceptisols
C37	Neocutanic	Oakleaf	Caledon 1210	Acrisols Lixisols Arenosols Cambisols	Inceptisols
C41	Orthic	Oakleaf	Caledon 1210	Acrisols Lixisols Arenosols Cambisols	Inceptisols

Mapping unit C37 – *Photograph taken by Faul C. (2017).*



Mapping unit C37 – *Photograph taken by Faul C. (2017).*

Mapping unit C37 – *Photograph taken by Faul C. (2017).*

Figure 13 (continued):Soil descriptions and classifications (Fey, 2010; IUSS Working Group WRB, 2006; Land Type Survey Staff, 1991; MacVicar *et al.*, 1977; Soil Classification Working Group, 1991; Soil Survey Staff, 1999).

MAPPING UNIT D

Mapping Unit	Horizon	Texture class	Depth (mm)	Clay %	Sand grade	Dry colour	Moist colour	Mottles		Lime		Structure			Coarse fragments	
								OCC	COL	OCC	Type	GRA	Size	Type	Type	%
D10	A	fi	0-400	0-15	fi	5YR 5/8	5YR 5/6	N/A	N/A	N/A	N/A	A	f	SG	S	20
D13	A	fi	0-300	0-15	fi	2,5YR 5/8	5YR 5/8	N/A	N/A	N/A	N/A	A	f	SG	N/A	N/A
D15	A	fi	0-220	0-15	fi	5YR 6/8	5YR 5/8	N/A	N/A	N/A	N/A	A	m	SG	S	20
D17	A	me	0-350	0-15	me	2,5YR 6/8	2,5YR 5/6	N/A	N/A	N/A	N/A	A	m	SG	G + S	20
D19	A	fi	0-200	0-15	fi	7,5YR 6/6	10YR 6/8	N/A	N/A	s	P	A	f	SG	S	10

Mapping Unit	Parent material	Efficient Depth (mm)	Terrain Unit	Depth limiting material
D10	Feldspar; Quartzite-schist	200	4	Quartz boulders
D13	Feldspar; Quartzite-schist	300	4	Quartz boulders
D15	Feldspar; Quartzite-schist	150	4	Quartz boulders
D17	Feldspar; Quartzite-schist	200	4	Quartz boulders
D19	Feldspar; Quartzite-schist; Calcrete	200	3	Quartz and calcrete boulders

Mapping Unit	Sample No.	Coordinates		Initial Weight (g)	Weight after (g)		
		Latitude	Longitude		Coarse (> 2 mm)	Fine (< 2 mm)	Total
D10	G43	29°11'57,6"S	20°24'10,1"E	2402	278	2116	2394
D13	G42	29°11'59,9"S	20°23'39,9"E	2118	174	1943	2117
D15	G37	29°12'02,2"S	20°22'57,5"E	2326	505	1820	2325
D17	G35	29°12'04,6"S	20°23'16,8"E	2540	642	1888	2530
D19	G60	29°12'05,0"S	20°22'07,5"E	2550	253	2298	2551

Mapping Unit	Diagnostic Soil Horizon	Soil Form	Soil Family	WRB Reference Soil Group	USDA Soil Taxonomy
D10	Neocarbonate B / Soft carbonate	Addo	Spekboom 1211	Calcisols	Aridisols Inceptisols
D13	Neocarbonate B / Soft carbonate	Addo	Spekboom 1211	Calcisols	Aridisols Inceptisols
D15	Neocarbonate B / Soft carbonate	Addo	Spekboom 1211	Calcisols	Aridisols Inceptisols
D17	Neocarbonate B / Soft carbonate	Addo	Spekboom 1211	Calcisols	Aridisols Inceptisols
D19	Neocarbonate B / Soft carbonate	Addo	Spekboom 1211	Calcisols	Aridisols Inceptisols

Figure 13 (continued):Soil descriptions and classifications (Fey, 2010; IUSS Working Group WRB, 2006; Land Type Survey Staff, 1991; MacVicar *et al.*, 1977; Soil Classification Working Group, 1991; Soil Survey Staff, 1999).

Mapping unit D10 – *Photograph taken by Faul C. (2017).*

Mapping unit D17 – *Photograph taken by Faul C. (2017).*

Figure 13 (continued):Soil descriptions and classifications (Fey, 2010; IUSS Working Group WRB, 2006; Land Type Survey Staff, 1991; MacVicar *et al.*, 1977; Soil Classification Working Group, 1991; Soil Survey Staff, 1999).

MAPPING UNIT E

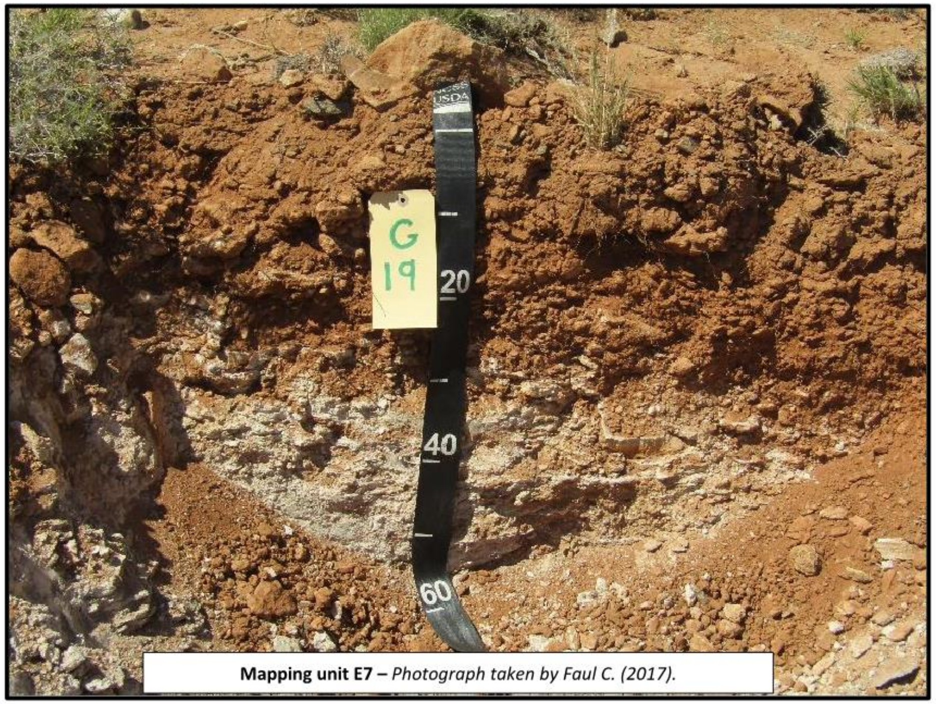
Mapping Unit	Horizon	Texture class	Depth (mm)	Clay %	Sand grade	Dry colour	Moist colour	Mottles		Lime		Structure			Coarse fragments	
								OCC	COL	OCC	Type	GRA	Size	Type	Type	%
E1	A	fi	0-300	0-15	fi	5YR 6/8	7,5YR 5/8	N/A	N/A	s	P	W	f	MA	G+S	60
	Transition	fi	300-850	0-15	fi	10R 7/4	10YR 7/4	N/A	N/A	a	P	W	f	MA	G+S	50
	B	fi	850-1650	0-15	fi	10R 7/3	10YR 7/3	N/A	N/A	a	P	W	f	MA	G	70
E3	A	fi	0-200	0-15	fi	5YR 6/8	5YR 5/6	N/A	N/A	N/A	N/A	A	f	SG	G + S	90
E5	A	fi	0-350	0-15	fi	7,5YR 7/6	7,5YR 5/8	N/A	N/A	a	P	A	f	SG	G	50
E7	A	fi	0-600	0-15	fi	7,5YR 6/8	5YR 5/8	N/A	N/A	s	P	A	f	SG	G	50
E9	A	fi	0-300	0-15	fi	7YR 6/8	5YR 6/8	N/A	N/A	c	P	A	f	SG	G+S	50
	Transition	fi	300-400	0-15	fi	10YR 8/4	7YR 7/6	N/A	N/A	a	P	A	f	SG	G+S	40
	B	fi	400-1100	0-15	fi	10YR 8/3	10YR 7/6	N/A	N/A	a	P	A	f	SG	G	30

Mapping Unit	Parent material	Efficient Depth (mm)	Terrain Unit	Depth limiting material
E1	Calcrete; Quartzite	600	3	N/A
E3	Quartz	50	2	Calcrete boulders
E5	Calcrete; Quartz	200	3	Calcrete boulders
E7	Calcrete; Quartz	200	3	Calcrete boulders
E9	Calcrete; Quartz	200	4	Calcrete boulders

Mapping Unit	Sample No.	Coordinates		Initial Weight (g)	Weight after (g)		
		Latitude	Longitude		Coarse (> 2 mm)	Fine (< 2 mm)	Total
E1	G07	29°11'24,5"S	20°23'13,7"E	2930	1411	1203	2614
	G08			1950	1084	794	1878
	G09			2067	1166	884	2050
E3	G57	29°11'45,4"S	20°23'24,4"E	3462	1602	1362	2964
E5	G18	29°12'34,5"S	20°21'42,2"E	2621	1070	1631	2701
E7	G39	29°11'33,8"S	20°22'18,4"E	2745	378	2363	2741
E9	G14	29°11'55,3"S	020°22'06,0"E	2992	729	2174	2903
	G15			1033	379	641	1020
	G16			2891	1280	1580	2860

Figure 13 (continued):Soil descriptions and classifications (Fey, 2010; IUSS Working Group WRB, 2006; Land Type Survey Staff, 1991; MacVicar *et al.*, 1977; Soil Classification Working Group, 1991; Soil Survey Staff, 1999).

Mapping Unit	Diagnostic Soil Horizon	Soil Form	Soil Family	WRB Reference Soil Group	USDA Soil Taxonomy
E1	Orthic	Brandvlei	Grootvloer 1000	Calcisols	Aridisols Inceptisols
	Soft carbonate				
E3	Orthic with underlying hardpan carbonate	Coega	Nabies 1000	Calcisols	Aridisols Inceptisols
E5	Orthic / Neocarbonate B	Augrabies	Khubus 1210	Luvisols Lixisols Arenosols Cambisols	Aridisols Inceptisols
E7	Orthic with underlying hardpan carbonate	Coega	Nabies 1000	Calcisols	Aridisols Inceptisols
E9	Orthic	Brandvlei	Grootvloer 1000	Calcisols	Aridisols Inceptisols
	Soft carbonate				



Mapping unit E7 – *Photograph taken by Faul C. (2017).*

Mapping unit E3 – *Photograph taken by Faul C. (2017).*

Figure 13 (continued):Soil descriptions and classifications (Fey, 2010; IUSS Working Group WRB, 2006; Land Type Survey Staff, 1991; MacVicar *et al.*, 1977; Soil Classification Working Group, 1991; Soil Survey Staff, 1999).

MAPPING UNIT F

Mapping Unit	Horizon	Texture class	Depth (mm)	Clay %	Sand grade	Dry colour	Moist colour	Mottles		Lime		Structure			Coarse fragments	
								OCC	COL	OCC	Type	GRA	Size	Type	Type	%
F3	A	me	0-100	0-15	me	7,5 YR 6/6	7,5YR 5/8	N/A	N/A	N/A	N/A	A	m	SG	S	50
F5	A	fi	0-400	0-15	fi	5YR 6/8	2,5YR 5/8	N/A	N/A	s	P	A	f	SG	G	30
	B	fi	400-600	0-15	fi	7,5YR 7/6	10YR 7/8	N/A	N/A	a	P	A	f	SG	G	10

Mapping Unit	Parent material	Efficient Depth (mm)	Terrain Unit	Depth limiting material
F3	Quartzite	50	3U	Calcrete boulders
F5	Calcrete	200	4	Calcrete boulders

Mapping Unit	Sample No.	Coordinates		Initial Weight (g)	Weight after (g)		
		Latitude	Longitude		Coarse (> 2 mm)	Fine (< 2 mm)	Total
F3	G38	29°11'54,3"S	20°22'46,0"E	1913	645	1020	1665
F5	G46	29°12'42.48"S	20°22'12.67"E	2776	641	2129	2770
	G47			1992	857	1118	1975

Mapping Unit	Diagnostic Soil Horizon	Soil Form	Soil Family	WRB Reference Soil Group	USDA Soil Taxonomy
F3	Neocarbonate B / Soft carbonate	Addo	Spekboom 1211	Carcisols	Aridisols Inceptisols
F5	Neocarbonate B / Soft carbonate	Addo	Spekboom 1211	Carcisols	Aridisols Inceptisols

Figure 13 (continued):Soil descriptions and classifications (Fey, 2010; IUSS Working Group WRB, 2006; Land Type Survey Staff, 1991; MacVicar *et al.*, 1977; Soil Classification Working Group, 1991; Soil Survey Staff, 1999).

Mapping unit F5 – *Photograph taken by Faul C. (2017).*

Mapping unit F5 – *Photograph taken by Faul C. (2017).*

Figure 13 (continued):Soil descriptions and classifications (Fey, 2010; IUSS Working Group WRB, 2006; Land Type Survey Staff, 1991; MacVicar *et al.*, 1977; Soil Classification Working Group, 1991; Soil Survey Staff, 1999).

MAPPING UNIT G

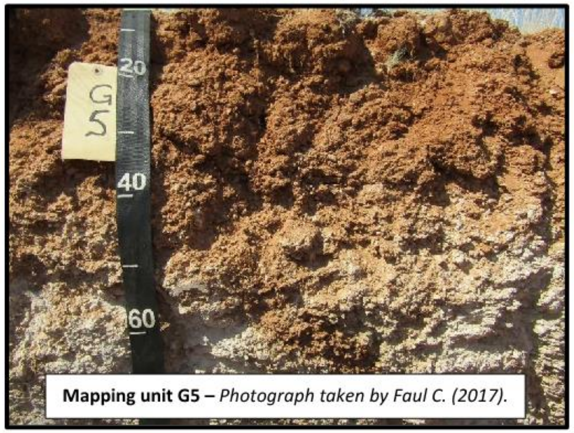
Mapping Unit	Horizon	Texture class	Depth (mm)	Clay %	Sand grade	Dry colour	Moist colour	Mottles		Lime		Structure			Coarse fragments	
								OCC	COL	OCC	Type	GRA	Size	Type	Type	%
G1	A	fi	0-200	0-15	fi	2,5YR 6/6	5YR 6/6	N/A	N/A	a	P	A	f	SG	G+S	40
G5	A	fi	0-70	0-15	fi	5YR 5/6	2,5YR 5/6	N/A	N/A	N/A	N/A	A	f	SG	G	30
	A continue	fi	70-150	0-15	fi	5YR 5/6	2,5YR 5/6	N/A	N/A	N/A	N/A	A	f	SG	G + S	70
G6	A	fi	0-200	0-15	fi	7,5YR 6/6	5YR 5/6	N/A	N/A	s	P	A	f	SG	S + G	60
G7	A	fi	0-200	0-15	fi	7,5YR 6/6	5YR 6/8	N/A	N/A	s	P	A	f	SG	S + G	50
	B	fi	200-600	0-15	fi	7,5YR 7/6	5YR 6/6	N/A	N/A	a	P	A	f	SG	S + G	50
G10	A	fi	0-130	0-15	fi	7,5YR 6/6	10YR 6/6	N/A	N/A	a	P	A	f	SG	S + G	70

Mapping Unit	Parent material	Efficient Depth (mm)	Terrain Unit	Depth limiting material
G1	Calcrete; Quartz	100	3	Calcrete boulders
G5	Quartz	70	3	Calcrete boulders
G6	Calcrete; Quartz; Feldspar	100	3L	Quartz & feldspar fragments
G7	Calcrete; Quartz; Feldspar	100	3U	Calcrete boulders
G10	Calcrete	50	3	Calcrete boulders

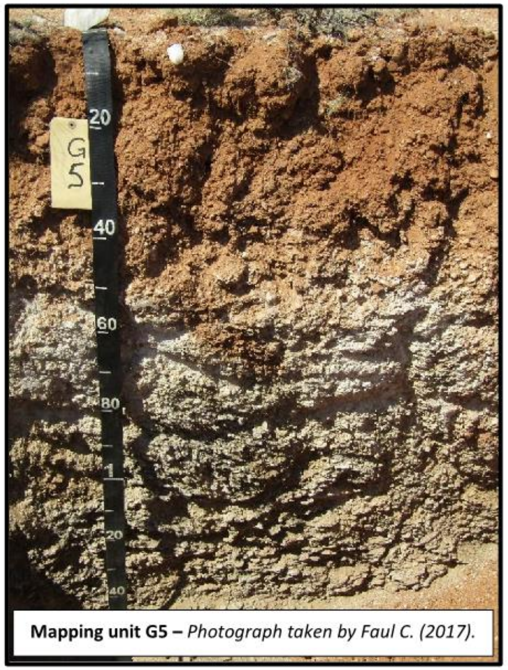
Mapping Unit	Sample No.	Coordinates		Initial Weight (g)	Weight after (g)		
		Latitude	Longitude		Coarse (> 2 mm)	Fine (< 2 mm)	Total
G1	G13	29°1'17,1"S	20°23'01,3"E	2353	688	1651	2339
G5	G55	29°11'36,8"S	20°23'22,1"E	2311	595	1715	2310
	G56			2324	980	1249	2229
G6	G40	29°11'43,3"S	20°22'29,6"E	2217	968	1239	2207
G7	G22	29°12'05,4"S	20°22'14,8"E	2516	1095	1355	2450
	G23			2208	1151	948	2099
G10	G45	29 12'31,8"S	20 21'58,3"E	2936	1220	1647	2867

Figure 13 (continued):Soil descriptions and classifications (Fey, 2010; IUSS Working Group WRB, 2006; Land Type Survey Staff, 1991; MacVicar *et al.*, 1977; Soil Classification Working Group, 1991; Soil Survey Staff, 1999).

Mapping Unit	Diagnostic Soil Horizon	Soil Form	Soil Family	WRB Reference Soil Group	USDA Soil Taxonomy
G1	Neocarbonate B / Soft carbonate	Addo	Spekboom 1211	Carcisols	Aridisols Inceptisols
G5	Neocutanic / Soft carbonate	Etosha	Tuli 1211	Calcisols Luvisols Lixisols	Aridisols
G6	Neocarbonate B / Soft carbonate	Addo	Spekboom 1211	Carcisols	Aridisols Inceptisols
G7	Neocarbonate B / Soft carbonate	Addo	Spekboom 1211	Carcisols	Aridisols Inceptisols
G10	Neocarbonate B / Soft carbonate	Addo	Spekboom 1211	Carcisols	Aridisols Inceptisols

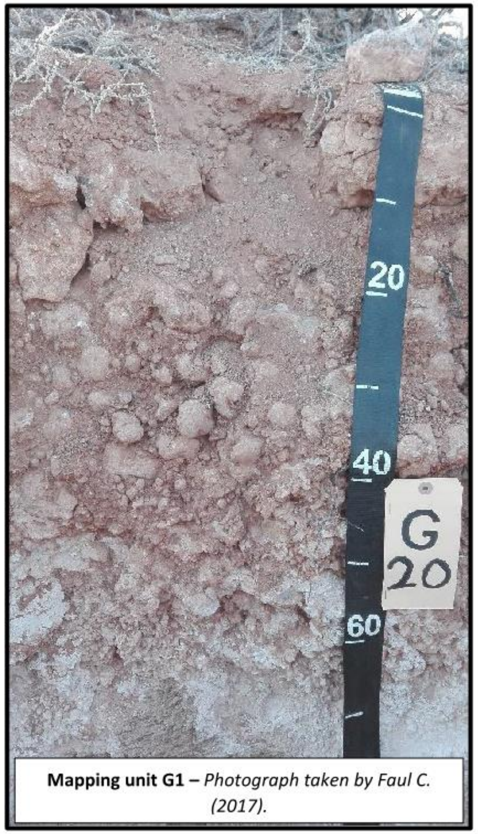


Mapping unit G5 – *Photograph taken by Faul C. (2017).*



Mapping unit G5 – *Photograph taken by Faul C. (2017).*

Mapping unit G1 – *Photograph taken by Faul C. (2017).*



Mapping unit G1 – *Photograph taken by Faul C. (2017).*

Figure 13 (continued):Soil descriptions and classifications (Fey, 2010; IUSS Working Group WRB, 2006; Land Type Survey Staff, 1991; MacVicar *et al.*, 1977; Soil Classification Working Group, 1991; Soil Survey Staff, 1999).

MAPPING UNIT H

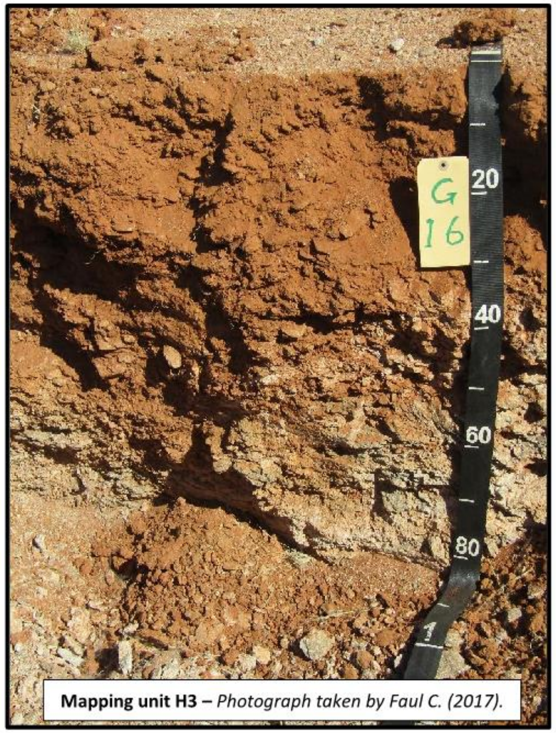
Mapping Unit	Horizon	Texture class	Depth (mm)	Clay %	Sand grade	Dry colour	Moist colour	Mottles		Lime		Structure			Coarse fragments	
								OCC	COL	OCC	Type	GRA	Size	Type	Type	%
H1	A	fi	0-470	0-15	fi	7,5YR 6/6	2,5 YR 4/6	N/A	N/A	a	P	A	f	SG	G	50
	B continue	fi	470-960	0-15	fi	10YR 8/2	7,5 YR 6/4	N/A	N/A	a	P	A	f	SG	G	50
	B continue	fi	960-1062	0-15	fi	2,5Y 8/4	7,5YR 5/6	N/A	N/A	a	P	A	f	SG	G	50
H3	A	me	0-400	0-15	me - co	5YR 5/8	2,5YR 4/8	N/A	N/A	N/A	N/A	M	m - c	CR	G	10
H4	A	fi	0-200	0-15	fi	7,5YR 7/6	5YR 6/8	N/A	N/A	c	P	A	f	SG	G	10
	B	fi	200-400	0-15	fi	7,5YR 6/6	5YR 6/6	N/A	N/A	a	P	A	f	SG	G	10
	B continue	fi	400-1200	0-15	fi	7,5YR 8/6	5YR 7/8	N/A	N/A	a	P	A	f	SG	G	10
	B continue	fi	1200-1500	0-15	fi	7,5YR 8/6	5YR 7/8	N/A	N/A	a	P	A	f	SG	G	10
H5	A	me	0-150	0-15	me	5YR 6/8	5YR 5/8	N/A	N/A	N/A	N/A	A	m	SG	S + G	60
H6	A	fi	0-450	0-15	fi	5YR 5/8	2,5YR 5/6	N/A	N/A	s	P	A	f	SG	G	10

Mapping Unit	Parent material	Efficient Depth (mm)	Terrain Unit	Depth limiting material
H1	Quartzite; calcrete; feldspar	100	3	Quartz and calcrete fragments
H3	Quartz; feldspar	200	4	Quartz and calcrete fragments
H4	Quartz; calcrete; feldspar	200	3U	N/A
H5	Quartz; feldspar	100	3	Calcrete boulders
H6	Quartz; calcrete	200	4	Hard rock

Mapping Unit	Sample No.	Coordinates		Initial Weight (g)	Weight after (g)		
		Latitude	Longitude		Coarse (> 2 mm)	Fine (< 2 mm)	Total
H1	G01	29°10'45,1"S	20°22'57,4"E	2582	1405	1161	2566
	G02			2566	1333	1227	2560
	G03			2360	1210	1148	2358
H3	G49	29°12'33,6"S	20°22'41,2"E	2620	559	2040	2599
H4	G26	29°12'05,7"S	20°21'53,7"E	2246	597	1631	2228
	G27			2161	845	1307	2152
	G28			2464	1189	1245	2434
	G29			1312	692	611	1303
H5	G36	29°12'07,9"S	20°23'06,5"E	2615	868	1743	2611
H6	G48	29°12'46.65"S	20°22'38.82"E	2311	547	1757	2304

Figure 13 (continued):Soil descriptions and classifications (Fey, 2010; IUSS Working Group WRB, 2006; Land Type Survey Staff, 1991; MacVicar *et al.*, 1977; Soil Classification Working Group, 1991; Soil Survey Staff, 1999).

Mapping Unit	Diagnostic Soil Horizon	Soil Form	Soil Family	WRB Reference Soil Group	USDA Soil Taxonomy
H1	Neocarbonate B / Soft carbonate	Addo	Spekboom 1211	Carcisols	Aridisols Inceptisols
H3	Neocutanic	Oakleaf	Caledon 1210	Acrisols Lixisils Arenosols Cambisols	Inceptisols
H4	Neocarbonate B / Soft carbonate	Addo	Spekboom 1211	Carcisols	Aridisols Inceptisols
H5	Hard rock	Mispah	Myhill 1100	Leptosols	Entisols
H6	Neocutanic	Oakleaf	Caledon 1210	Acrisols Lixisils Arenosols Cambisols	Inceptisols



Mapping unit H3 – *Photograph taken by Faul C. (2017).*

Mapping unit H3 – *Photograph taken by Faul C. (2017).*

Figure 13 (continued):Soil descriptions and classifications (Fey, 2010; IUSS Working Group WRB, 2006; Land Type Survey Staff, 1991; MacVicar *et al.*, 1977; Soil Classification Working Group, 1991; Soil Survey Staff, 1999).

MAPPING UNIT I

Mapping Unit	Horizon	Texture class	Depth (mm)	Clay %	Sand grade	Dry colour	Moist colour	Mottles		Lime		Structure			Coarse fragments	
								OCC	COL	OCC	Type	GRA	Size	Type	Type	%
I1	A	me	0-250	0-15	me	2,5YR 5/8	5YR 5/8	f	Bl	c	NP	W	m	G	G + S	30
	Transition	fi	250-350	0-15	fi	5YR 6/6	10YR 6/8	N/A	N/A	a	P	A	f	SG	G	30
	B	fi	350-450	0-15	fi	7,5YR 8/3	10YR 7/4	N/A	N/A	a	P	A	f	SG	G	30
I2	A	fi	0-200	0-15	fi	7,5YR 6/6	7,5YR 5/8	N/A	N/A	s	P	A	f	SG	S	10

Mapping Unit	Parent material	Efficient Depth (mm)	Terrain Unit	Depth limiting material
I1	Calcrete; Quartz; Feldspar	200	3	Rock fragments
I2	Calcrete; Quartz; Feldspar	200	4	Calcrete boulders

Mapping Unit	Sample No.	Coordinates		Initial Weight (g)	Weight after (g)		
		Latitude	Longitude		Coarse (> 2 mm)	Fine (< 2 mm)	Total
I1	G32	29°12'21,5"S	20°23'07,1"E	3327	1058	2254	3312
	G33			1360	601	749	1350
	G34			996	484	507	991
I2	G59	29°11'54,1"S	20°23'40,7"E	2678	528	2143	2671

Mapping Unit	Diagnostic Soil Horizon	Soil Form	Soil Family	WRB Reference Soil Group	USDA Soil Taxonomy
I1	Neocarbonate B / Soft carbonate	Addo	Spekboom 1211	Carcisols	Aridisols Inceptisols
I2	Neocarbonate B / Soft carbonate	Addo	Spekboom 1211	Carcisols	Aridisols Inceptisols

Figure 13 (continued):Soil descriptions and classifications (Fey, 2010; IUSS Working Group WRB, 2006; Land Type Survey Staff, 1991; MacVicar *et al.*, 1977; Soil Classification Working Group, 1991; Soil Survey Staff, 1999).

Mapping unit I1 – *Photograph taken by Faul C. (2017).*

Mapping unit I2 – *Photograph taken by Faul C. (2017).*

Figure 13 (continued):Soil descriptions and classifications (Fey, 2010; IUSS Working Group WRB, 2006; Land Type Survey Staff, 1991; MacVicar *et al.*, 1977; Soil Classification Working Group, 1991; Soil Survey Staff, 1999).

MAPPING UNIT J

Mapping Unit	Horizon	Texture class	Depth (mm)	Clay %	Sand grade	Dry colour	Moist colour	Mottles		Lime		Structure			Coarse fragments	
								OCC	COL	OCC	Type	GRA	Size	Type	Type	%
J1	A	fi	0-150	0-15	fi	5YR 5/6	5YR 5/8	N/A	N/A	s	P	A	f	SG	S + G	80
J2	A	fi	0-50	0-15	fi	5YR 5/6	5YR 5/8	N/A	N/A	N/A	N/A	A	f	SG	S	30
J3	A	fi	0-10	0-15	fi	2,5YR 5/8	2YR 5/6	N/A	N/A	N/A	N/A	A	f	SG	N/A	N/A
J4	A	fi	0-150	0-15	fi	5YR 6/8	5YR 5/6	N/A	N/A	N/A	N/A	A	f	SG	G+S	80
J5	A	fi	0-190	0-15	fi	2,5YR 5/8	2,5YR 4/8	N/A	N/A	N/A	N/A	A	f	SG	G+S	40

Mapping Unit	Parent material	Efficient Depth (mm)	Terrain Unit	Depth limiting material
J1	Quartzite	50	2	Meta-quartzite
J2	Quartzite	50	2	Meta-quartzite
J3	Quartzite	10	2	Meta-quartzite
J4	Quartzite	100	3U	Meta-quartzite
J5	Quartzite	100	3U	Meta-quartzite

Mapping Unit	Sample No.	Coordinates		Initial Weight (g)	Weight after (g)		
		Latitude	Longitude		Coarse (> 2 mm)	Fine (< 2 mm)	Total
J1	G19	29°12'10,9"S	20°22'01,5"E	2590	871	1603	2474
J2	G17	29°12'20,1"S	20°21'48,8"E	2456	919	1520	2439
J3	G30	29°11'24,85"S	20°22'24,3"E	1183	92	1094	1186
J4	G12	29°11'22,9"S	20°22'39,5"E	3354	1143	1682	2825
J5	G11	29°11'28,4"S	20°22'50,7"E	6060	1578	1638	3216

Mapping Unit	Diagnostic Soil Horizon	Soil Form	Soil Family	WRB Reference Soil Group	USDA Soil Taxonomy
J1	Hard rock	Mispah	Carnavon 1200	Leptosols	Entisols
J2	Hard rock	Mispah	Myhill 1100	Leptosols	Entisols
J3	Hard rock	Mispah	Myhill 1100	Leptosols	Entisols
J4	Hard rock	Mispah	Myhill 1100	Leptosols	Entisols
J5	Hard rock	Mispah	Myhill 1100	Leptosols	Entisols

Figure 13 (continued):Soil descriptions and classifications (Fey, 2010; IUSS Working Group WRB, 2006; Land Type Survey Staff, 1991; MacVicar *et al.*, 1977; Soil Classification Working Group, 1991; Soil Survey Staff, 1999).

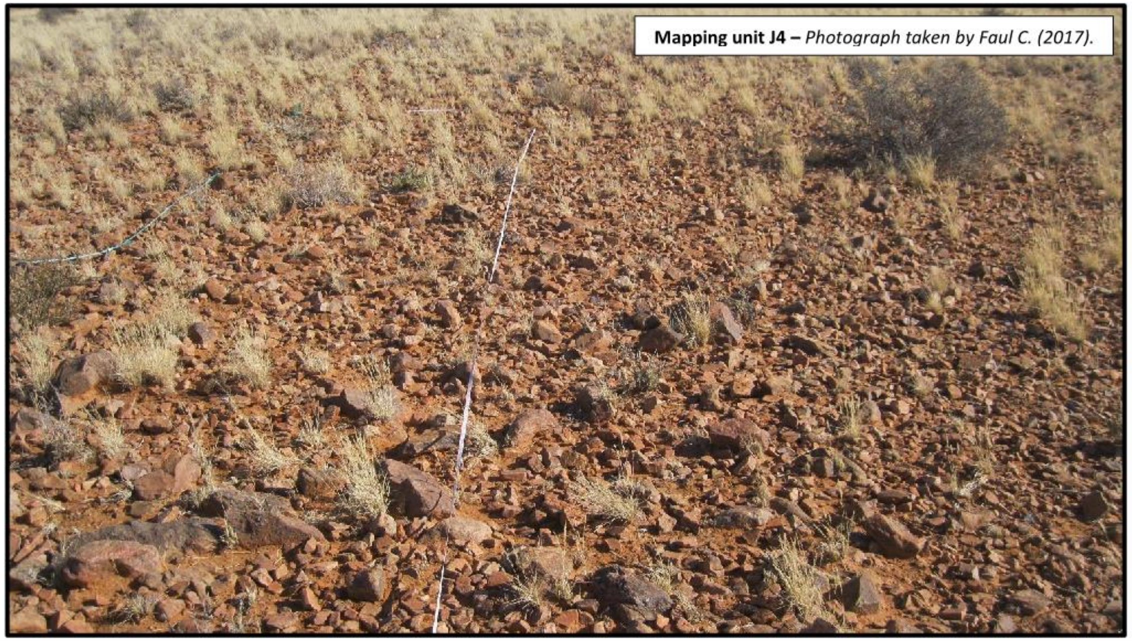


Figure 13 (continued):Soil descriptions and classifications (Fey, 2010; IUSS Working Group WRB, 2006; Land Type Survey Staff, 1991; MacVicar *et al.*, 1977; Soil Classification Working Group, 1991; Soil Survey Staff, 1999).

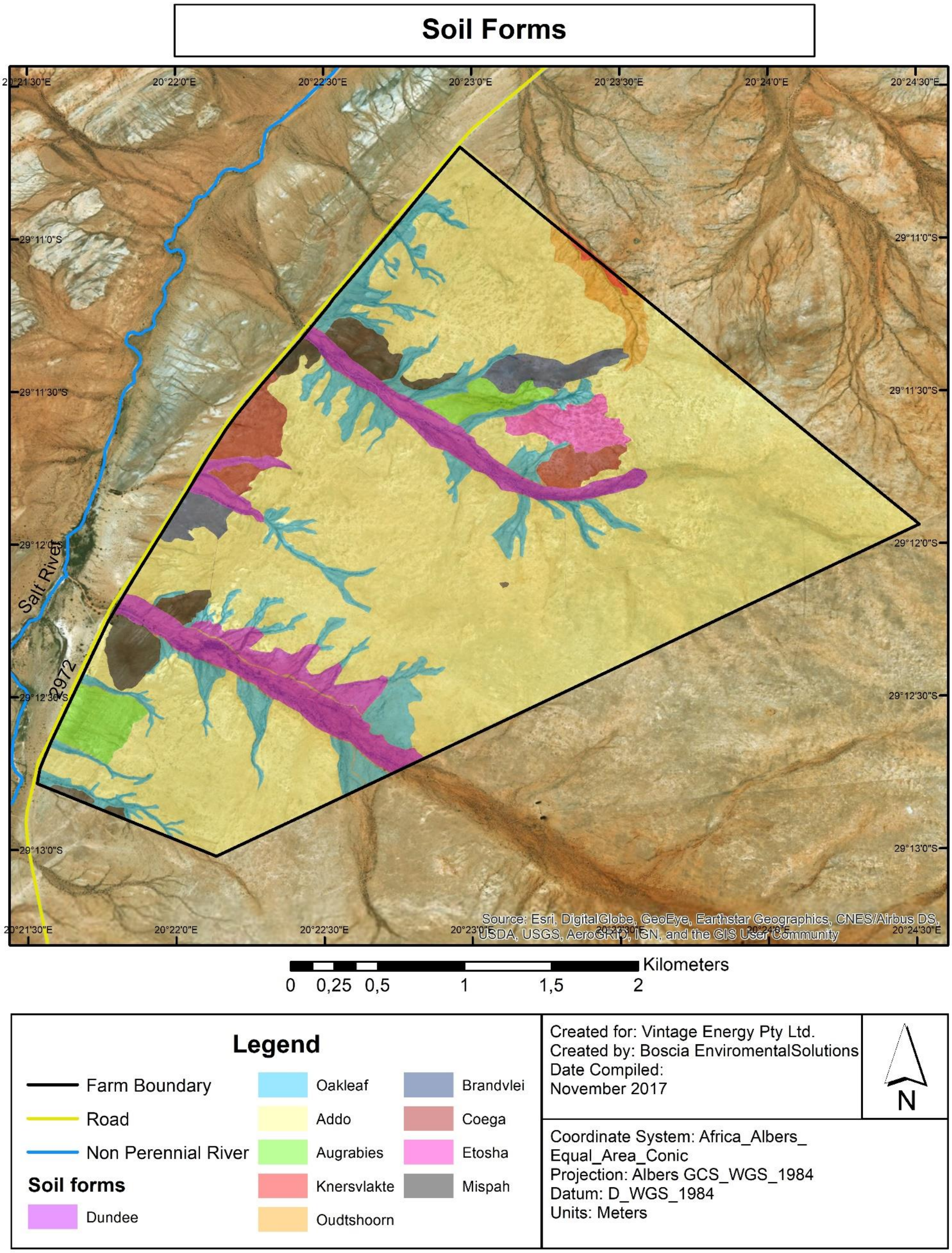
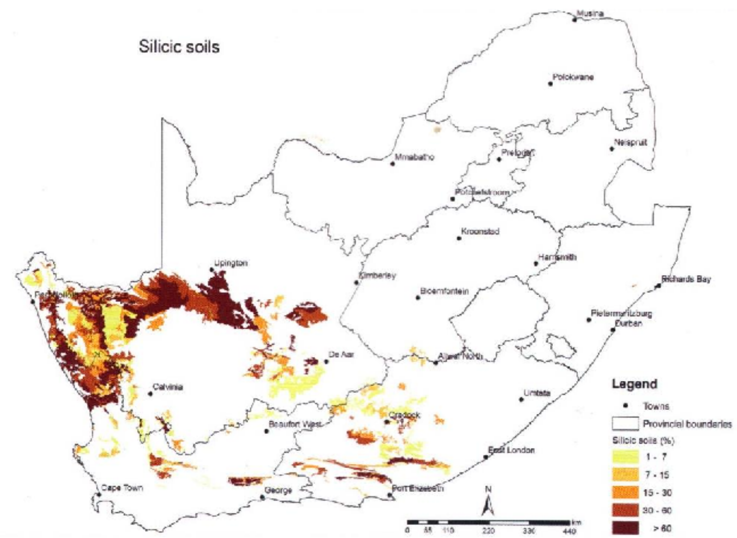


Figure 14: Map indicating the soil forms for the study area (Google Earth, 2016).

Table 3: Discussion of silicic soil group and associated soil forms in this study area (Fey, 2010; Brummer, 2015; Fanourakis, 1991; IUSS Working Group WRB, 2006; Schmidhuber, 2015; Von M Harmse & Hatting, 1985).

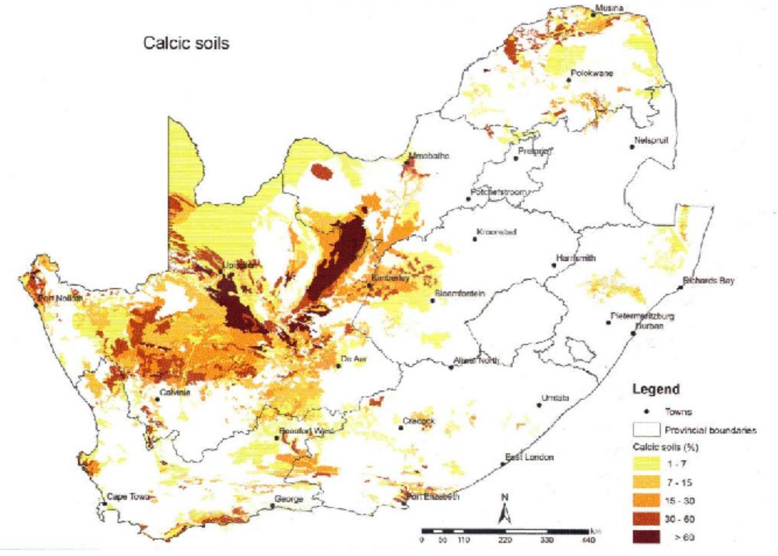
Soil group	Concept	Identification	Soil Forms	Description	Properties	Morphology	Genesis
Silicic	Silica enrichment; arid	Dorbank	Oudtshoorn (Doringbaai 1210) Knersvlakte (Bitterfontein 1000)	Silicic soils are defined by their characteristic surface horizon where the silica becomes mobile during weathering under arid conditions and precipitates as a laminar or massive dorbank in the subsurface horizon.	Silicic soils are considered as active, currently forming soils with no slaking properties. Silicic soils are found in level or gently sloping erosion terraces typically originating from colluvial or alluvial parent material. A neocutanic B horizon is typically identified by its presence beneath a diagnostic A horizon or an E horizon, present in unconsolidated material that does not qualify as stratified alluvium or regic sand. A dorbank is typically identified by its extreme hardness, massive or platy structure and silica cementation.	Silicic soils are typically medium to coarse textured with platy or massive features and are considered as well to moderately drained. These soils have a typical abrupt upper boundary with the overlying material. There may be an occurrence of accessory cements which includes calcium carbonate and possibly iron oxide. On this site, the Oudtshoorn form had a red, non-bleached B-horizon with no luvic properties. Therefore, this soil form was classified as a Oudtshoorn form with soil family Doringbaai 1210. The Knersvlakte form had no free lime within the A-horizon and was therefore classified as a Knersvlakte form with soil family Bitterfontein 1000.	The texture of the overlying material determines the depth of the dorbank, with lower clay content giving raise to deeper dorbanks. For this part of South Africa dorbanks originate due to the presence of silica enrichment together with regular atmospheric additions of sodium in dust, combined with hydrolysis and high tempos of evaporation. Within the Oudtshoorn form the B-horizon may be unrelated to the underlying dorbank. The B-horizon may also be affected by pedoturbation or addition of material. The Knersvlakte form is characteristically shallow and found in areas where material removal through wind or water erosion took place.



Silicic soils in South Africa, where the abundance classes refer to the estimated percentages within the land type (Fey, 2010).

Table 4: Discussion of calcic soil group and associated soil forms in this study area (Fey, 2010; Brummer, 2015; Fanourakis, 1991; IUSS Working Group WRB, 2006; Schmidhuber, 2015; Von M Harmse & Hatting, 1985).

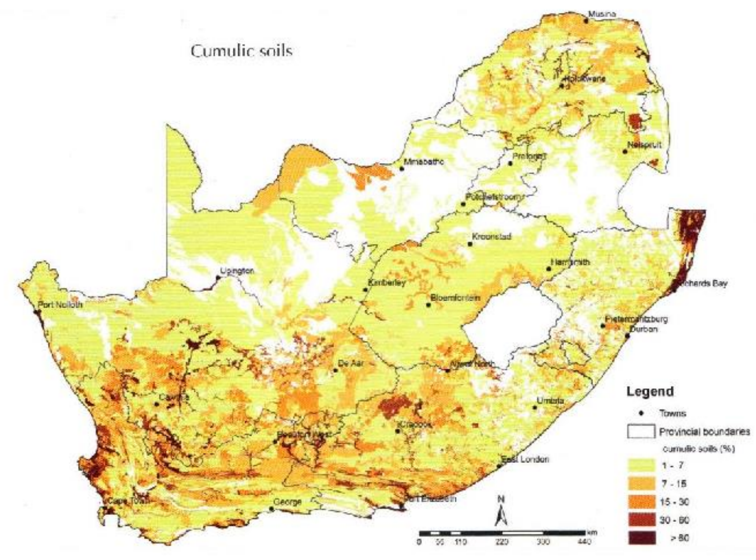
Soil group	Concept	Identification	Soil Forms	Description	Properties	Morphology	Genesis
Calcic	Carbonate or gypsum, enrichment; arid	Soft or hardpan carbonate or gypsic horizon	Etosha (Tuli 1211) Addo (Spekboom 1211) Brandvlei (Grootvloer 1000) Coega (Nabies 1000)	Calcic soils are defined by their characteristic surface horizon. In arid environments evaporation tempos are high and calcium will consequently remain behind to form a cemented soil. However, less intense aridity (in comparison with silicic soils) is needed for calcium retention.	The formation of calcic soils is due to the progressive accumulation of calcium from neocarbonate to soft to hardpan carbonate. The colour and morphology of calcic soils is a result of the composition of the carbonates. With respect to parent material, structure development and occurrence, a neocarbonate B horizon is similar to a neocutanic B horizon. However, unlike the neocutanic B horizon a neocarbonate B horizon contains calcium carbonate. A soft carbonate contains large amounts of carbonates in various forms, hence the morphology of the carbonates give rise to its characteristics. A hardpan carbonate is cemented by carbonates and identified as a solid pedon.	Calcic soils typically have well developed topsoil with crumb or granular structure and a pale brown colour. With the presence of elevated amounts of exchangeable magnesium, the structure becomes massive or platy. The colour of the subsoil depends on the parent material and may vary from brown to yellow to red. In arid environments the orthic A-horizon may have properties like crusts, bleaching and desert pavement. On this site the Etosha form had a red, non-luvic B-horizon with no signs of wetness. Therefore, this soil form was classified as a Etosha form with soil family Tuli 1211. The Addo form also had a red, non-luvic B-horizon with no signs of wetness and was classified as a Addo form with soil family Spekboom 1211. The Brandvlei form showed no signs of wetness and was classified as a Brandvlei form with soil family Grootvloer 1000. The Coega form had a non-calcic A-horizon and was classified as a Coega form with soil family Nabies 1000.	Calcic soils are considered as extremely old and polygenetic. Calcite precipitation result as CO_2 pressure and soil water levels decrease, causing increased ionic concentrations. pH levels also play an important role in the precipitation or dissolution of calcite. The origin of calcic soils may be internal or external, thus originating from the soil parent material or from outside sources for instance dust. Arid and semi-arid climate is an important factor controlling the distribution of calcic soils.



Calcic soils in South Africa, where the abundance classes refer to the estimated percentages within the land type (Fey, 2010).

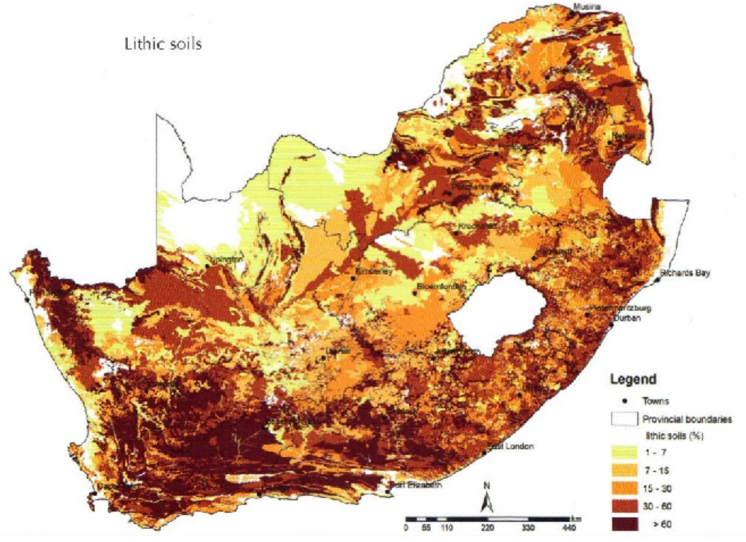
Table 5: Discussion of cumulic soil group and associated soil forms in this study area (Fey, 2010; Brummer, 2015; Fanourakis, 1991; IUSS Working Group WRB, 2006; Schmidhuber, 2015; Von M Harmse & Hatting, 1985).

Soil group	Concept	Identification	Soil Forms	Description	Properties	Morphology	Genesis
Cumulic	Young soil (colluvial, alluvial, aeolian).	Neocutanic or neocarbonate B, regic sand, deep E or stratified alluvium	Oakleaf (Caledon 1210) Augrabies (Khubus 1210) Dundee (Marico 2110)	Cumulic soils are youthful and formed in recent, unconsolidated, natural deposits such as colluvium, alluvium or aeolian sediments. Cumulic soils typically identify concave foot slopes and valley basins.	The Oakleaf form is weakly altered having higher clay content with increasing depth. The Augrabies form is weakly altered having higher carbonate concentrations. The Dundee form is known to be negligibly altered in fluvic conditions. Soil families can be classified based on features like surface bleaching, reddening of soil colour, clay lamellae in the E-horizon, clay illuviation, presence of carbonates or signs of wetness. Stratified alluvium is typically unconsolidated with minimal pedogenic differentiations formed by depositional processes.	The Oakleaf form has neocutanic properties which has similar structural properties as an apedal B horizon but differs from the apedal B horizon in terms of colour. One of the properties used to identify a neocutanic horizon is the bleaching of the overlying A horizon. On this site the Oakleaf form were characterised by a red B-horizon with no luvic properties. Therefore, this soil form was classified as a Oakleaf form, with soil family Caledon 1210. The Augrabies form has neocutanic properties; however it also has a neocarbonate B horizon. On this site the Augrabies form were characterised by a red B-horizon with no luvic properties. Therefore, this soil form was classified as a Augrabies form, with soil family Khubus 1210. The Dundee form is identified based on the dominance of stratified alluvium. On this site the Dundee form were characterised by red stratified alluvium with no signs of wetness and no carbonates present within the first 1500 mm. Therefore, this soil form was classified as a Dundee form, with soil family Marico 2110.	The Dundee form is typically restricted to floodplains. The red colour is an indication of sufficient aeration for sufficient iron oxide preservation. No clear stratification was observed, indicating a gradual accumulation of sediments. The Oakleaf form was initially identified to describe the concept of developing pedogenesis in unconsolidated material. Variations in colour can be observed based on localities, faunal activity, clay illuviation as well as the degree of structure development.



Cumulic soils in South Africa, where the abundance classes refer to the estimated percentages within the land type (Fey, 2010).

Table 6: Discussion of lithic soil group and associated soil forms on this site (Fey, 2010; Brummer, 2015; Fanourakis, 1991; IUSS Working Group WRB, 2006; Schmidhuber, 2015; Von M Harmse & Hatting, 1985).

Soil group	Concept	Identification	Soil Forms	Description	Properties	Morphology	Genesis
Lithic	Young soil on weathered rock	Lithocutanic B or hard rock	Mispah (Myhill 1100) Mispah (Carnavon 1200)	Lithic soils are youthful, typically identifying convex crests and steep slopes. The Mispah form is characterised by an orthic A overlying hard rock.	Lithic soils are characterised by their affinity with the underlying parent rock. Hard rock can be described as a continuous rock layer, not changing colour in wet conditions. A lithocutanic B horizon gradually changes into weathered rock and show some correlation with the parent material.	The tongues of topsoil into saprolite is an indication of clay movement. It is also possible to find horizontally discontinuous pockets of well-formed ped within the lithocutanic B which may cause confusion regarding the properties of the pedocutanic and the prismacutanic B horizon. On this site the majority of the soil forms were characterised by a non-bleached A horizon with no carbonates present. In this case the soil form was classified as a Mispah form with soil family Myhill 1100. However, there were one locality where calcium carbonate was present alternating the classification to a Mispah form, with soil family Carnavon 1200.	There is a strong correlation between the occurrence of lithic soils and climate determined by vegetation cover, vegetation root penetration and consequently erosion tempos. Lithic soils dominate in arid environments due to the domination of natural erosion over weathering. Due to the nature of natural reactions, lithic soils are ideal for studying the transformation from primary to secondary minerals.
 *Lithic soils in South Africa, where the abundance classes refer to the estimated percentages within the land type (Fey, 2010).*							

7 Interpretation of Soil Survey and Analytical Data

7.1 Agricultural Potential

The agricultural potential of the site is determined mainly by the climate in that the rainfall effectively excludes any form of crop production, therefore the site is suited only for grazing. Due to the water quality and restricted availability no crop production is possible. Even if water was available for irrigation, due to the finer texture of the subsoils within the level terrain area the long-term viability of irrigated agriculture will be limited through the limited potential of irrigation induced salt leaching.

7.2 Overall Soil and Land Impact

The impact on soil and agriculture is expected to be low, due to the low agricultural potential as well as the variable rainfall in this environment if:

- Erosion prevention and storm water management measures are implemented; and
- A large enough footprint area around the development area is left open.

Soil sensitivity can be established by determining the dispersivity and erosion potential of soil by means of calculating the sodium exchangeable percentage:

$$\frac{Na}{CEC} \, x \; 100$$

Sodium exchangeable percentage values are divided into classes based on the amount of exchangeable potential indicating the degree of soil dispersivity. Class 1 indicates the lowest sodium exchangeable percentage hence being the most favourable class, while class 4 indicates the highest sodium exchangeable percentage, thus being the least favourable.

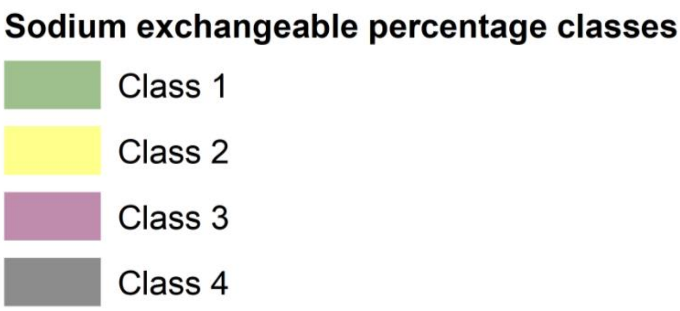


Figure 15 illustrates the soil sensitivity map based on soil dispersivity (sodium exchangeable percentage).

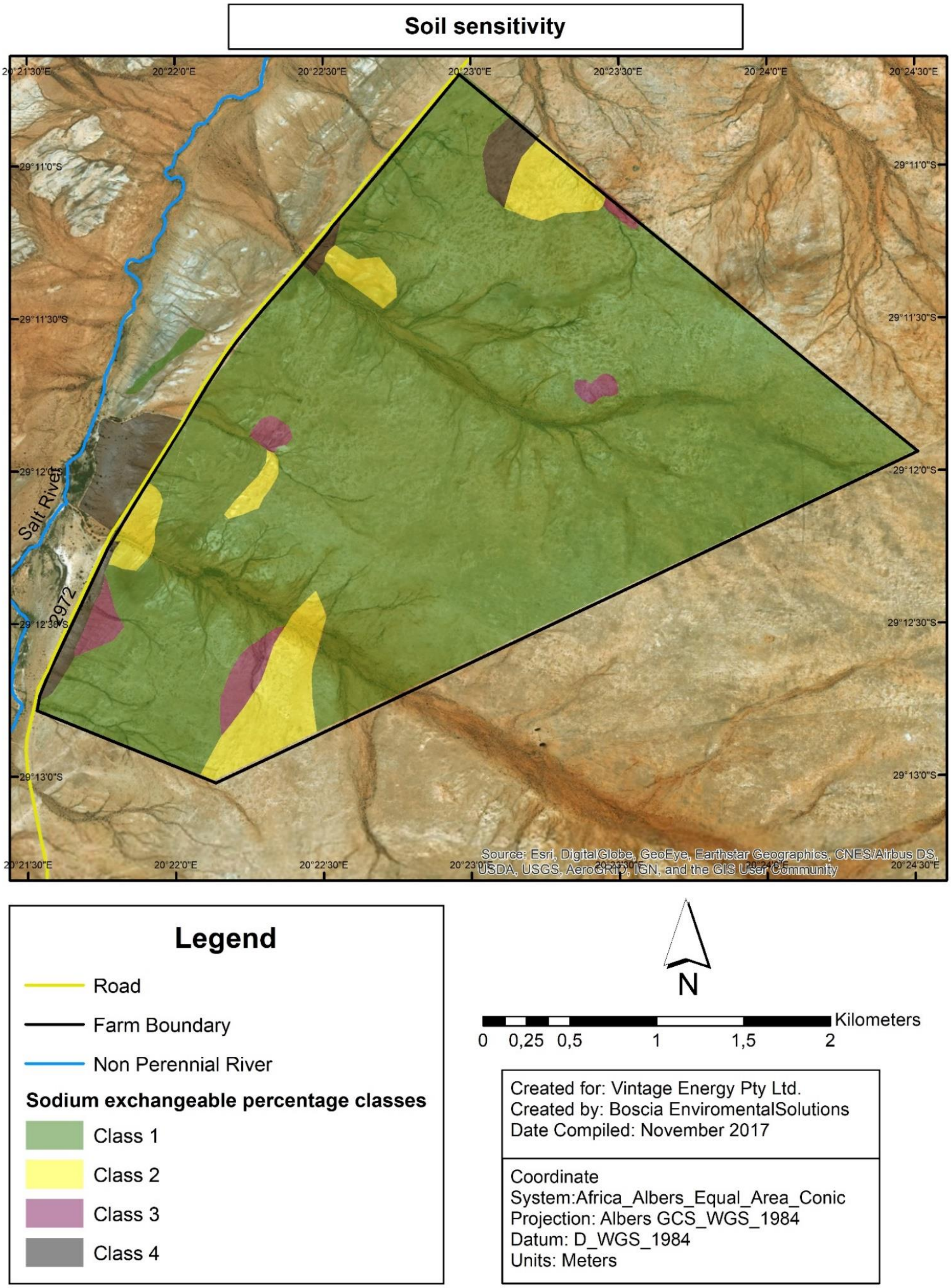


Figure 15: Soil sensitivity map of the study area (Google Earth, 2016).

8. Assessment of Impacts

8.1 List of Activities for this Site

Table 7: A list of the activities and forms of soil degradation.

Activity	Form of Degradation	Geographic Extent
Construction Phase		
Construction of solar panels and associated mountings	Physical (surface) degradation	Two dimensional
Construction of associated infrastructure	Physical (compound) degradation	Two dimensional
Construction of roads	Physical (compound) degradation	Two dimensional
Construction and Operational Phase		
Vehicle operation on site	Physical and chemical (hydrocarbon spills) degradation	Point and one dimensional
Dust generation	Physical degradation	Two dimensional

8.2 Identification and Nature of Impact

Some of the impacts that will result during/after the development of the proposed facility include the loss of arable land due to the construction of the various types of infrastructure, loss of soil resources as a result of erosion and loss of utilisation of arable land.

8.2.1 Impact 1: Loss of agricultural land

This impact includes the loss of arable land due to the construction of different types of infrastructure. This impact would be of limited significance and local in extent. The removal of the structures at the end of the project life would enable the land to be returned to a more natural state following rehabilitation.

8.2.2 Impact 2: Increased susceptibility erosion

Where soil is loosened, and vegetation cover is stripped erosion is a common occurrence. The nature of the development should only include the partial clearance of vegetation within the development footprint. It should be permitted that vegetation remains underneath the solar panel system and should be maintained throughout the operation phase.

8.2.3 Impact 3: Dust generation

Generated dust can impact large areas depending on environmental and climatic conditions. The main source of dust pollution is to be anticipated from the dirt road and to a lesser extent from the construction terrain during the construction phase. The roads on the site will have a minor effect on dust pollution during the operation phase.

8.2.4 Impact 4: Vehicle operation on site

It is assumed that vehicle movement will be restricted to the construction site and established roads. Vehicle impacts in this sense are restricted to spillages of lubricants and petroleum products.

8.2.5 Impact 5: Cumulative impact of the loss of agricultural land

The cumulative impacts on soil and agricultural potential as result of this proposed project, will be low as a result of the climatic conditions and the low agricultural potential on this area. Therefore, the contribution of this project to the cumulative impacts is expected to be low. It is however important to implement appropriate soil erosion management measures during the construction phase, in order to minimize the loss of topsoil resources.

8.3 Assessment of Impacts

Impact 1: Loss of agricultural land

Impact Nature: Land that is no longer able to be utilized due to the construction. This impact is expected to be of low significance as a result of the limited agricultural potential of the site.		
	Without Mitigation	**With Mitigation**
Extent	Local (1)	Local (1)
Duration	Permanent (5)	Long-term (4)
Magnitude	Minor (2)	Minor (2)
Probability	Highly probable (4)	Probable (3)
Significance	MEDIUM (32)	LOW (21)
Status	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources	Yes	No
Can impacts be mitigated?	Yes	
Mitigation	Without mitigation the loss of agricultural land might be permanent. Mitigation will include rehabilitation of construction site and re-establishment of natural vegetation. Ensuring that as little surface disturbance as possible occurs, is crucial. It is also important to avoid al drainage systems in the site, as these areas are more prone to erosion.	
Cumulative Impacts	The cumulative impact is expected to be low, due to the limited agricultural potential, as a result of limited water ad low rainfall.	
Residual Impacts	Minor residual risks: the recovery of the land to original potential might take decades in these arid climates, however, it is important to note that the agricultural potential is very low.	

Impact 2: Increased susceptibility to erosion

Impact Nature: Loss of soil resources as a result of erosion during all phases.		
	Without Mitigation	**With Mitigation**
Extent	Local (1)	Local (1)
Duration	Long-term (4)	Long-term (4)
Magnitude	Low (4)	Minor (2)
Probability	Highly probable (4)	Probable (3)
Significance	MEDIUM (36)	LOW (21)
Status	Negative	Negative
Reversibility	Irreversible	Irreversible
Irreplaceable loss of resources	No	No
Can impacts be mitigated?	Yes	
Mitigation	Ensuring that as little surface disturbance as possible occurs. Where vegetation is removed for construction, specific measures would need to be out in place like the minimal removal of vegetation, soil conservation measures, re-vegetation as soon as possible, and the regular monitoring of erosion.	
Cumulative Impacts	Due to the erosion effect beyond the initial disturbed area and on vulnerable soil types, there is a cumulative effect within the surrounding environment. Therefore, the spread of erosion will continue into intact areas even with good vegetation cover present.	
Residual Impacts	Unless appropriate mitigation is implemented, loss of topsoil through erosion can occur. Loss of soil resources is irreversible.	

Impact 3: Dust generation

Impact Nature: This activity entails the operation of vehicles on site and their associated dust generation.		
	Without Mitigation	**With Mitigation**
Extent	Local (2)	Local (2)
Duration	Short (2)	Short (2)
Magnitude	Moderate (6)	Minor (2)
Probability	Highly probable (4)	Probable (3)
Significance	MEDIUM (40)	LOW (18)
Status	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources	No	No
Can impacts be mitigated?	Yes	
Mitigation	Ensure that road surfaces are moist during maximum vehicle movement periods. Use existing roads as far as possible and minimise impact on undisturbed ground.	
Cumulative Impacts	The cumulative impact of this activity will be small if managed but can have widespread impacts if ignored.	
Residual Impacts	Minor residual risks: with adequate mitigation dust generation will be low and relatively localised.	

Impact 4: Vehicle operation on site

Impact Nature: This activity entails the operation of vehicles on site and their associated impacts in terms of spillages of lubricants and petroleum products.		
	Without Mitigation	**With Mitigation**
Extent	Local (1)	Local (1)
Duration	Short (2)	Short (2)
Magnitude	Low (4)	Minor (2)
Probability	Highly probable (4)	Improbable (2)
Significance	LOW (28)	LOW (10)
Status	Negative	Negative
Reversibility	Irreversible	Reversible
Irreplaceable loss of resources	No	No
Can impacts be mitigated?	Yes	
Mitigation	Maintain vehicles, prevent, and address spillages.	
Cumulative Impacts	The cumulative impact of this activity will be small if managed.	
Residual Impacts	Unless appropriate mitigation is implemented, this activity can become problematic to the environments and hazardous to human health.	

Impact 5: Cumulative impact of the loss of agricultural land

Impact Nature: Land that is no longer able to be utilised.		
	The impact of the proposed project in isolation	**The cumulative impact of the project together with other projects within the area**
Extent	Local (1)	Local (1)
Duration	Long-term (4)	Long term (4)
Magnitude	Low (3)	Low (2)
Probability	Definite (4)	Definite (4)
Significance	MEDIUM (32)	LOW (28)
Status	Negative	Negative
Reversibility	Low	High
Irreplaceable loss of resources	No	No
Can impacts be mitigated?	Yes	
Mitigation	Ensuring that as little surface disturbance as possible occurs. Avoid all drainage lines/systems. Care must be taken with excavation into soils. Rehabilitate construction site by using indigenous grasses. Implement effective erosion control measures and an Erosion Management Plan.	

9 Discussion and Conclusion

Based on the information obtained, an area of 320 ha with the most favourable soil characteristics was selected. Figure 1 illustrates the proposed development area for the Brypaal Solar Power (PV) Project.

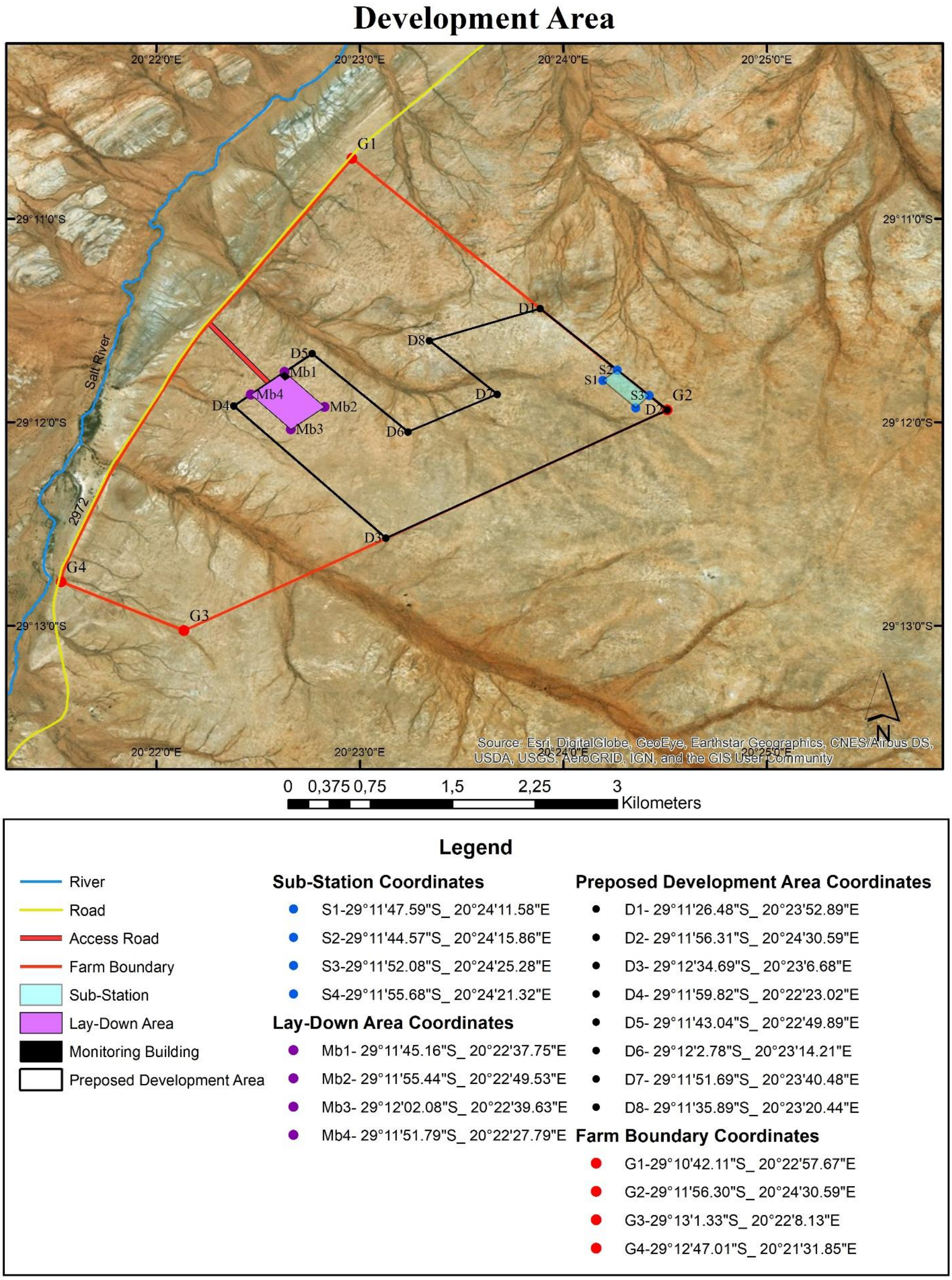


Figure 16: Map indicating the proposed development area (Google Earth, 2016).

During this investigation it was confirmed that the most favourable soil conditions is within the south-eastern part of the study area, due to the overall low soil dispersivity.

A summary of the pre- and post-mitigation impact significance ratings for the different impacts and risk factors identified for the proposed development are provided below (Table 8).

Table 8: Summary of pre- and post-mitigation impact significance ratings.

Construction and Operational Phase			
Phase	**Impact**	**Significance Pre-mitigation**	**Significance Post-mitigation**
Construction and Operational	Loss of agricultural land.	MEDIUM (32)	LOW (21)
	Increased susceptibility to erosion.	MEDIUM (36)	LOW (21)
	Dust generation.	MEDIUM (40)	LOW (18)
	Vehicle operation on site.	LOW (28)	LOW (10)

Cumulative Impacts			
Phase	**Impact**	**The impact of the proposed project in isolation**	**The cumulative impact of the project together with the projects within the area**
Cumulative	Cumulative impact of the loss of agricultural land	MEDIUM (32)	LOW (28)

From this Soil Impact Assessment, the following conclusions can be drawn:

- The arid climate of the study area coupled with the shallow soils limits the agricultural potential to low intensity grazing. Therefore, the impact of the proposed development on agricultural resources is considered to be small.
- The long-term challenges regarding the management of salts in the dust are problematic and can be managed through the application of dust suppressant polymers on the dirt roads.
- Erosion must be controlled through appropriate mitigation and control structures.
- Impacts from vehicles such as spillages, should be prevented and mitigated.
- Dust generation should be mitigated and minimised.

In perspective, the impacts of the proposed facility can be motivated as necessary in decreasing the impacts in areas where agriculture potential plays a more significant role. The importance of generating cleaner energy in and for South Africa cannot be overemphasised. Consequently, there will be no impacts that cannot be mitigated or that should prevent the development from being approved.

10. Erosion Management Plan

10.1 Purpose

Exposed and unprotected soils are the main cause of erosion. This erosion management plan and the revegetation and rehabilitation plan are closely linked to one another. The Erosion Management Plan addresses the management and mitigation of significant impacts relating to soil erosion. Therefore, it is crucial to construct a general framework for soil erosion and sediment control and to provide an outline of general methods to monitor, manage and rehabilitate erosion throughout all the phases of development.

The technology used for this development is known as the Screw-In Pilon technology, which eliminates the problem of topsoil stripping, terracing or concrete mattress foundation systems. This technology ensures minimal environmental disturbance therefore a Soil Management Plant will not be acquired.

10.2 Relevant Aspects of the Site

One land type (Ag3) dominates the entire study area. According to the Land Type Survey Staff (2003), 40% of land type Ag3 consists of freely drained, shallow (< 300 mm deep), red, eutrophic, apedal soils with yellow-brown soils comprising less than 10% of this land type. The average depth of all soils is 280.5 mm. Approximately 77% of land type Ag3 consist of soils with a depth of ≤ 300 mm (depth class D1), whereas 12.5% consist of soil with a depth of 901 mm to 1200 mm (depth class D4). The average topsoil clay percentage of land type Ag3 is 10.7%. Around 88.5% of land type Ag3 consist of loamy sand soils (clay class C2) with an average clay percentage of 6.1% to 15% in the topsoil, whilst 1% consist of sandy loam soils (clay class C3) with an average clay percentage of 15.1% to 25% in the topsoil (Land Type Survey Staff, 2003).

The soils of land type Ag3 can be divided into three soil classes. Table 9 illustrates the different soil classes, description of soil classes, soil forms and percentage occupancy of each soil class within land type Ag3.

Table 9: Description of soil classes within land type Ag3 (Land Type Survey Staff, 2003).

Soil Classes	Description	Soil Form	Percentage occupancy
S2	Freely drained, structureless soils.	*Hutton, Clovelly, Griffen, Shortlands, Oakleaf.*	58,3%
S13	Lithic soil (shallow soils on hard weathering rocks).	*Mispah, Glenrosa.*	31,2%
S16	Non-soil land classes	*Pans, rivers, stream beds, erosion structures, marshes, reclaimed land, dunes, gravel, etc.*	0,5%

Approximately 58.3% of land type Ag3 consists of freely drained, structureless soils, whereas 31.2% consist of characteristic lithic soils. A small part (0.5%) of land type Ag3 is occupied by structures like pans, rivers, stream beds, erosion structures, marshes, reclaimed land, dunes and gravel.

Due to climatic restrictions as well as poor quality and lack of water, the major use of this area is for grazing. The expected impact of the proposed solar facility on soils is considered to be low, however, mitigation measures need to be implemented in order to prevent and contain erosion associated with soil disruptions during the construction phase.

10.3 Erosion and sediment control principles

In order to control and prevent soil erosion during and after construction it is important to:

- Protect the land surface from erosion;
- Avoid the disturbance of natural drainage systems; or intercept and redirect run-off water; and
- Progressively revegetate the disturbed areas.

The following management practices are described for the purpose of preventing soil erosion.

10.3.1 On-site Erosion Management

Note the following factors regarding erosion risk at the site:

- Soil erosion will be greater during wet periods (occasional summer thunder storms), therefore precautions to prevent soil erosion should be present throughout the year.
- Steeper slopes are more prone to soil erosion, therefore, no not disturb or remove vegetation on steep slopes, as it will increase erosion potential.
- The time passed before rehabilitation will also influence soil loss. Keep the gap between construction activities and rehabilitation to a minimum.
- Erosion is also influenced by the extent of disturbance; therefore, site clearance should be restricted to areas required for construction purposes. According to the design specifications used for this proposed project, the only site clearing necessary is for access and maintenance roads, the lay-down area, the substation, temporary workshops, mobile offices vehicle parking areas etc. and for permanent buildings. No soil stripping is acquired for the area where the solar panels are places.
- The planning and construction of roads and infrastructure should occur in a manner to minimise erosion potential. Roads should follow the contour as far as possible and be built on water sheds.
- Constructed roads should include water diversion structures if necessary according to the Storm Water Management Plan.

- Disturbed areas should be regularly monitored for erosion during the routine maintenance program. Erosion problems should be rectified and monitored thereafter.
- Drainage systems are required for compacted areas. Heavy machinery, which causes surface compaction, should keep on the constructed roads or directed areas as described by engineers.
- Revegetation of bare areas with appropriate locally occurring species is necessary to limit erosion potential.
- On-site activity after rainfall should be kept to a minimum to keep erosion risk at a minimum.
- Regular monitoring of erosion problems during construction and operation phase is recommended.

10.3.1.1 Erosion control mechanisms

The following mechanisms can be used in order to minimise erosion:

- Reno Mattresses
- Gabion Baskets
- Storm water channels and catch pits
- Soil stabilisation chemicals approved by the Department of Agriculture
- Hydro-seeding or revegetation together with rock rip rap or rock armour covers
- Boulders and rocks of different sizes

10.3.2 Engineering Specifications

A detailed Storm Water Management Plan describing and illustrating the proposed storm water control measures is attached to the EMP report. Requirements for project design include the following:

- Erosion control measures including the final Storm Water Management Plan, should be implemented before and during the construction period.
- An on-site Environmental Officer will be responsible for ensuring the implementation of the erosion control measures on site during the construction period.
- The Developer holds ultimate responsibility for remediation in the event of damage to the environment.

10.3.3 Monitoring

Continuous monitoring during construction and operational phase is required, in order to establish the indication and degree of erosion. If erosion features as a result of the activities on site are recorded, the Environmental Officer (construction phase) or Environmental Manager (operational phase) must:

- Assess the degree of erosion.
- Take photographs and notes of the soil degradation.
- Determine the cause of soil erosion.
- Inform the operator about the problem and that rehabilitation must take place. The operator must implement a rehabilitation method statement and management plan.
- Report and monitor the process of rehabilitation weekly and record all findings in a site register.
- All actions with regard to the incidents must be reported monthly by means of a monthly compliance report which will be submitted to the Competent Authority (construction phase) and filed for consideration during annual audits (construction and operational phase).

10.4 Conclusion

The Erosion Management Plan assist the Developer with guidelines on how to manage erosion. This document forms part of the EMPr and is required to be considered during the design, construction, operation and decommissioning phases of the project.

11 Mitigation Considerations

With respect to erosion control and minimising of dust generation, it is important to implement measures to minimise these problems.

Objective	Erosion Control	
Project components	Erosion control measures: Soil stabilisation, construction of impoundments and erosion mitigation structures.	
Potential impact	Water erosion, loss of topsoil, erosion gullies.	
Activity risk/source	Inadequate planning of road network and poor planning of rainfall surface and storm water management.	
Mitigation objectives	Prevent soil erosion.	
Action/control	**Responsibility**	**Timeframe**
Adequate planning of roads, contour walls and other erosion control measures if necessary.	Civil engineers and construction team.	Throughout the duration of the project.
Performance indicator	That no soil erosion occurs on and/or directly downstream of the site (with specific reference to gully erosion) as result of overland flow from the proposed development. Assessment of storm water structures and erosion mitigation measures.	
Monitoring	Periodic visual site inspections, especially following rain events. Use updated satellite imagery to compare with imagery prior to development, in order to determine whether existing erosion drainage systems expanded. If expansion did occur, more intensive monitoring will be acquired where suspended sediments are measured during and after rain events to ensure that rehabilitation actions are effective.	

Objective	Dust generation due to vehicle activity on the site	
Project components	Limit the generation of dust associated with vehicle activity.	
Potential impact	Dust generation, potential health risk for humans and animals.	
Activity risk/source	Excessive traffic on dirt roads.	
Mitigation objectives	Prevent soil erosion.	
Action/control	**Responsibility**	**Timeframe**
Restrict vehicle movement to a minimum, ensure that dirt roads are moist using dust suppressants during peak construction periods.	Civil engineers and construction team.	Throughout the duration of the project.
Performance indicator	Excessive dust generation does not degrade natural veld, no complaints from excessive dust from local inhabitants.	
Monitoring	Visual observations and ensure compliance with National Dust Control Standards.	

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LEGISLATION

National Environmental Management Act (No. 107 of 1998)

Subdivision of Agricultural Land Act (Act 70 of 1970)

Conservation of Agricultural Resources Act (Act 43 of 1983)

Bill of Rights

Environmental Conservation Act (No. 73 of 1989)

Mineral and Petroleum Resources Development Act (No. 28 of 2002)

Conservation of Agricultural Resources Act (No. 43 of 1983)

National Veld and Forest Fire Bill (of 10 July 1998)

Fertiliser, Farm Feeds, Agricultural Remedies, and Stock Remedies Act (No. 36 of 1947)

Sub-division of Agricultural Land (SALA) Act (Act 70 of 1970)

ANNEXURE A: BACKGROUND INFORMATION & SOIL DATA

EXPLANATION OF SYMBOL

OBSERVATION NUMBER
Personal

FORM/SERIE/FAMILY
Depends on requirement e.g.
Hu36 or Hu3200 or Hu36/3200

TEXTURE CLASS
(of the A horizon for classification purposes)

fi = fine
me = medium
co = coarse
Sa = sand
Cl = clay
Lm = loam
Sl = silt

PHASE
Phase notations where necessary

OBSERVATION TYPE
Circle correct letter

A = auger
C = cutting or pit

HORIZONS
ob = overburden
O = O horizon
A1-A2 = A horizon
E = E horizon
B1-B2 = B horizon
C = saprolite/uncon. mat.
G = G horizon
R = hard rock

DEPTH
Lower boundary of the horizon in mm.

CLAY PERCENTAGE
Field method

SAND GRADE
fi = fine
me = medium
co = coarse

COLOUR
Munsell colour of the horizon (always the moist colour, optional dry colour e.g. for E and bleached A, etc.)

MOTTLES

OCC = OCCURANCE

f = few (<2%)
c = common (2-20%)
m = many (>20%)

COL = COLOUR
Y = yellow
R = red
BR = brown
Bl = black
G = grey
O = orange

LIME

OCC = OCCURANCE
s = sporadic
c = common
a = abundant

TYPE
N = nodular
P = powdary
NP = nodular and powdary

STRUCTURE

GRA = GRADE
A = apedal
W = weak
M = medium
S = strong

SIZE
f = fine
m = medium
c = coarse

TYPE
SG = single grain
MA = massive
AB = angular blocky
SB = subangular blocky
GR = granular
CR = crumb
PR = prismatic
CO = columnar
PL = platy

COARSE FRAGMENTS
TYPE
G = gravel
S = stones
B = boulders
P = plinthite

%
Estimated percentage of the horizon occupied by coarse fragments

DIAGNOSTIC HORIZONS
oo = Organic O horizon
ah = Humic A horizon
vc = Vertic A horizon
ml = Melanic A horizon
ot = Orthic A horizon
gs = E horizon
gh = G horizon
re = Red apedal B horizon
ye = Yellow-brown apedal B horizon
vr = Red structured B horizon
sp = Soft plinthic B horizon
hp = Hard plinthic B horizon
pr = Prismacutanic B horizon
gc = Gleycutanic B horizon
vp = Pedocutanic B horizon
lc = Lithocutanic B horizon
ne = Neocutanic B horizon
nc = Neocarbonate B horizon
pz = Podzol B horizon
pp = Podzol B horizon with
PP = Placic pan
rs = Regic sand
al = Stratified alluvium
db = Dorbank
so = Saprolite
sc = Soft carbonate horizon
hc = Hard carbonate horizon
ud = Unconsolidated material, without signs of wetness
uw = Unconsolidated material,
on = Unspecified material, with
mm = Man-made soil deposit
ro = Hard rock

PARENT MATERIAL
UN = Unknown
AL = Alluvium
AE = Aeolian
CO = Colluvium
GA = Gabbro
GR = Granite
BA = Basalt, dolerite
AN = Andesite
RH = Rhyolite
QS = Quartz sandstone
FS = Feldspathic sandstone
MS = Micaceous sandstone
SH = Shale
MU = Mudstone
SI = Siltstone
DO = Dolomite, chert
TI = Tillite
IR = Banded Ironstone
GN = Gneiss
SC = Schist
SL = Slate
DI = Diabase
BR = Breccia

EFFECTIVE DEPTH
Effective depth of profile for general plant growth in mm

TERRAIN UNIT
1 = Crest
2 = Scarp
3 = Midslope
3U = Upper Midslope
3L = Lower Midslope
4 = Footslope
4U = Upper Footslope
4L = Lower Footslope
5 = Valley bottom
6 = Terrace
7 = Closed depression

DEPTH LIMITING MATERIAL
so = saprolite
hp = hard plinthite
R = rock
gc = gleyed material
st = strong structure
k = calcrete
sl = stone line

GPS (optional)
Reading of Global Positional System instrument .

In case of map reading, cross GPS text

SKETCH
Optional for e.g. landtype surveys

REMARKS
Soil features for which no provision is made, e.g. surface rock, consistance, vegetation, disturbed profile, water table, erosion and type of analysis required for the samples are noted here.

Figure A-1: Soil description categories (Land Type Survey Staff, 1991).

SURVEY: ______________________ SURVEYER: ______________________ DATE: ____________ PAGE: ______

Observ. no.:	Hor.	Depth (mm)	Clay %	Sand grade	Dry colour	Moist colour	Mottles		Lime		Structure			Coarse Frag.		Diag. hor.	Bag no.	Parent mat.
Form/Serie/Family							Occ	Col.	Occ	Type	Gra	Size	Type	Type	%			Eff. depth:
																		Terrain unit:
Text. class.:																		Depth lim. mat.:
																		GPS Lat.:
Phase:																		Long.:
Observ. type: A C	Remarks:																	
Obsv. no.:																		Parent mat.:
Form/Serie/Family																		Eff. depth:
																		Terrain unit:
Text. class.:																		Depth lim. mat.:
	Observ. type: A C		Remarks:															GPS Lat.:
Phase:																		Long.:
Obs. no.:																		Parent mat.:
Form/Serie/Family																		Eff. depth:
																		Terrain unit:
Text. class.:																		Depth lim. mat.:
	Observ. type: A C		Remarks:															GPS Lat.:
Phase:																		Long.:
Obs .no.:																		Parent mat.:
Form/Serie/Family																		Eff. depth:
																		Terrain unit:
Text. class.:																		Depth lim. mat.:
	Observ. type: A C		Remarks:															GPS Lat.:
Phase:																		Long:

Figure A-2: Standard soil description form (Land Type Survey Staff, 1991)

LAND TYPE / *LANDTIPE* .... :	Ag3	Occurrence (maps) and areas / *Voorkoms (kaarte) en oppervlakte :*		Inventory by / *Inventaris deur :*
CLIMATE ZONE / *KLIMAATSONE* .... :	185S	2818 Onseepkans (54250 ha)	2820 Upington (119200 ha)	R W Bruce, J P Coetzee & P R Swanepoel
Area / *Oppervlakte* .... :	529750 ha	2918 Pofadder (111920 ha)	2920 Kenhardt (244380 ha)	Modal Profiles / *Modale profiele :*
Estimated area unavailable for agriculture *Beraamde oppervlakte onbeskikbaar vir landbou :*	2520 ha			P27 P437 P819 *6393 11772 2151*

	1	1(1)	2	3	3(1)	4	5
Terrain unit / *Terreineenheid* .... :	1	1(1)	2	3	3(1)	4	5
% of land type / *% van landtipe* .... :	0.3	32	0.3	0.4	50	10	7
Area / *Oppervlakte (ha)* .... :	1589	169520	1589	2119	264875	52975	37082
Slope / *Helling (%)* .... :	0 - 8	0 - 2	>100	15 - 100	1 - 4	0 - 2	0 - 1
Slope length / *Hellingslengte (m)* .... :	50 - 300	500 - 1500	10 - 100	50 - 400	1000 - 2500	300 - 1000	50 - 500
Slope shape / *Hellingsvorm* .... :	Y	Y	Z	X	Z	Z-X	X-Z
MB0, MB1 (ha) .... :	0	0	0	0	10595	26488	28924
MB2 - MB4 (ha) .... :	1589	169520	1589	2119	254280	26487	8158

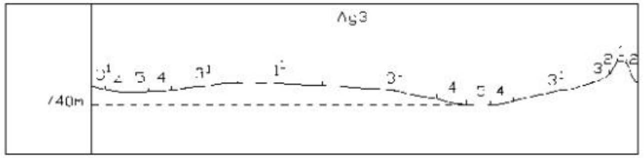
Soil series or land classes ***Grondseries of landklasse***	**Depth** ***Diepte*** **(mm)**	**MB**	**ha**	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**	**Total** ***Totaal*** **ha**	**%**	**Clay content %** ***Klei-inhoud %*** **A**	**E**	**B21**	**Hor**	**Texture** ***Tekstuur*** **Class / *Klas***	**Depth limiting material** ***Diepte-beperkende materiaal***
Rock / Rots		4	1065	67	25428	15	1589	100	1589	75	21190	8	2119	4			52980	10.0						
Mispah Ms10, Kalkbank Ms22, Muden Ms20	50-100	3	524	33	91541	54			530	25	66219	25	5298	10	1112	3	165224	31.2	5-12			A	me/coSa-LmSa	R,ka,db
Portsmouth Hu35, Vergenoeg Hu45, Zwartfontein Hu34, Malonga Hu44	100-400	3			32209	19					79462	30	8476	16	2225	6	122372	23.1	6-12		6-15	B	me/coSa-SaLm	R,so,ka,
Shorrocks Hu36, Shigalo Hu46	100-400	3			20342	12					87409	33	10595	20	2225	6	120571	22.8	9-20		15-25	B	me/coSaLm-SaClLm	R,ka,so,
Shorrocks Hu36, Shigalo Hu46	450-1200+	0									5298	2	13244	25	12979	35	31520	6.0	9-20		15-25	B	me/coSaLm-SaClLm	R,ka,so,
Portsmouth Hu35, Vergenoeg Hu45, Zwartfontein Hu34, Malonga Hu44	450-1200+	0									5298	2	13244	25	10754	29	29295	5.5	6-12		6-15	B	me/coSa-SaLm	R,ka,so,
Letaba Oa26, Leeufontein Oa16, Dundee Du10	450-1200+	0													5191	14	5192	1.0	10-25		15-30	B	me/coSaLm-SaClLm	R,ka,so
Stream beds/Stroombeddings		4													2596	7	2596	0.5						

For an explanation of this table consult LAND TYPE INVENTORY (table of contents)

Ter verduideliking van hierdie tabel kyk LANDTIPE - INVENTARIS (inhoudsopgawe)

Terrain type /*Terreintipe* : A2

Terrain form sketch / *Terreinvormskets*



Geology: Migmatite, gneiss and granite predominantly; small outcrops of ultrametamorphic rocks in places (Namaqualand Metamorphic Complex). Lime nodules and calcrete abundant; dorbank in places; occasional very small pans.

Geologie: Migmatiet, gneis en graniet hoofsaaklik; klein dagsome van ultrametamorfe gesteentes op plekke (Namakwaland Metamorfe Kompleks). Volop kalknodules en kalkreet; dorbank op plekke; enkele baie klein panne.

14 November 2003 B16

Figure A-3: Land type data for land type Ag3 (Land Type Survey Staff, 2003).

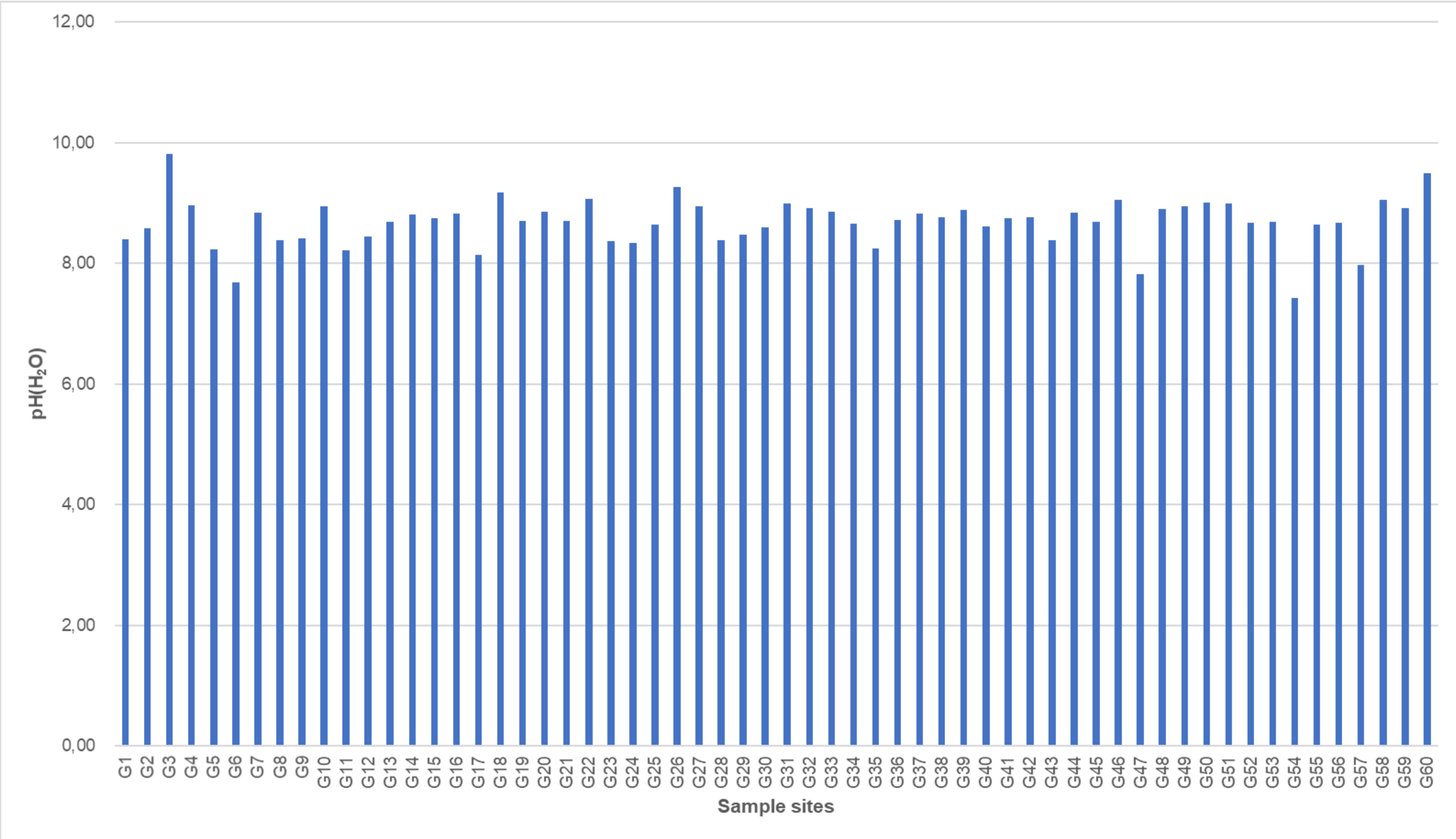


Figure A-4: The Ph (H_2O) of all 60 samples taken during the soil survey.

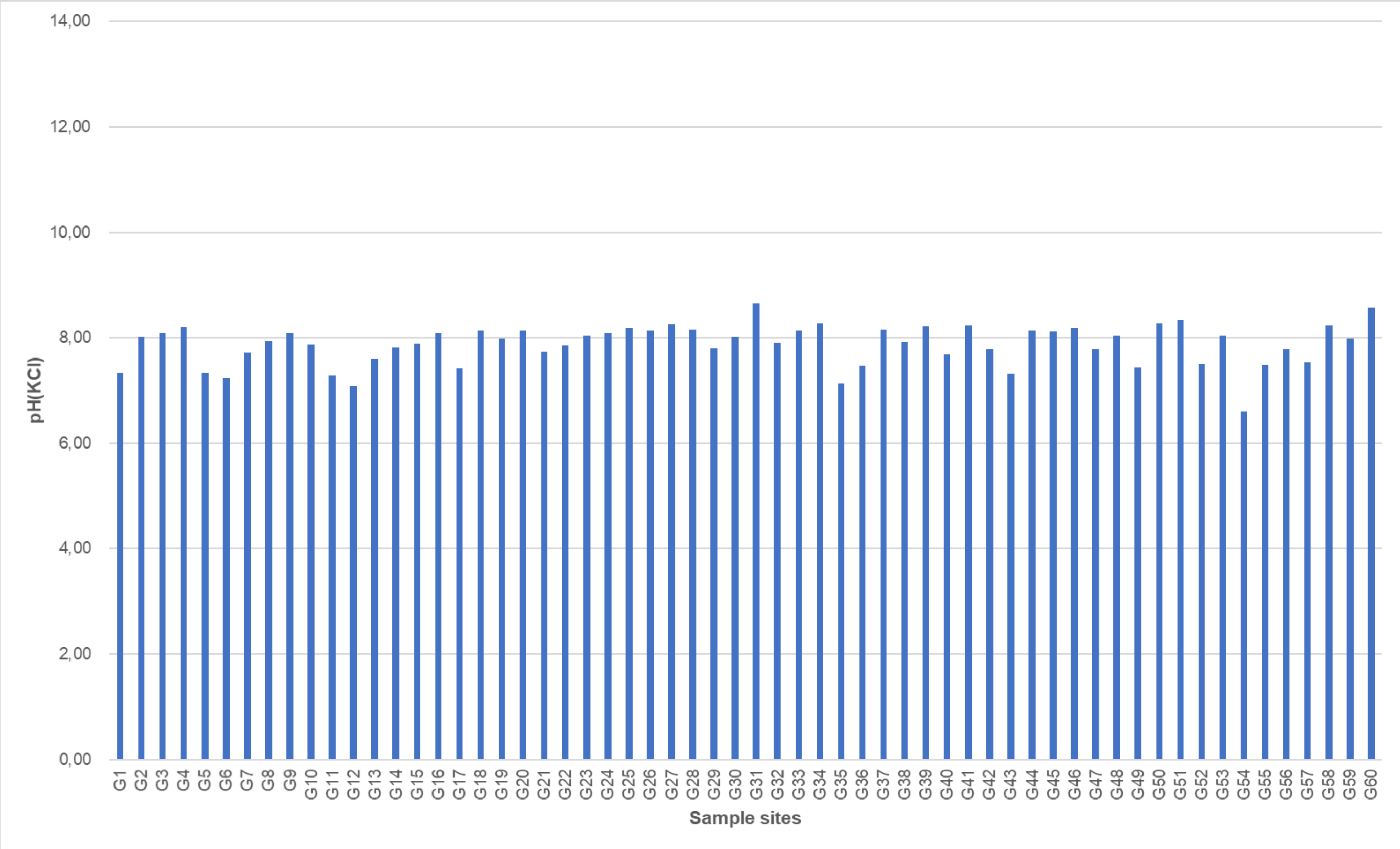


Figure A-5: The pH (KCl) of all 60 samples taken during the soil survey.

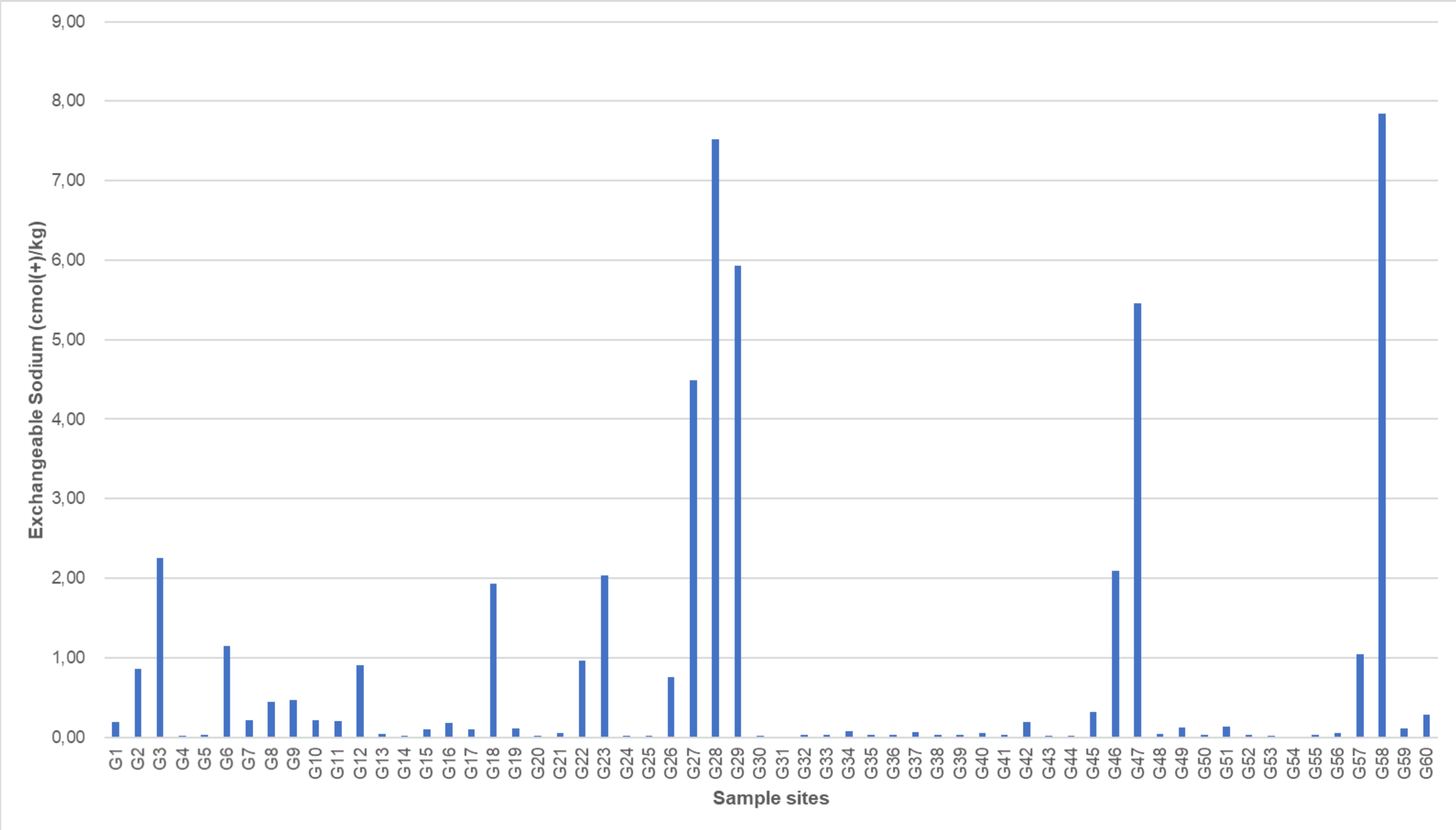


Figure A-6: Exchangeable sodium (cmol(+)/kg) of all 60 samples taken during the soil survey.

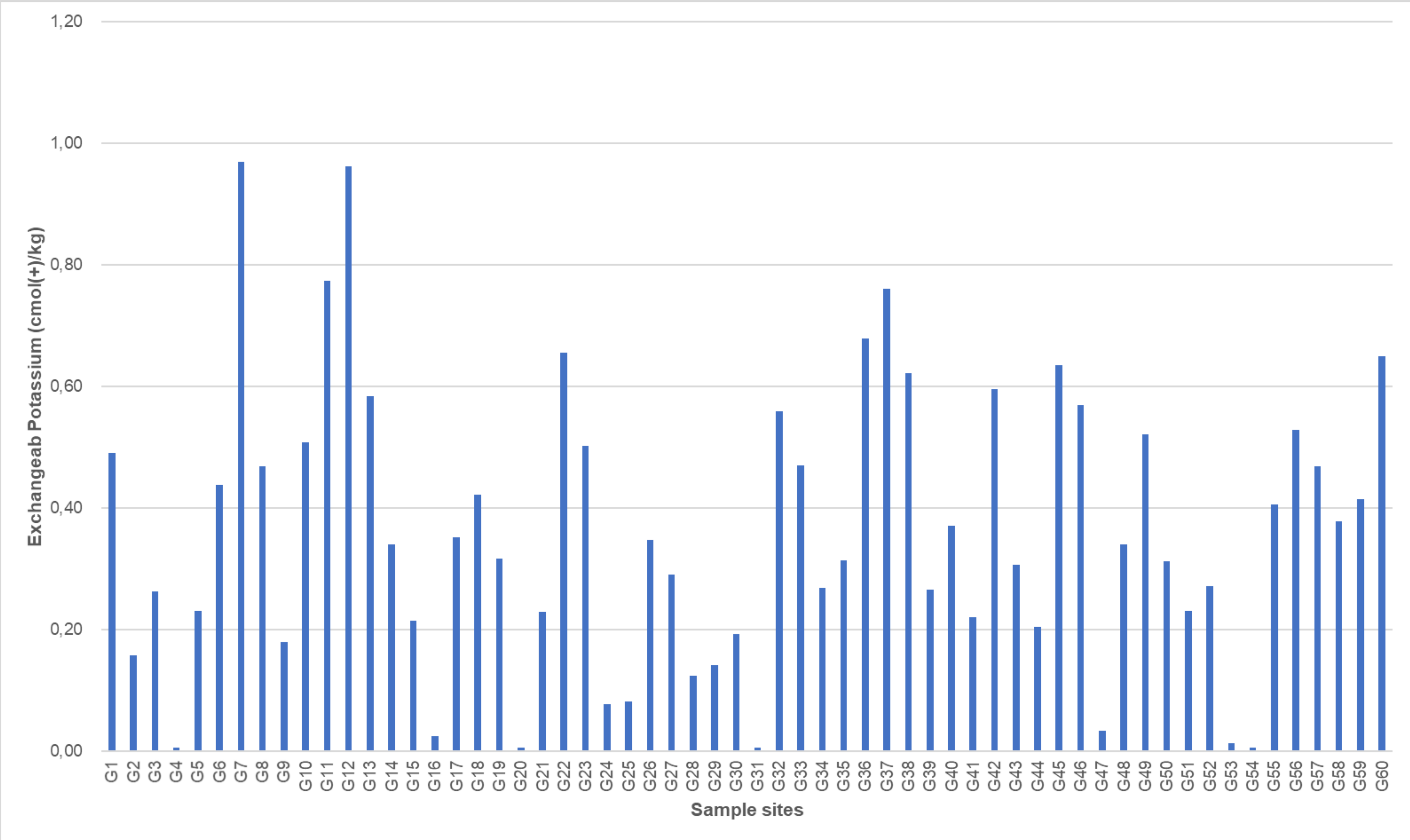


Figure A-7: Exchangeable potassium (cmol(+)/kg) of all 60 samples taken during the soil survey.

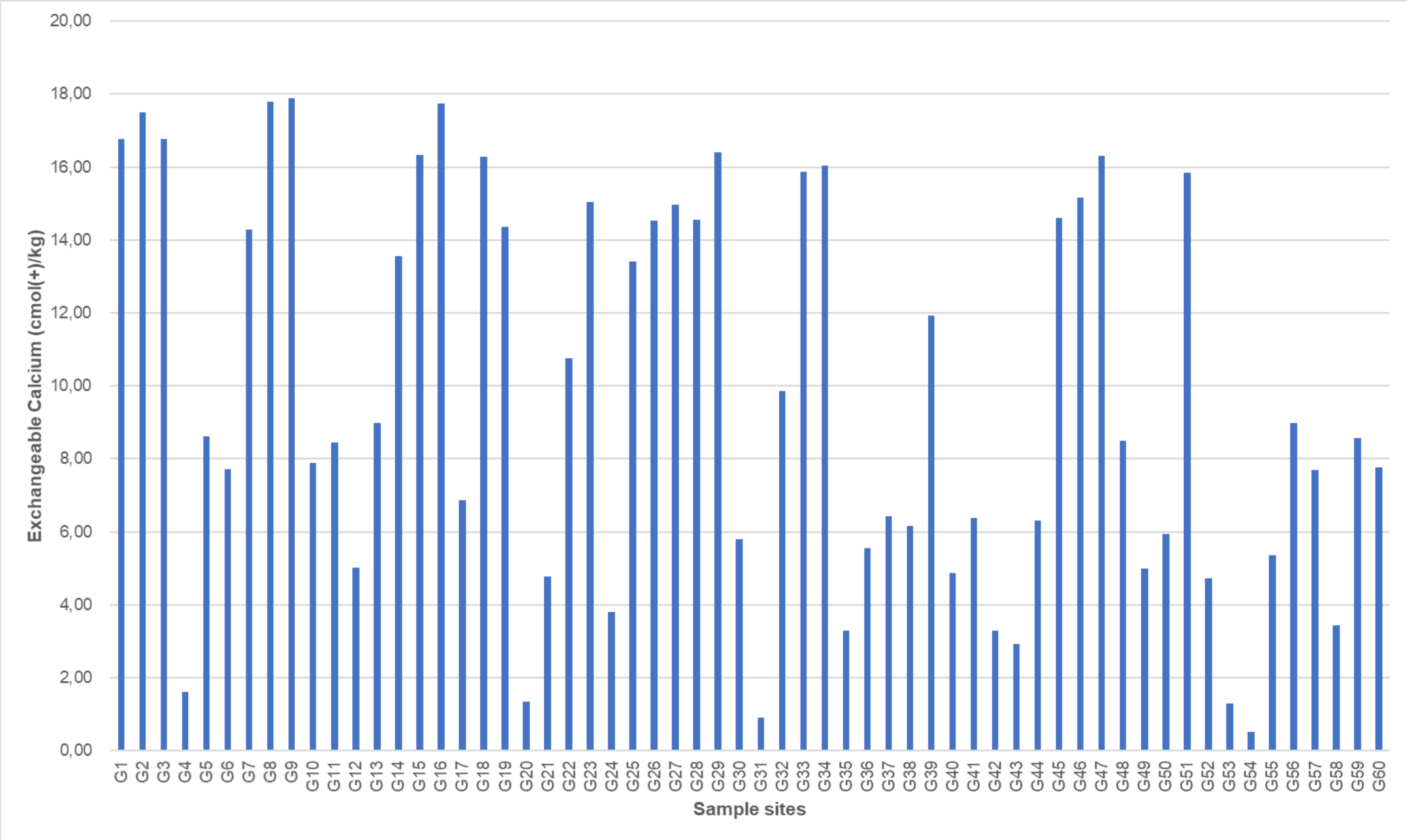


Figure A-8: Exchangeable calcium (cmol(+)/kg) of all 60 samples taken during the soil survey.

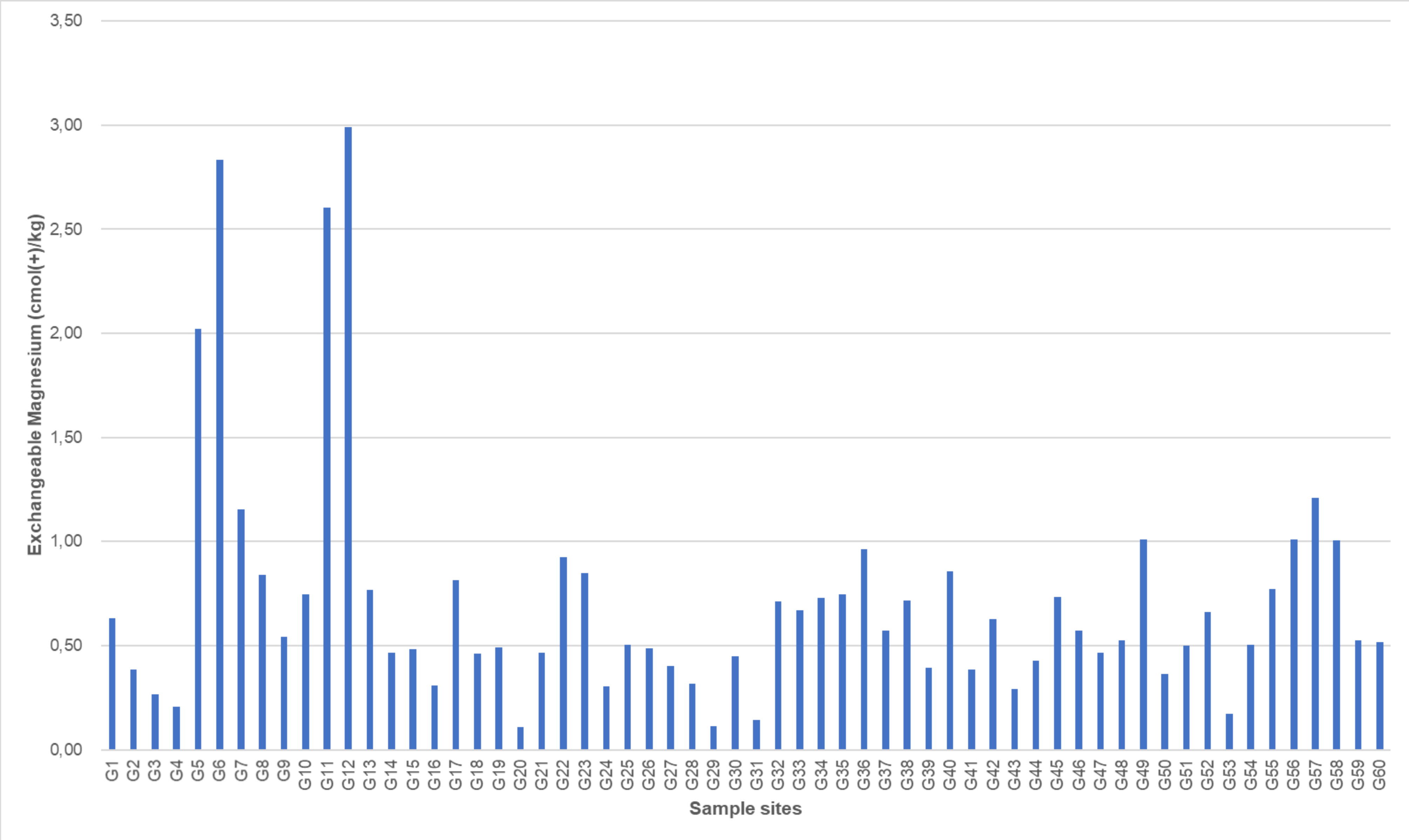


Figure A-9: Exchangeable magnesium (cmol(+)/kg) of all 60 samples taken during the soil survey.

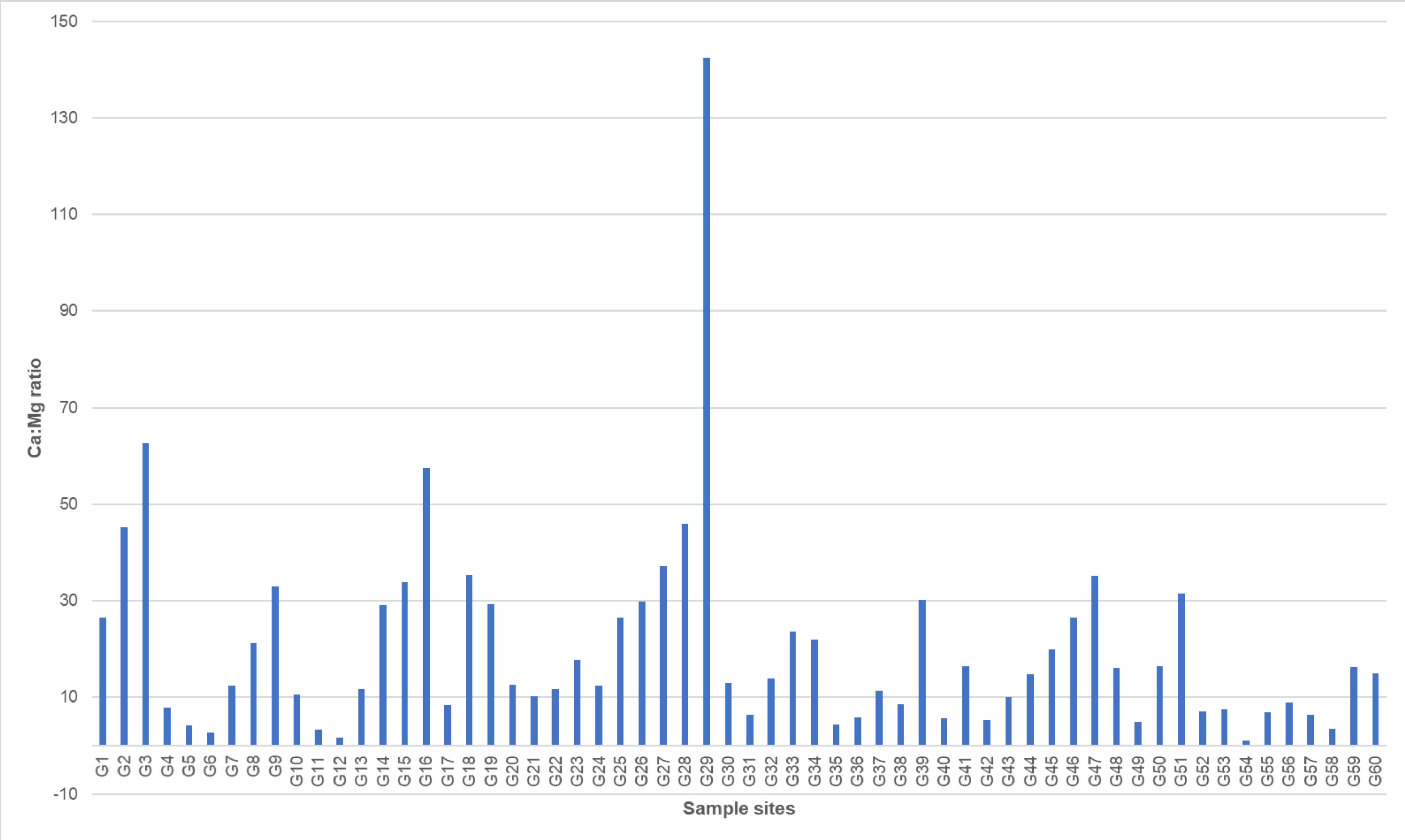


Figure A-10: Ca:Mg ratio of all 60 samples taken during the soil survey.

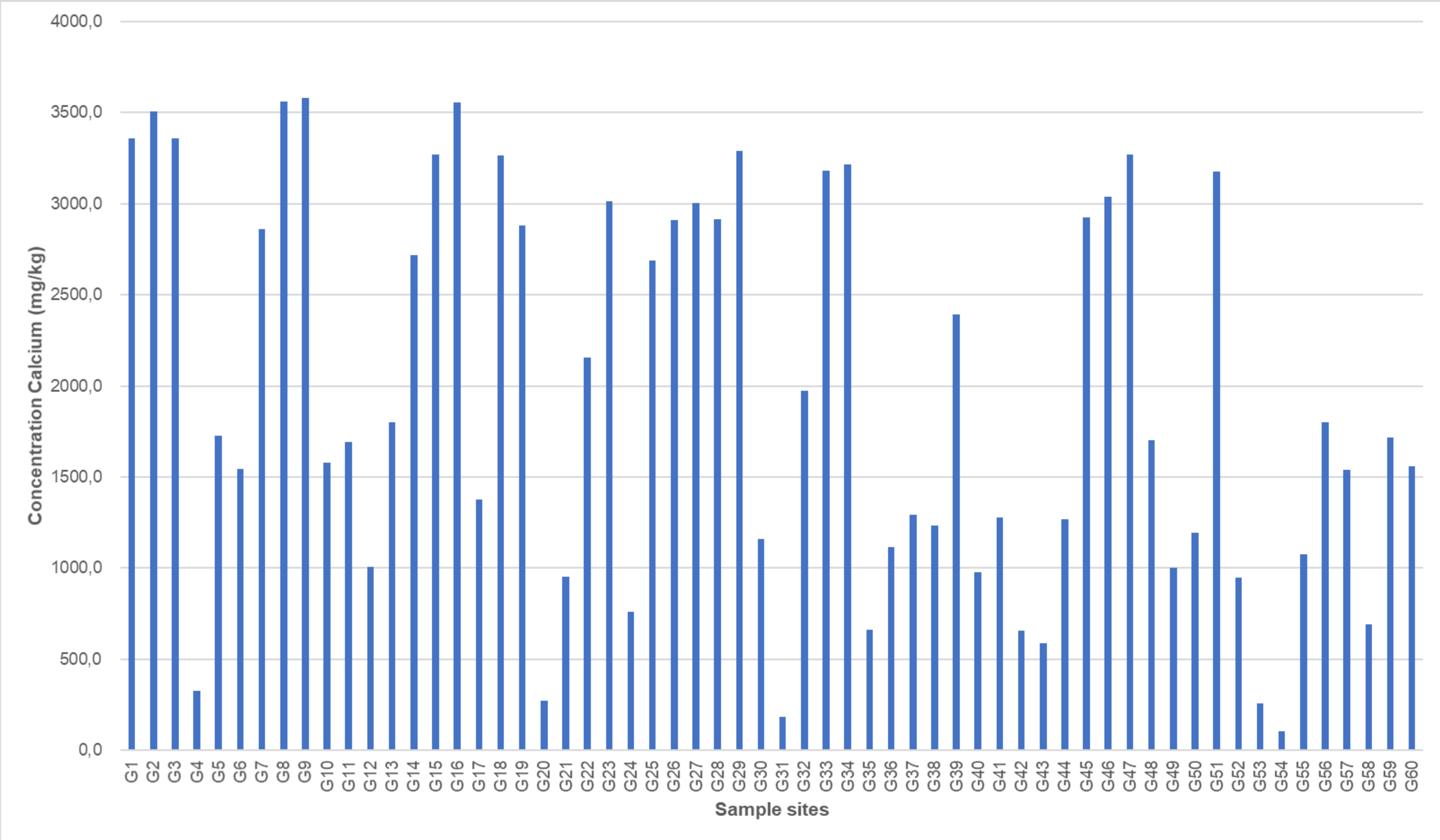


Figure A-11: Concentration calcium (mg/kg) of all 60 samples taken during the soil survey.

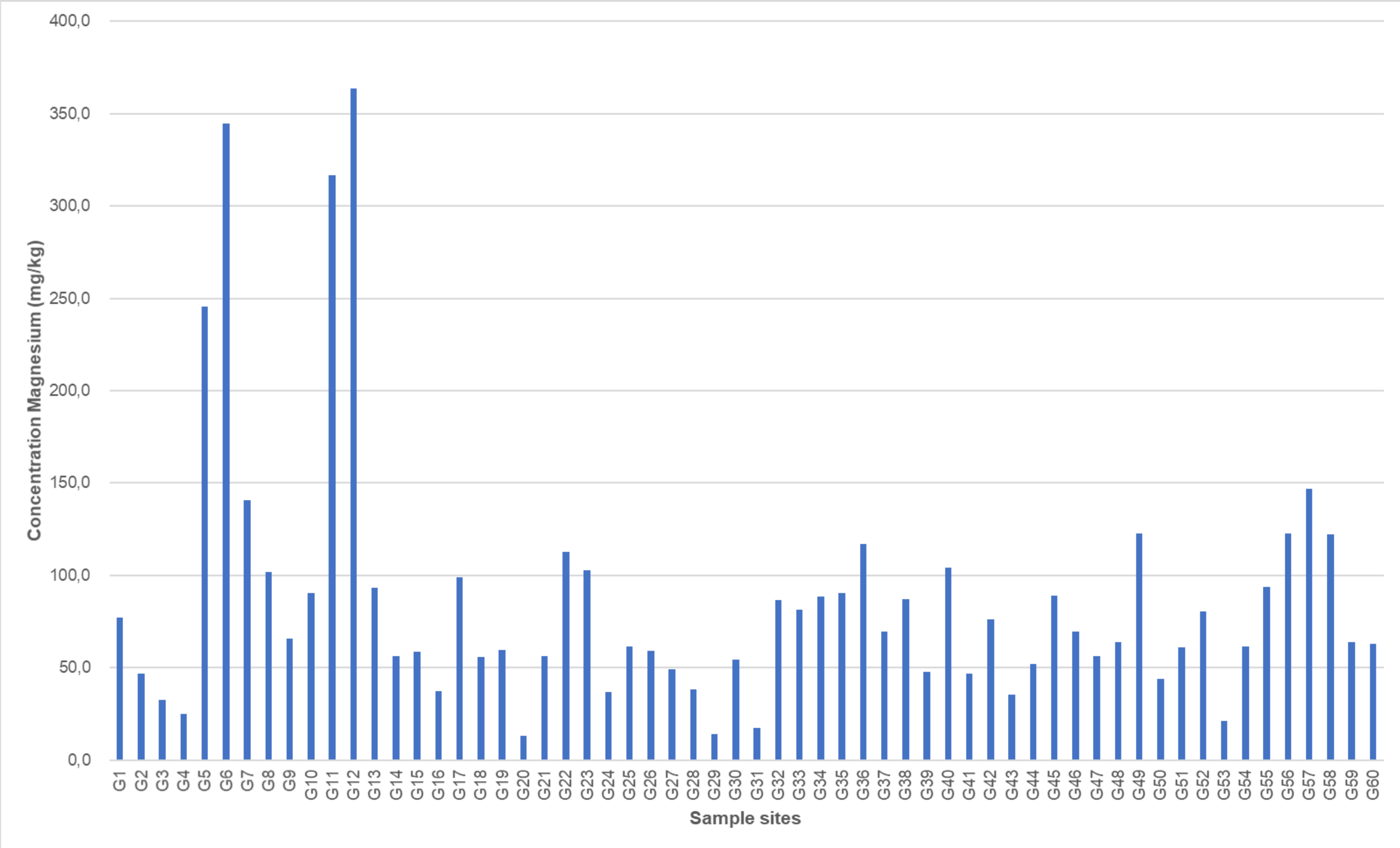


Figure A-12: Concentration magnesium (mg/kg) of all 60 samples taken during the soil survey.

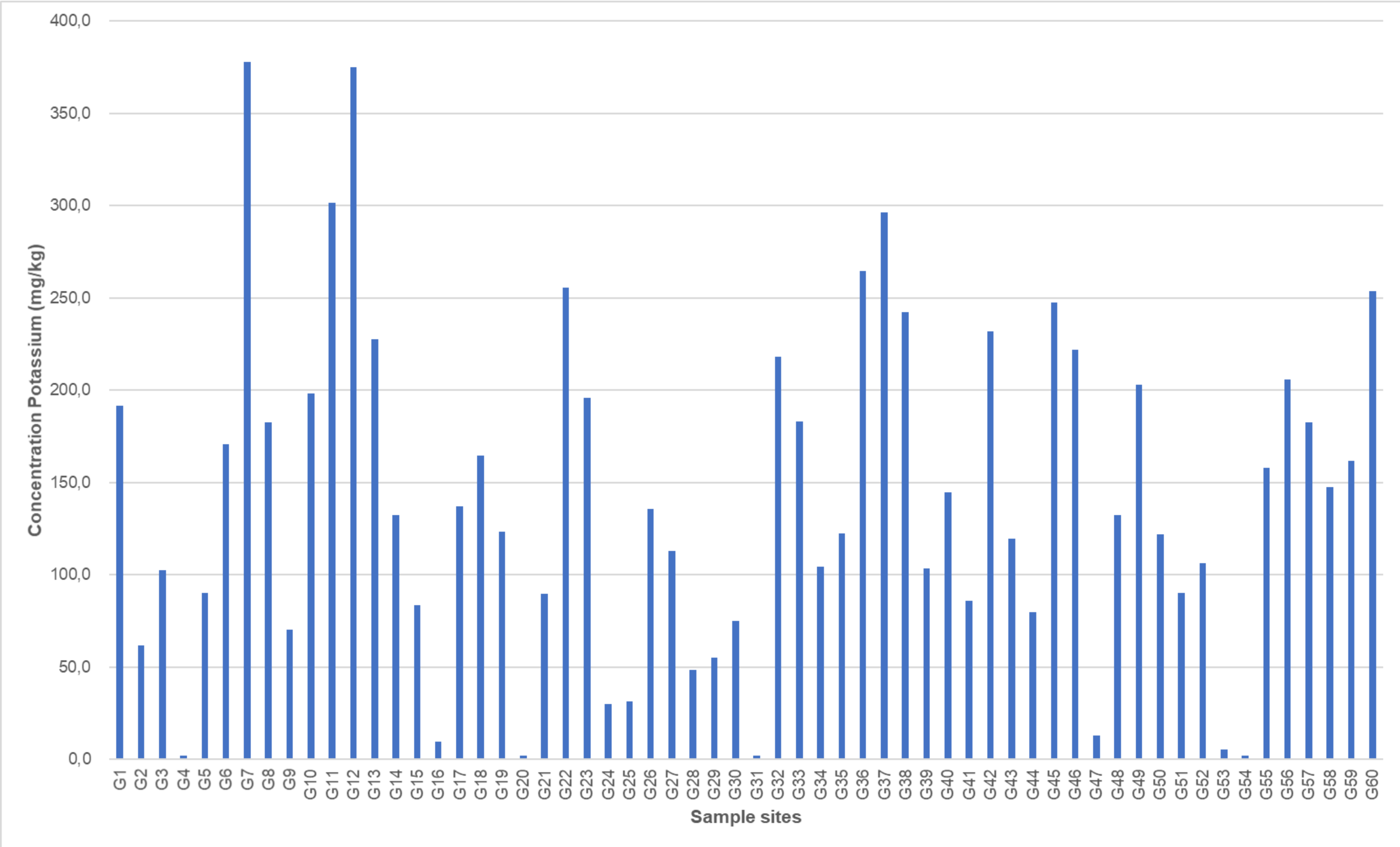


Figure A-13: Concentration potassium (mg/kg) of all 60 samples taken during the soil survey.

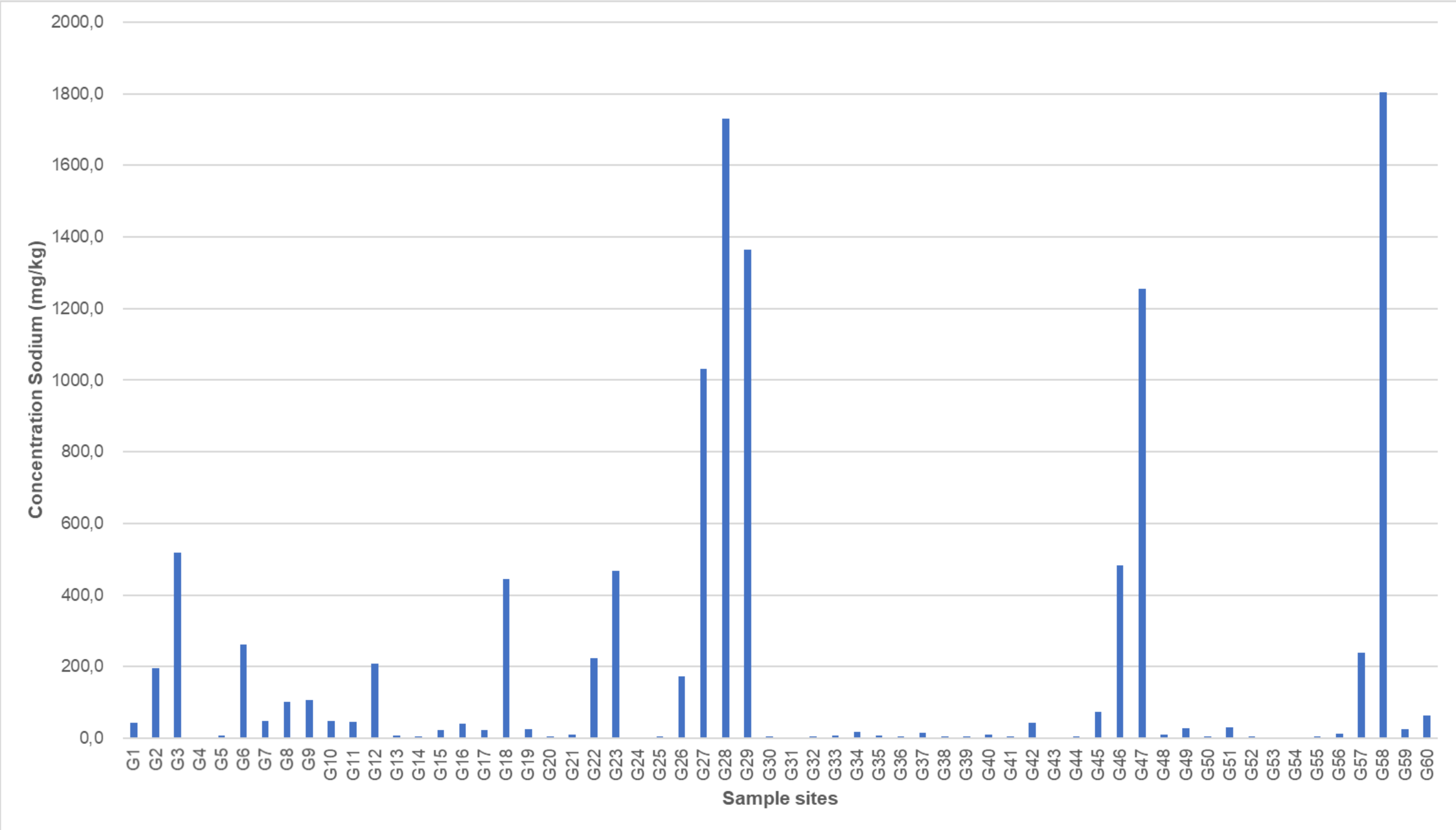


Figure A-14: Concentration sodium (mg/kg) of all 60 samples taken during the soil survey.

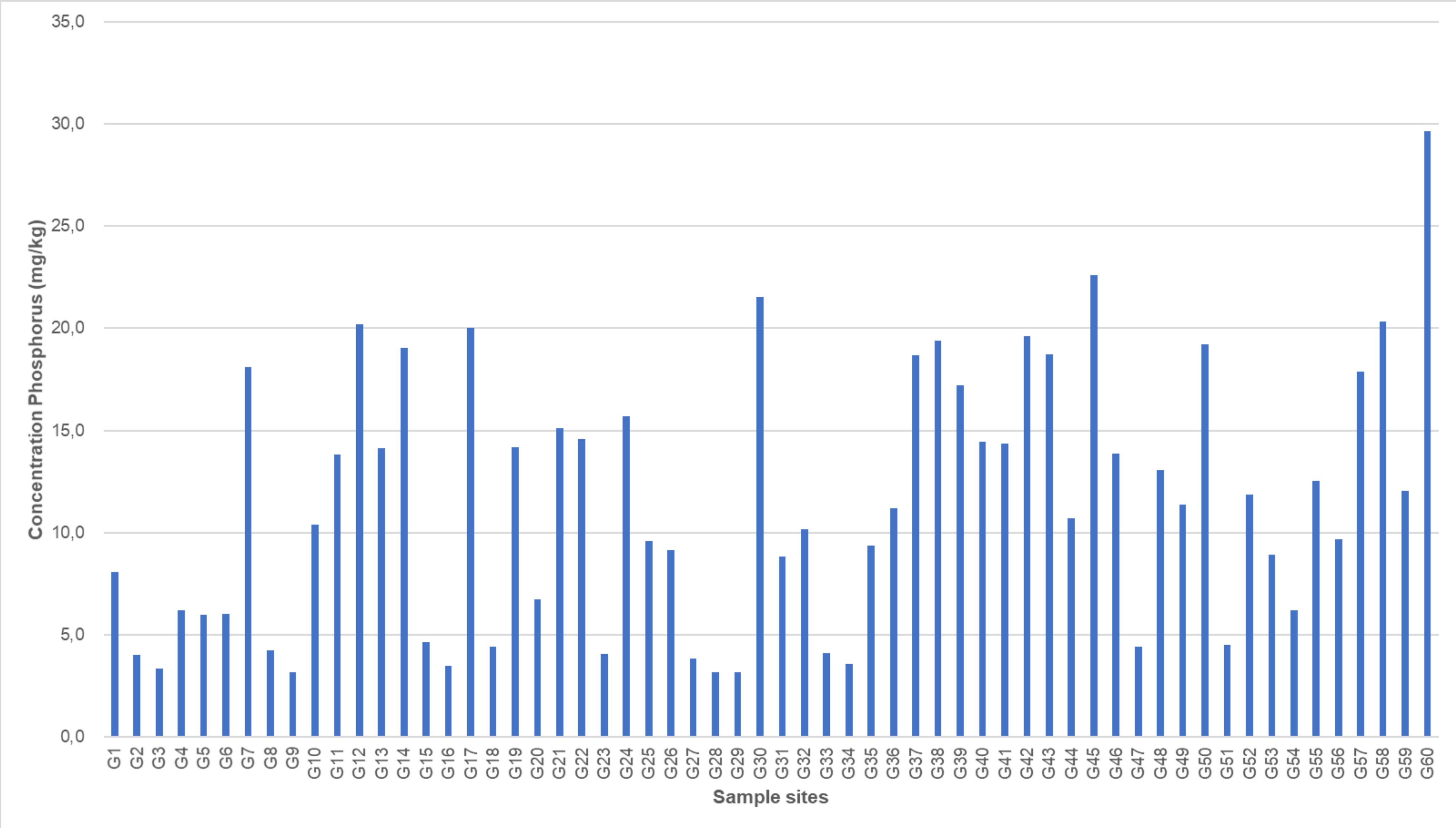


Figure A-15: Concentration phosphorus (mg/kg) of all 60 samples taken during the soil survey.

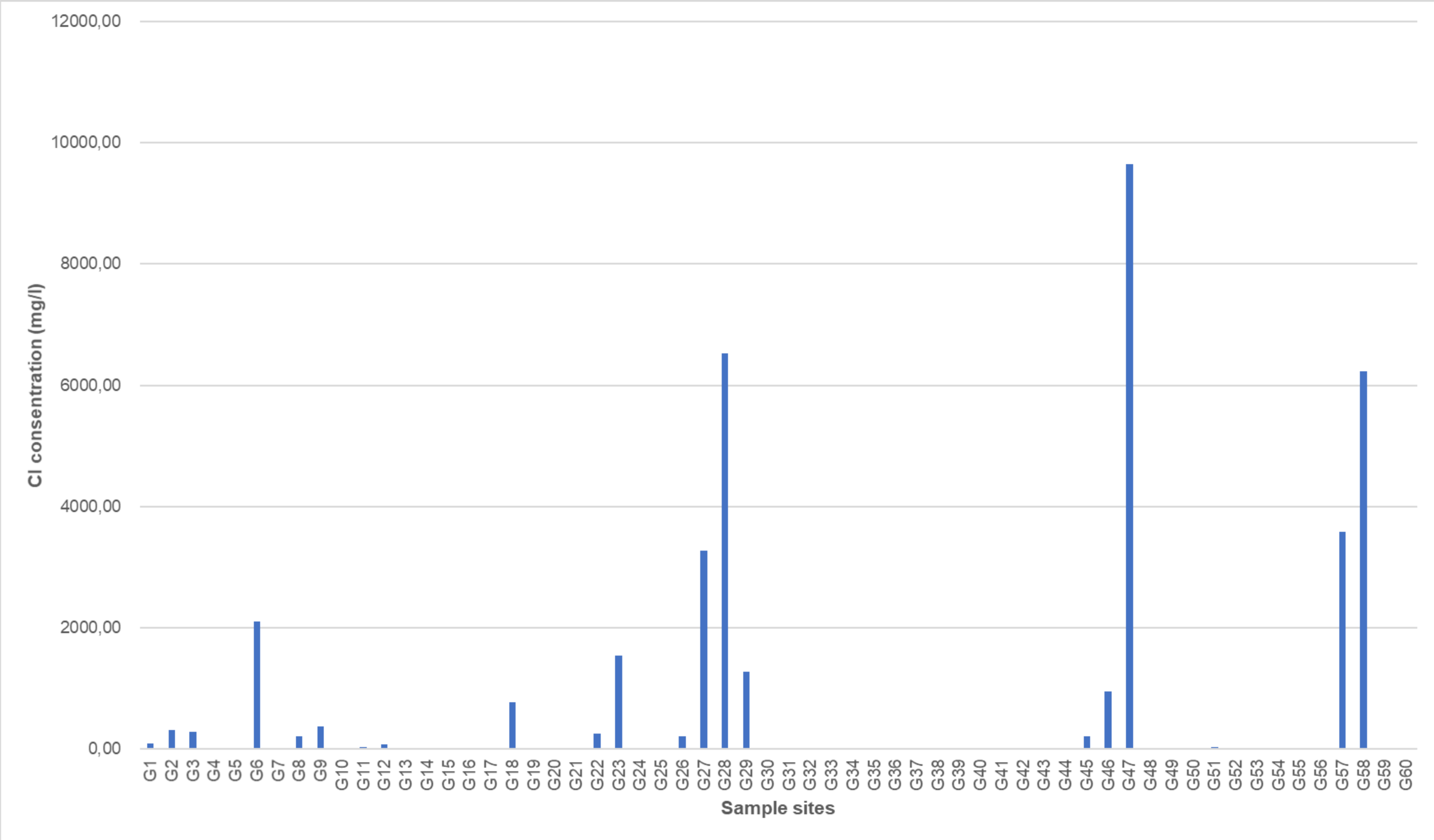


Figure A-16: Chloride concentration (mg/l) of all 60 samples taken during the soil survey.

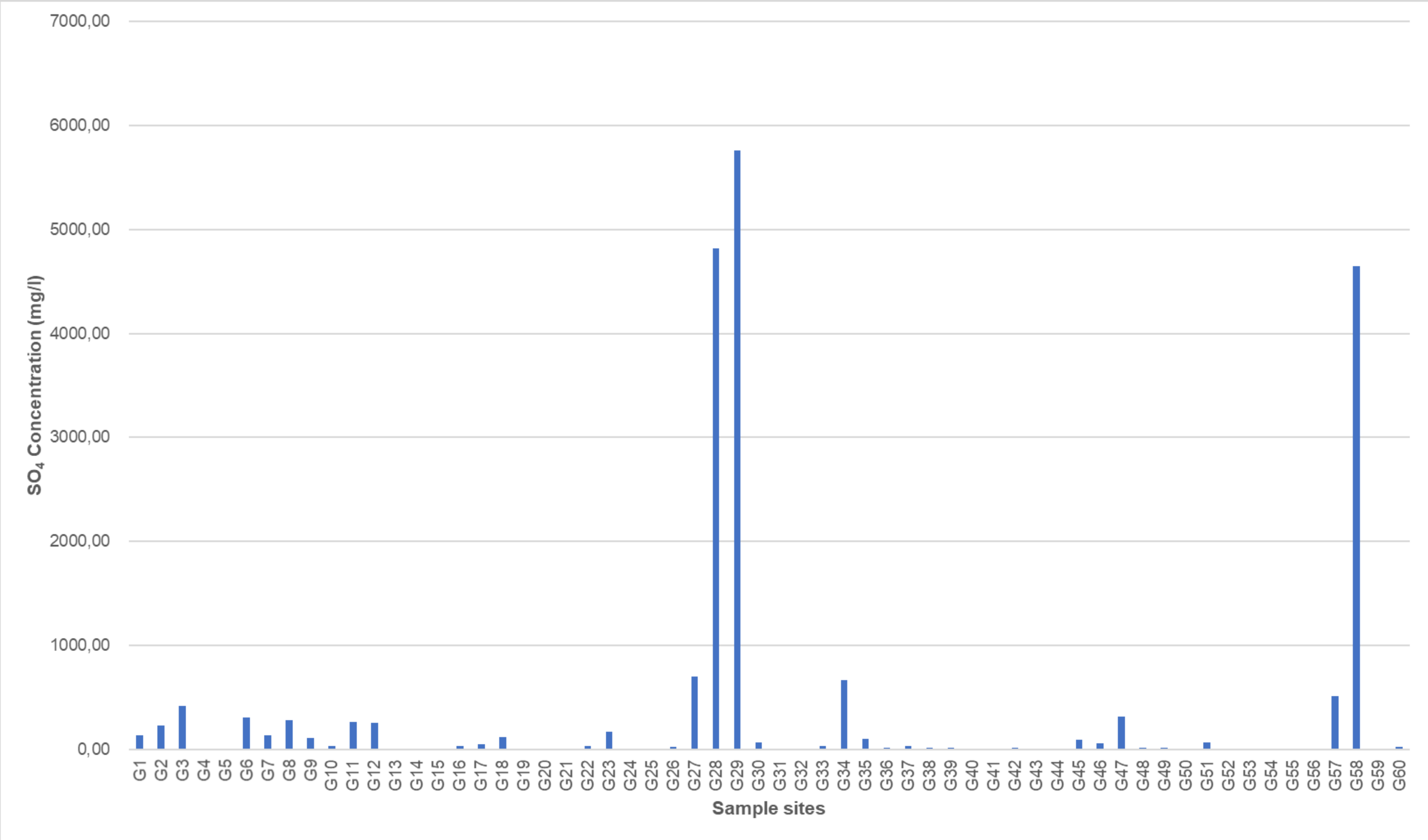


Figure A-17: Sulphate concentration (mg/l) of all 60 samples taken during the soil survey.

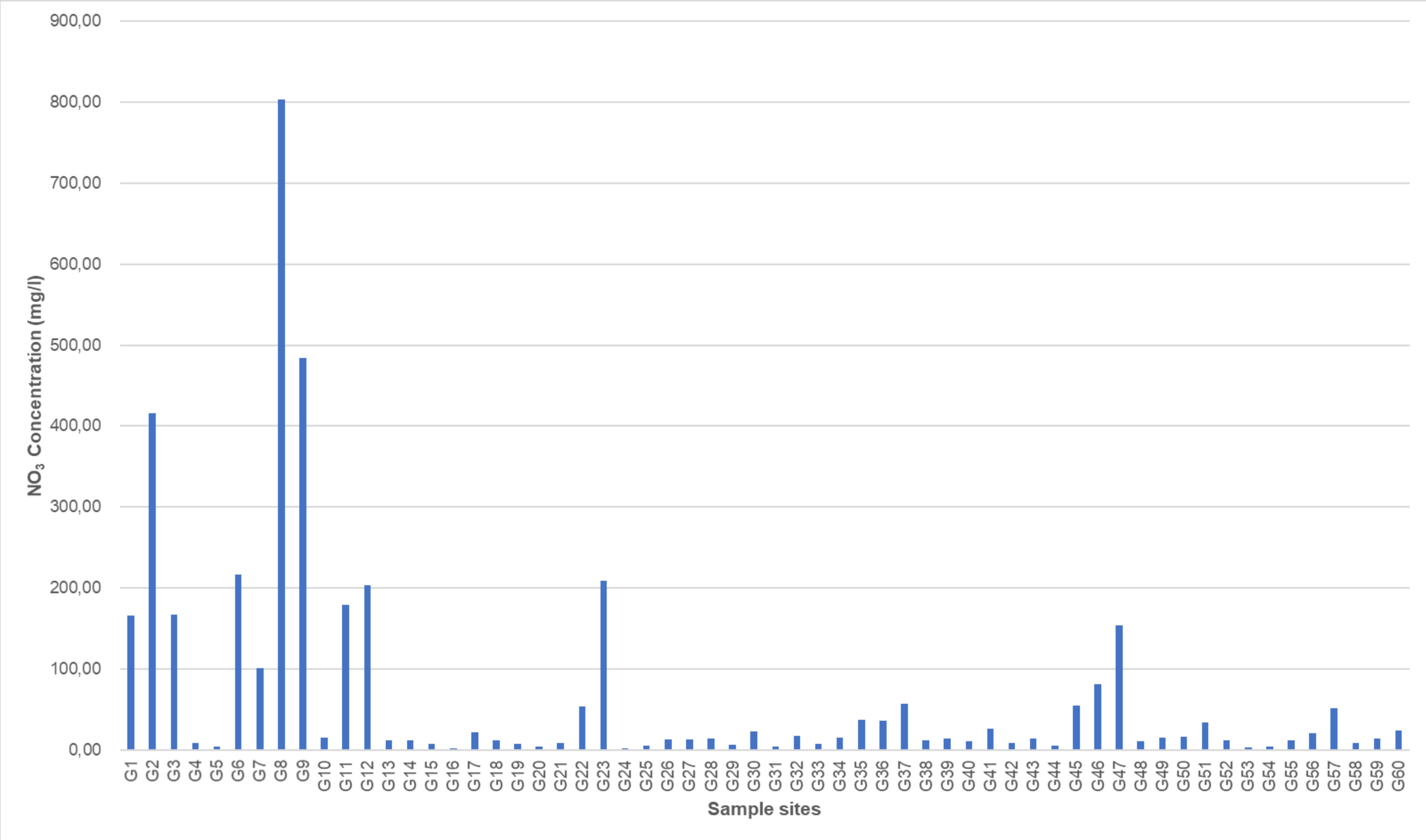


Figure A-18: Nitrate concentration (mg/l) of all 60 samples taken during the soil survey.

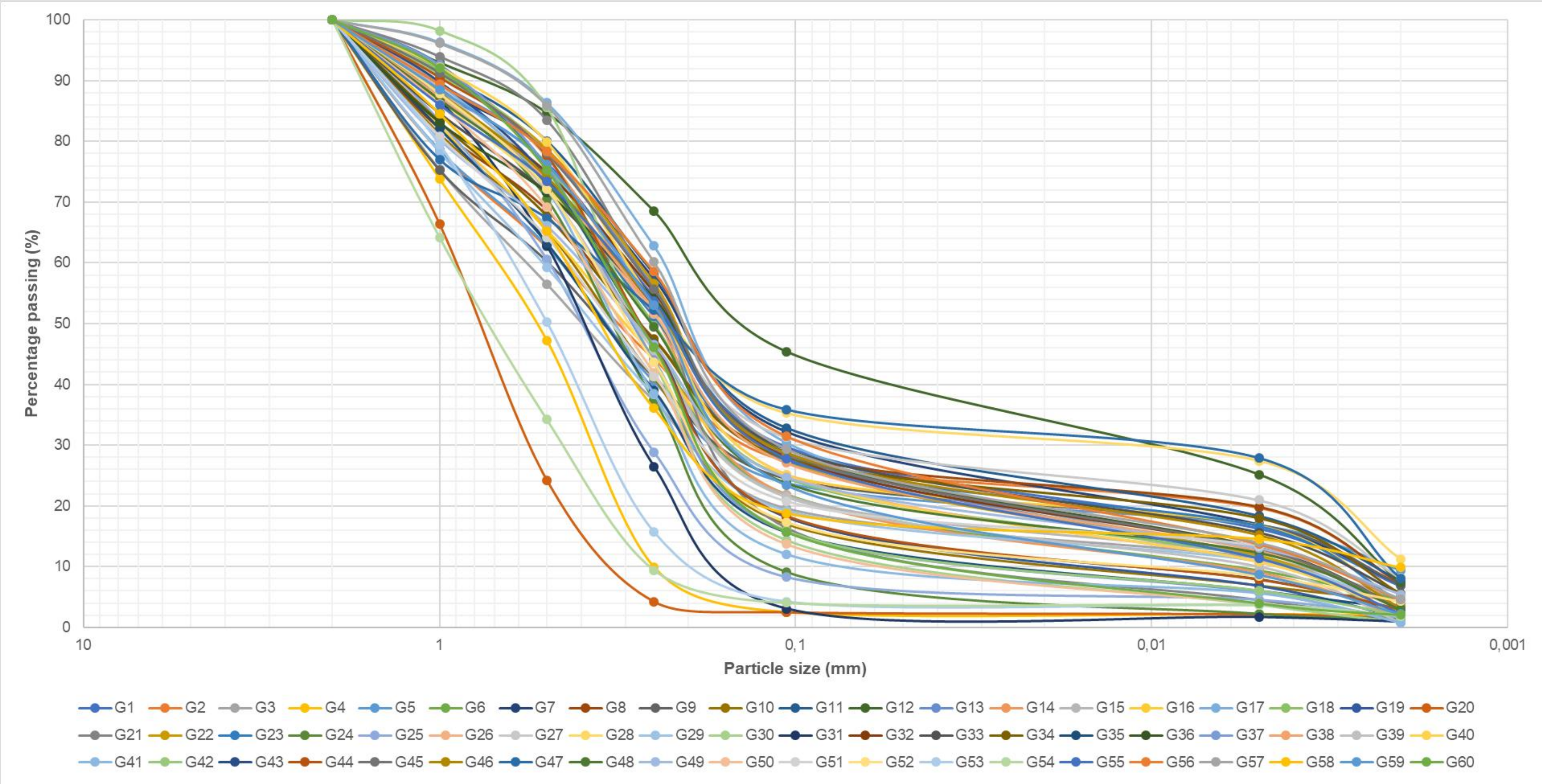


Figure A-19: Particle size distribution curves of all 60 samples taken during the soil survey.

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CINDY FAUL

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◘ *Soil Science | Geology | Botany* ◘

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EXECUTIVE SUMMARY

Environmental Scientist

Offering ▪ New knowledge in the field of Environmental Sciences and Management ▪ Currently enrolled for PhD in Environmental Sciences at North-West University ▪ Experience in administrative coordination, project coordination, project management as well as Geological-, Soil- and Vegetation Surveying ▪ A self-motivated, loyal and market oriented approach ▪ With strong skills in managing and obtaining targets and objectives.

▪ BSc Soil Science, Botany and Geology ▪ BSc Hons Environmental Science ▪ MSc in Environmental Science

"Special value – well qualified up to MSc level; knowledge and exposure to international research; and 'hands-on' 'farm-girl' type understanding of farmers."

CAREER SUMMARY

Enrolled for PhD in Environmental Sciences	**2018**
Director: Boscia Environmental Solutions	**2016 - present**

- Project Coordinator – Environmental Impact Assessment for Solar Energy Facility.
- Conducting vegetation, soil and geological specialist studies.

Writing research proposals and managing budgets (Total of R 5 201 705,00)	**2015**
Student Member of the Land Rehabilitation Society of Southern Africa	**2015**
Administrative assistant at North-West University	**2015**
Successfully completed the Short Course Mining, Radiation, and the Environment	**2014**
Successfully completed the Short Course Mining and the Environment	**2014**
Successfully completed ArcGIS training course for Applied Geology and Soil Science	**2014**
Student internship at BHP Billiton	**2012**
Successfully completed the short course Introduction to Latin for Botany	**2012**

FELLOWSHIPS, AWARDS AND HONOURS

Award for 2nd best student poster presentation at the 11th International Phytotechnologies Conference; Heraklion; Crete; Greece (30 Sept – 3 Oct 2014).	**2014**
Member of the Golden Key Honour Society, since 2013, for exceptional academic performance.	**2013**

PROFESSIONAL ACTIVITIES

Publications:

K Koch,J., Chakraborty, S., Li, B., Moore-Kucera, J., Van Deventer, P., Daniell, A., Faul, C., Man, T., Pearson, D., Duda, B., Weindorf, C.A. & Weindorf, D.C. 2017. Proximal sensor analysis of mine tailings in South Africa: An exploratory study. *Journal of Geochemical Exploration,* 181: 45-57.

Poster at the 35th Land Rehabilitation Society of Southern Africa 2016 Conference; Kimberley; South Africa. *(The need for proper specialist studies in order to evaluate the impact of environmental processes on solar plant facilities.)* **2016**

Presentation at the 35th International Geological Congress; Cape Town; South Africa. *(Climate Change: A reality or a myth? Koa Dunefield case study, Northern Cape, South Africa.)* **2016**

Presentation at the South African Association of Botanists – 41st Annual Conference; Tshipise Forever Resort; South Africa. *(Physiological stress factors associated with different tailings materials on the Chlorophyll Fluorescence of plants).* **2015**

Presentation at the Combined Congress (Soil Science); Tramonto; George; South Africa. *(The influence of soil quality of anthropogenic mine soils on the chlorophyll fluorescence of some winter crops.)* **2015**

Attending the XIX INQUA Conference: Quaternary Perspectives on Climate Change, Natural Hazards and Civilization; Nagoya; Japan. **2015**

Presentation at the Land Rehabilitation Society of Southern Africa 2015 Conference; Glenburn Lodge; Muldersdrift; South Africa. *(Physiological stress factors associated with different tailings materials on the Chlorophyll Fluorescence of plants.)* **2015**

Presentation at the 12th Annual Kimberley Biodiversity Symposium; McGregor Museum; Kimberley; South Africa. *(The geo-environmental diversity of the Swartoup dune structures, Northern Cape Province; South Africa.)* **2015**

Poster & presentation at the 11th International Phytotechnologies Conference; Heraklion; Crete; Greece. *(Physiological stress factors associated with different tailings materials on the Chlorophyll Fluorescence of plants.)* **2014**

EDUCATIONAL DETAILS

MSc Environmental Sciences | North-West University, 2015 - 2017

BSc Hons Environmental Sciences | North-West University, 2014

BSc Soil Science, Botany, & Geology | North-West University,2010 – 2013

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RESEARCH INTERESTS

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- Correlations between vegetation, soil and geology.
- Project management

PERSONAL DETAILS

Full Name | Cindy Faul **Nationality** | South African
Languages | English & Afrikaans