HYDROPEDOLOGY IMPACT ASSESSMENT FOR A WATER USE LICENCE APPLICATION FOR A PROPOSED DAM FOR IRRIGATION AND THE USE OF SLUDGE DAMS IN THE DARTFORD FARMING TRUST

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Attention To:

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Date:

January-2024

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HUNTS GREEN

Hydropedology Impact Assessment for a Water Use Licence Application for a proposed dam for irrigation and the use of sludge dams for the Dartford Farming Trust

January-2024

Required Client Review and Approval

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STRICTLY CONFIDENTIAL

EXECUTIVE SUMMARY

Hunts Green Consulting (Pty) Ltd was appointed by Emanzini WULA Consultants to conduct a hydropedology impact assessment for a Water Use License Application (WULA) for a proposed dam that will be utilised for irrigation purposes, as well as the continued use of two existing sludge dams for irrigation purposes. The proposed dam and existing sludge dams are located on two farm portions, Portion 0 of the Farm Lot FP 173 No. 8581, and Portion 0 of the Farm Lot 1B No. 7604, within the Underberg area, Kwazulu-Natal. A review of the wetland impact assessment report and the hydrological assessment was undertaken as part of the desktop component of the hydropedology assessment. The wetland impact assessment report identified four wetland systems within the study site. These were classified as three seep systems and one floodplain system associated with the Ekamanzi River. The three seep systems will be directly impacted by the proposed dam. The proposed dam wall is to be constructed in the Ekamanzi River and a portion of one of the seep systems (HGM 2). When the dam is at full capacity there will be a loss of 26.94ha of wetland habitat from the three seep systems (HGM 1, HGM 2 and HGM 3). The wetland systems were assessed with regards to their health according to the Wet-Health methodology. They were classified as Moderately Modified (PES Category C), and Largely Modified (PES Category D).

The hydrological assessment did not find anything of concern regarding the project. The Mean Annual (adjusted) Runoff into the proposed dam was calculated at 5.2 Mm^3/annum. The irrigation requirement of perennial pastures is estimated to be approximately 570 mm. The average annual dam yield to irrigate an area 155 ha of pastures was calculated at 860 500 m^3. The dam simulation accounts for 90 mm per month released during summer, which would contribute to the irrigation of undefined vegetable crops below the dam. These water demands are met by the proposed dam. There is more than enough water available in the river and from the proposed storage dam to justify granting the proposed licence.

Furthermore, a stormwater management of the sludge dams was undertaken in the hydrological assessment. The stormwater management on the farm is adequate and there are no concerns with pollution of nearby watercourses. Any spillages that occur would be limited to overland flow, with minimal contribution to the water resources, which are situated approximately 300 to 400 m away from the ponds. Soils adjacent to the sludge ponds are deep, well drained Hutton soils, and most of the nutrient-rich overland flows from any sludge spillages would infiltrate into these soils. No significant impacts to the environment or downstream users are anticipated in the event of spillages.

Land type data for the site was obtained from the Agricultural Research Council (ARC). The study site and catchment are situated within the Ac373, and Ac376 Land Types. Ac indicates land with red and yellow soils. Soil forms are therefore represented by either a red apedal (structureless) or yellow-brown apedal horizons. These soils are classified as the Hutton, Clovelly, and Griffin soil forms. They are regarded as mature soils which are deep and have a high infiltration rate. They generally have an increase in clay content with depth in the profile.

Shallow soils on steeper slopes are classified as the Mispah and Glenrosa soil forms, while the Dundee soil form is generally associated with streams and riverbeds.

Based on the 5m contours of the area, the delineated wetlands and watercourses, and the soil samples taken within the site, hillslope catenas were identified. A soil hillslope catena sequence is a description of a sequence of soils in a landscape and how the soils change down a slope. Six hillslope catenas were mapped within the study site and associated with the four wetland systems. These six catenas were then further classified into four different types of hillslope catenas. The following hillslope catena sequence is described for hillslope 1. The soils grade from soils which are shallow and consist of a lithic horizon (Glenrosa soils) to a red apedal soil (Hutton soils) in the mid position of the landscape straight through to the saturated soils associated with the Katspruit soil form or the alluvial soils of the Ekamanzi River.

With regards to hillslope catena 2 and 4, the Glenrosa soils are described at the top of the position of the catena, with this soil grading into a yellow-brown apedal soil (Clovelly) in the mid slope position as the landscape has a gentler topography. As one moves down the catena, the Clovelly soil starts to show signs of saturation in the lower profile in the form of a gleyic horizon. These soils are then classified as the Pinedene soil forms. The Pinedene soils then grade into the more permanently saturated soils classified as the Katspruit soil form and associated with the wetland and watercourse systems.

Hillslope catenas 3 and 5 are similar to catenas 1, 2 and 4. The soils grade from shallow Glenrosa soils to the deeper Hutton soils in the mid position of the landscape and then to the yellow-brown Clovelly soils. Water then moves into the Pinedene soils, which show signs of saturation in the gleyic horizon. Water then finally exits the catena through the permanently saturated soils of the Katspruit soil form or the alluvial soils of the Ekamanzi River.

Lastly hillslope catena 6 consists of a more transformed soil type as a result of the development of the farm at the top of the hillslope. This soil was most likely a combination of Glenrosa and Hutton before development took place. The soil then grades into the Hutton soil form and then into the Bloemdal soil form as signs of saturation start to show in the form of a gleyic horizon. This soil form then grades into the more permanently saturated Katspruit soil form in the floodplain wetland system at the base of the catena.

Based on the information obtained during the field investigation, the following hydrological soil type classes are associated with the hillslope catenas identified throughout the site.

Hillslope catena 1:

- Recharge (shallow) – Glenrosa
- Recharge (deep) - Hutton
- Responsive soils (saturated) – Katspruit

Hillslope catenas 2, and 4 :

- Responsive (shallow) – Glenrosa
- Responsive (deep) - Clovelly

- Interflow (soil/bedrock) –Pinedene
- Responsive soils (saturated) – Katspruit

Hillslope catenas 3 and 5 :

- Recharge (shallow) – Glenrosa
- Recharge (deep) – Hutton
- Recharge (deep) - Clovelly
- Interflow (soil/bedrock) – Pinedene
- Responsive soils (saturated) – Katspruit

Hillslope catenas 6

- Responsive (shallow) – transformed area
- Recharge (deep) – Hutton
- Interflow (soil/bedrock) – Bloemdal
- Responsive soils (saturated) – Katspruit

Development within a catchment has a profound effect on the flow dynamics of soils and changes the rate of recharge, the rate of interflow as well as their responsive nature. Changes to the flow dynamics can be seen if there is an increase in hardened surfaces, changes to topography, changes to flow dynamics, as well as a decrease in vegetation which acts as a barrier to allow for stormwater infiltration into the soil profile. To understand the flow dynamics of the site and the impacts of the proposed dam as well as the continued use of the sludge dams, the use of the SWAT+ model was incorporated into this study and the fluxes from the site simulated.

The simulation shows that water fluxes from the site follow the climatic conditions (and specifically the precipitation) for the time period simulated, with fluxes peaking during the summer months (November to March) when rainfall events occur and dropping during the drier winter months. Furthermore, wetter years (e.g., 2014, 2017 and 2020) produce greater water fluxes passing through the water resource systems and out of the site. Baseflows from the watershed are constant, even in the drier winter months, and this allows for a continuous flow of water through the wetland systems as well as Ekamanzi River year-round. The fluxes are impacted from the land use of the entire watershed area, including existing agricultural activities, grasslands, and existing Tree plantations.

The site currently has both contributions from interflow as well as surface flow contributing to the total overall flow of water coming from the site and entering into the downstream environment. The interflow dominates the flow paths of the soils of the site. This is due to the soil types which occur within the area, including the shallow and deep recharge soils of the Glenrosa, Hutton and Clovelly soil forms as well as the interflow soils including the Pinedene and Bloemdal soil forms. Surface flow is minor and occurs through the saturated Katspruit soils (classified as the saturated responsive soils) as well as the more compacted developed areas of the site.

The proposed dam will change the flow dynamics of the seep wetlands in which it will be situated, including an increase in saturated conditions at this point. The increase in saturation levels will change the current interflow soils of the Pinedene soil form to responsive saturated soils and create more overland (surface) flow. The design of the dam will be important in mitigating this increase in overland flow so as not to cause erosion downstream of the site. The use of the sludge dams for irrigation water does not have a significant impact on the flow dynamics of the site. This is due to the irrigation water being used in the deep recharge soils (Hutton soil form) and this water infiltrating quickly into the soil profile. Within the area where the irrigation takes place, no erosion was noted allowing one to come to conclusion that irrigation levels take place at a sustainable rate.

It is therefore recommended that should the mitigation measures outlined in this report be adhered too, long-term impacts can be minimised on both the wetlands and river system. Should all mitigation measures including any required monitoring be implemented it is the author’s opinion that the project be authorised.

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1 Introduction

Hunts Green Consulting (Pty) Ltd was appointed by Emanzini WULA Consultants to conduct a hydropedology impact assessment for a Water Use License Application (WULA) for a proposed dam that will be utilised for irrigation purposes, as well as the continued use of two existing sludge dams for irrigation purposes. The proposed dam and existing sludge dams are located on two farm portions, within the Underberg area, within Dr Nkosazana Dlamini-Zuma Local Municipality, Kwazulu-Natal (Figure 1-1 and Figure 1-2) namely:

- Portion 0 of the Farm Lot FP 173 No. 8581, and
- Portion 0 of the Farm Lot 1B No. 7604,

It is the intention of the applicant to construct a storage dam with a capacity of 1 500 000 m^3 to be used for the irrigation of existing cultivation fields including perennial grass pastures and vegetables. Furthermore, the applicant currently utilises two sludge dams for irrigation purposes and these form part of the WUL application.

As part of the WULA processes, all wetlands, and watercourses within 500m of the study site must be identified and assessed. This was undertaken by Land Matters Environmental Consulting (2024). Four wetland systems were delineated and assessed within the study area. The hydropedological behaviour of soils associated with the site must furthermore be studied at a catchment scale. Based on the 5m contours, the site is situated within a larger catchment area (Figure 1-3), which includes the wetlands delineated on site, and areas outside of the site. The catchment area culminates in the Ekamanzi River system located at the outlet of the proposed dam site.

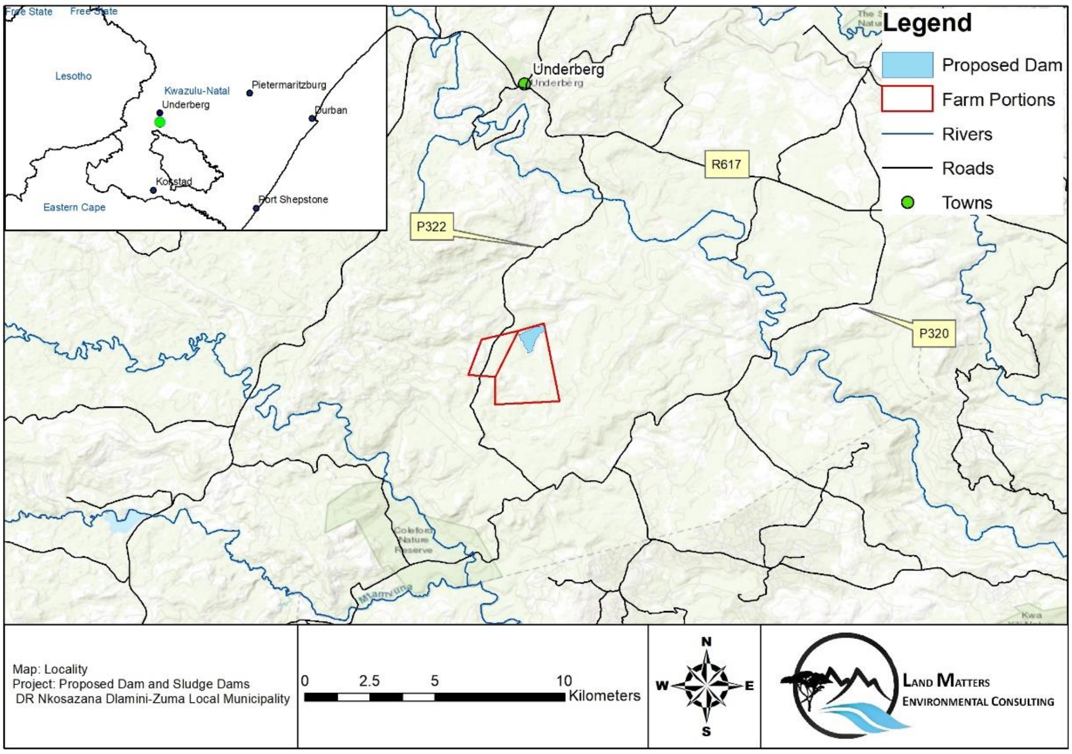

Figure 1-1: Local setting of the project area

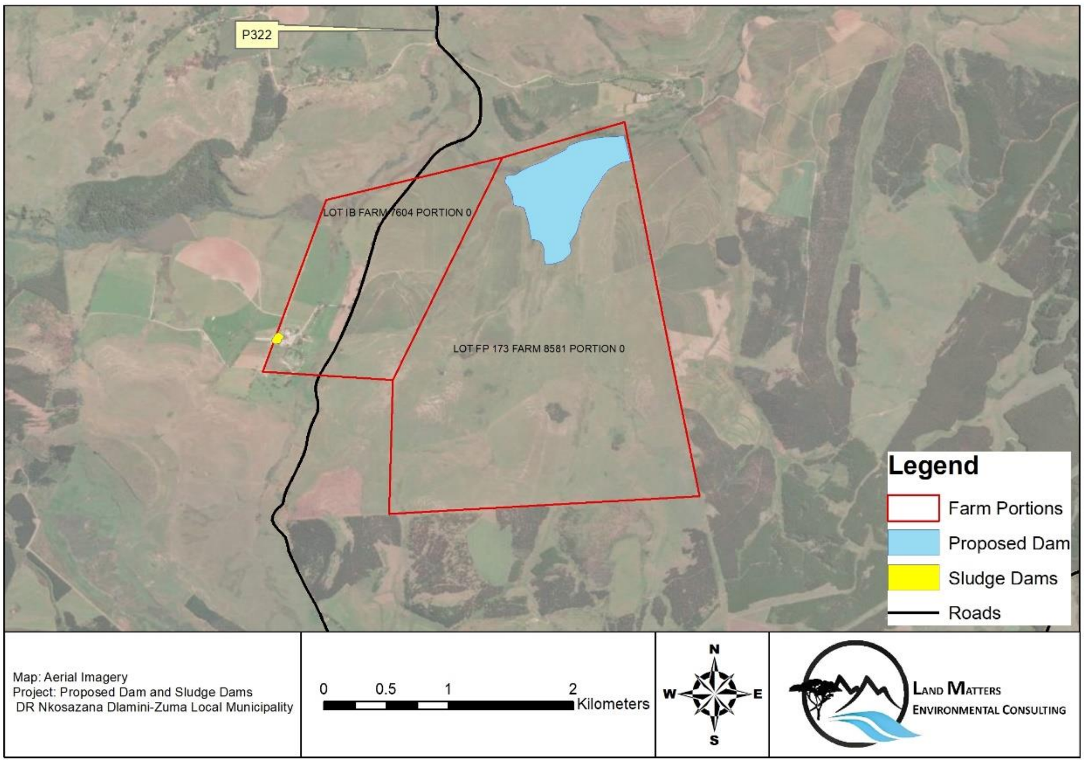

Figure 1-2: Description of the project site

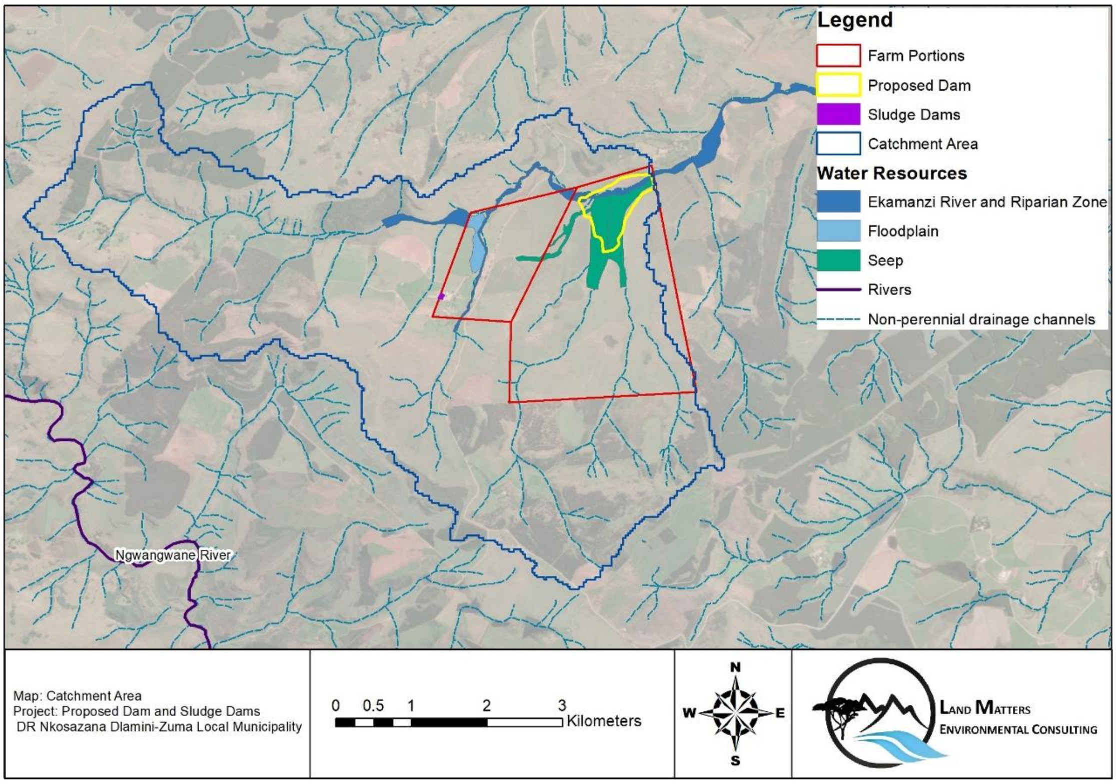

Figure 1-3: Larger catchment area in which the project site is situated

2 Scope of Work

The terms of reference for the current study are set out in the Department of Water and Sanitation ‘Guidelines for Hydropedological Assessments and Minimum Requirements’ document (2021). The scope of this assessment is therefore as follows:

- An investigation of the land types associated with the study site (proposed dam and sludge dams). The land types are classified according to the Binomial System of 1977. Soil data was extracted from the land type information and re-classified as per the Soil Classification Working Group (2018).
- A review of the geology, topography, and wetlands delineated within the site and its catchments to gain an understanding of the position of certain soils within the catchments and their unique properties.
- A field investigation to map the particular soil forms within each of the identified hillslopes associated with each of the wetlands, within the project site.
- Report on the various flow dynamics of the hillslopes associated with the wetland systems delineated in the study site, including the hydropedological behaviour of the identified soils and any sensitive areas.
- A modelling exercise to understand the flow dynamics of the soils within the hillslopes associated with each of the wetlands.

- Report on how the hydropedology of the hillslopes will be affected by the proposed dam and well as the continued use of the existing sludge dams and the implementation of mitigation measures to reduce this impact within the study site.

The proposed dam and sludge dams require a water use license and this hydropedology assessment forms part of the environmental requirements in the Water Use Licence Application (WULA) in terms of the National Water Act (Act 36 of 1998).

3 Legal and Administrative Framework

This specialist surface water assessment was compiled in support of the Water Use License Application and is be utilised in environmental authorisations legislated under the;

- The Constitution Act (Act 108 of 1996) , Section 24 on environmental rights.
- National Water Act (Act 36 of 1998) (NWA).

4. Methodology

4.1. Hydropedology Background

The term hydropedology was first used in 1966 by Kutilek (Kutilef and Nielson, 2007) and was defined as:

> *'the synergistic integration of pedology with hydrology to enhance the holistic study of soil-water interactions and landscape-soil-hydrology relationships across time and space, aiming to understand pedologic controls on hydrologic process and properties and hydrologic impacts on soil formation, variability and functions (Lin et al 2008).*

Hydropedology is therefore an intertwined branch of soil science and hydrology that studies interactive pedologic and hydrologic processes and properties in the Earth's Critical Zone. It aims to bridge disciplines, scales, and data, connect soils with the landscape, link fast and slow processes, and integrate mapping with monitoring and modelling to provide a holistic understanding of the interactions between the pedosphere and the hydrosphere (Ma et al., 2017). It aims to focus on two fundamental questions:

1) *How does soil architecture and the distribution of soils over a landscape exert a direct influence on the hydrologic processes? and*
2) *The vice versa, how do hydrologic processes influence soil genesis, evolution, variability, and function, both across time and space? (Lin, 2012).*

The protection and management of surface and groundwater resources, particularly in highly variable semi-arid areas (such as South Africa), requires the accurate analysis of hydrologic processes. This involves the identification, definition and quantification of the pathways, connectivity, thresholds, and residence times of the components of flow making up stream discharge. Soils integrate the influences of parent material, topography, vegetation/land use and climate and can therefore act as a first order control on the partitioning of these hydrological flow paths (van Tol et al., 2011).

Three major pathways exist in a typical hillslope namely overland flow, subsurface lateral flow, and bedrock flow. Subsurface lateral flow can be divided into:

- subsurface macropore flow;
- subsurface lateral flow at the A/B horizon interface;
- return flow at the footslope and toeslope; and
- flow at the soil-bedrock interface (Lin et al., 2006).

These flowpaths are not mutually exclusive and water tends to move between them. Some paths are also only connected when the hillslope is wet. The relative importance of the various pathways is determined by the soil characteristics, the macropore network and the parent material at the base of the soil.

<u>Overland Flow</u>:

Overland flow occurs either as infiltration excess or as saturation excess. In general, steeper slopes generate large volumes of overland flow with significant erosive energy. Thinner A horizons usually indicate that the overland flow is dominant, in thicker soils more infiltration due to the greater volume of water needed to saturate the soil is expected. The assumption can be made that thicker soils support more vegetation, and this causes a decrease in the overland flow proportion (Ticehurst el al., 2007). The amount of overland flow is greatly affected by the texture of the soil, specifically the percentage of clay and sand. Sandy soil is generally more permeable and has a greater hydraulic conductivity than clay rich soil, and therefore infiltration excess induced overland flow seldom occurs in sandy soils (van Tol et al., 2011).

Subsurface Lateral Flow:

There are three factors determining the contribution of subsurface macropore flow of water namely, size of the macropores; the accessibility of the macropores; and the continuity of the pores. The continuity of these pores seems to increase with an increase in soil moisture. Water moves through tree root channels, pores created by organisms (ie. earthworms), as well as cracks.

Lateral flow occurs at the A/B horizon interfaces due to differences in the structures, densities and hydraulic conductivities of the horizons. Vertical flow will be hindered, and water will tend to move laterally if the A horizon is more permeable than the B horizon. Similar mechanisms might result in a flowpath at the bottom of the profile at the interface between the soil and the underlying parent material. The permeability, the depth as well as the differentiation between horizons would affect the amount of water moving through this flowpath. Since the clay content of the B horizon in lower slopes usually shows an increase due to illuviation, this pathway would generally originate in the upper slopes (van Tol et al., 2011).

Bedrock Flow:

The general movement of water in this region is vertical and soils are usually well drained. Due to the age of the soils and the small amount of deposition, little differentiation between horizons is generally present and water drains vertically through the B horizon into the C horizon. The water that doesn't move on top of the bedrock moves through cracks in the bedrock or on solid bedrock within the saprolite. The bedrock flowpath is extremely important for recharge of lower slopes, groundwater levels and generating baseflow in some catchments (Fanning and Fanning 1989; Ticehurst et al., 2007; van Tol et al., 2011).

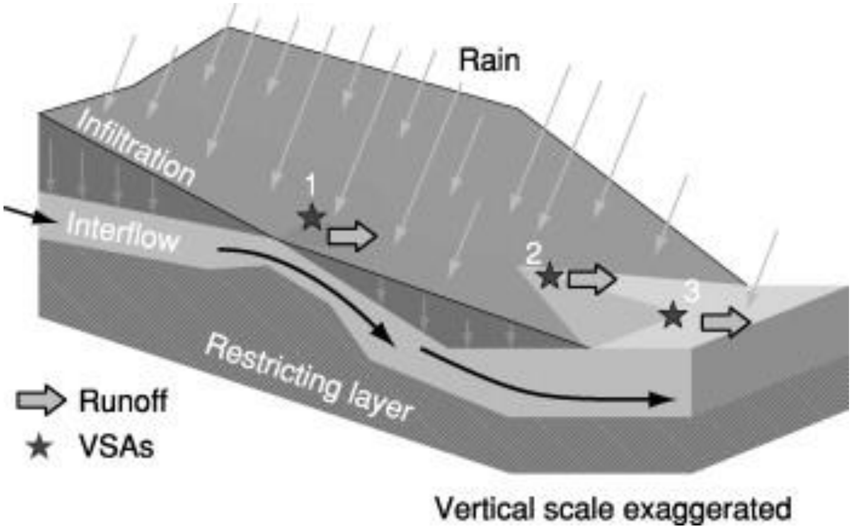

Figure 4-1: Incidence of saturation-excess hydrology: 1, shallow soil; 2, convergence area; and 3, decreasing downhill slope. VSA, variable source area (Steenhuis et al., 2005).

4.2. Assessment Methodology

The techniques and tools utilised for this assessment can be divided into baseline data as well as a field investigation. Baseline data was utilised during the desktop component to determine the biophysical context of the site.

4.2.1. Baseline Data

The study made use of the following data sources:

- Google Earth^{TM} satellite imagery was used at the desktop level.
- Relief dataset from the Surveyor General was used to calculate slope.
- Land type data was obtained from the Agricultural Research Council (Land Type Survey Staff, 1972 – 2006) for the site. This is presented at a scale of 1:250 000 and includes the division of South African land into land types based on typical terrain cross sections and dominant soil forms for each identified terrain unit.
- Geology dataset was obtained from the Council for Geosciences (www.geoscience.org.za).
- Vegetation type dataset from Mucina & Rutherford (2006), with amendments by SANBI (NBA, 2018) were used in determining the vegetation type of the study area.
- Wetlands within the study site and within 500m were identified from the wetland impact assessment Report (Land Matters Environmental Consulting, 2024).

4.2.2. Site Investigation

In field data collection was taken between the 27th and the 28th of November 2023. This included the sampling and classification of soils within the study site to form level in order to inform the soil map, the determination of the topographical setting, the identification of current land use and the identification of existing impacts within the site.

5. Assumptions and Limitations

The following assumptions and limitations are applicable to this assessment:

- Accurate data regarding the movement of water in the soil profile and within a landscape involves the installation of either piezometers or ground water monitoring wells at specific locations within a catchment. The movement of water within the soil profile can then be measured using these instruments over a number of seasons. This current study has both time and financial limitations and thus relied on information gathered in the field from soil sampling over a two-day period as well as desktop investigations. No instrumentation of the study site was undertaken, and this restricts the level of accuracy and confidence in the flow paths of the soils identified.
- Soil mapping was inferred from extrapolations from the auger sampling points, whose locations were recorded on GPS coordinate waypoints with an accuracy of 3m to 6m. The boundaries of the soil forms delineated within the site are based on these waypoint locations. It is impossible to achieve 100% purity in soil mapping, the delineated soil map units could include other soil types as the boundaries between the mapped soils are not sharp but rather gradual in reality.
- Soil texture, particle size analysis, as well as the bulk density information utilised in the SWAT+ model was obtained from laboratory analysis on representative soil samples collected during the field investigation. Further information was obtained from the land type data for the area. The information gathered from these sources was considered detailed enough to gain a general understanding of the flow dynamics of the site.

6. Biophysical Characteristics

6.1. Climate

The Underberg area is characterised by a warm and temperate climate, with a summer rainfall pattern with intermittent rainfall events in the winter months. The mean annual precipitation according to the BioResource Unit information for the area (BRU – Xd5 Coleford) is approximately 886 mm with 74 % occurring between November and March. The seasonality of precipitation is a driving factor behind the hydrological cycles of rivers and drainage lines within the area. Typically, rivers and drainage lines have a higher flow rate during the summer months. The high intensity rainfall conditions experienced in the area are conducive to high levels of surface runoff and subsequent erosion where soils are shallow, occur on steep slopes or are overgrazed (Mucina and Rutherford, 2006). Temperatures vary throughout the year, with the annual average of 14.6 ^{0}C. Maximum temperatures range from 17.6 ^{0}C in June to 25.8 ^{0}C in January. The region is coldest in June and July with average minimum temperatures of 0.5 ^{0}C on average (Table 6-1).

Table 6-1: Mean annual rainfall and temperature data for Underberg (BRU – Xd5 Coleford)

	January	February	March	April	May	June	July	August	September	October	November	December
Precipitation (mm)	154	148	122	53	21	12	11	23	38	69	101	134
Mean monthly maximum temperature (°C)	24.8	24.6	23.5	21.3	19.5	17.6	18.4	20.1	22.0	21.9	23.0	24.3
Mean monthly minimum temperature (°C)	12.9	12.8	11.1	7.6	3.6	0.5	0.5	2.9	6.1	8.4	10.3	11.9

6.2. Geology

The geology of the surrounding area is underlain by Early Triassic-aged sedimentary rock of the Tarkastad Subgroup of the Beaufort Group, Karoo Supergroup. The Tarkastad Subgroup comprises a lower Katberg and upper Burgersdorp Formation, characterised by fine to medium grained sandstone, and maroon, green, and blue mudstone. The Tarkastad Subgroup sediments are associated with a fluvial meandering river environment to lacustrine environment during the Triassic period (Groenewald, 2017; Butler, 2021). The Tarkastad sediments accumulated as channel (sandstone) and overbank (mudstone) deposits from drainage lines that flowed into the ancient inland basin which was present on southern Gondwana during the Carboniferous, Permian, and Triassic periods (Trower, 2021).

6.3. National Vegetation Type

The study area is situated within the Grassland Biome, and more specifically within the Drakensberg Foothill Moist Grassland vegetation type (Mucina & Rutherford, 2006; updated 2018 on BGIS) (Figure 6-1). This vegetation type is distributed within the KwaZulu-Natal and Eastern Cape Provinces at altitudes between 880 and 1680m asl. Drakensberg Foothill Moist Grassland vegetation is comprised of moderately rolling and mountainous terrain covered in forb-rich grasslands dominated by short bush grasses including *Themeda triandra* and *Tristachya leucothrix*. This habitat unit is often incised by river gorges of drier vegetation types and forested systems. Drakensberg Foothill Moist Grassland is classified as Least Threatened and statutorily conserved in the uKhahlamba Drakensberg Park, Ntsikeni Wildlife Reserve as well as in the Karkloof, Mount Currie, Coleford, Fort Nottingham, Impendle, Ngeli, and Umgeni Vlei Nature Reserves. Threats to this vegetation unit include loss of habitat for cultivation, plantations and urban sprawl. Woody invasive alien vegetation threatens remaining patches and common species noted include *Rubus* species, *Acacia dealbata* and *Solanum mauritianum*.

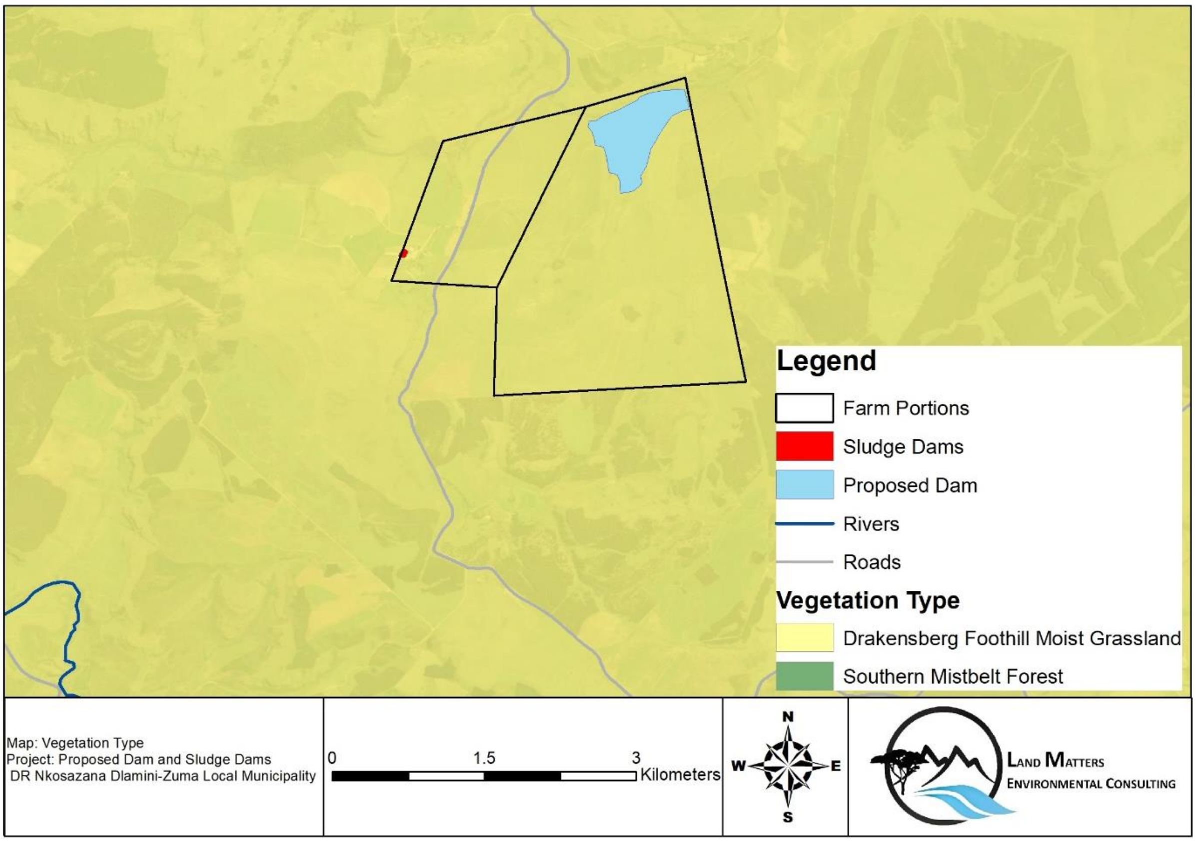

Figure 6-1: National vegetation type associated with the project site

6.4. Typography and Quartenary Catchment area

The study site is situated within an area characterised by a gentle to moderate landscape. The study site ranges in altitude from approximately 1700 m above sea level in southern areas to 1500 m above sea level in the valley bottoms along the Ekamanzi River (Figure 6-2). Slopes range from gentle to steep, with average moderate slopes of 5-6 %. This topography gives rise to seep systems which form between the slopes as well as floodplain systems along the slowly meandering river system.

The study site is located within the Pongola-Mtamvuna Water Management Area (WMA) and more specifically in the T51C quaternary catchment (Figure 6-3). The main river which flows within the quartenary catchment is the Mzimkhulu River which flows approximately 4.2 km to the east of the study site. A number of smaller non-perennial watercourses flow within the study site (Figure 6-3).

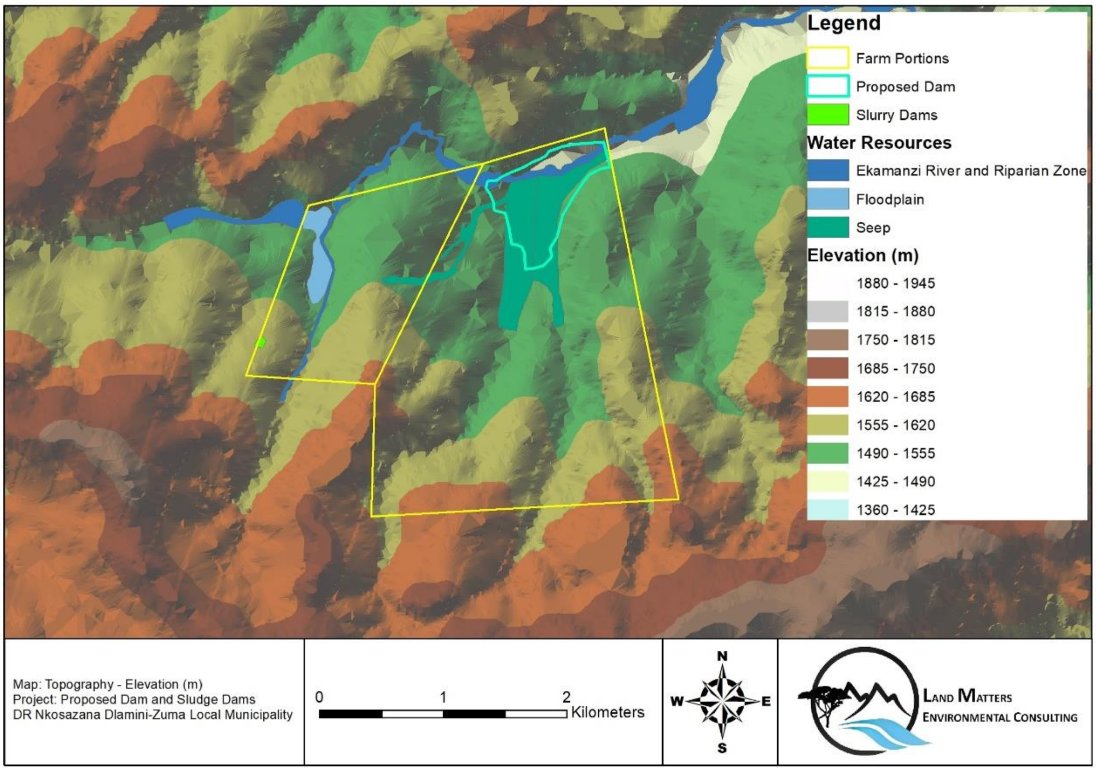

Figure 6-2: Topography (elevation of the study site)

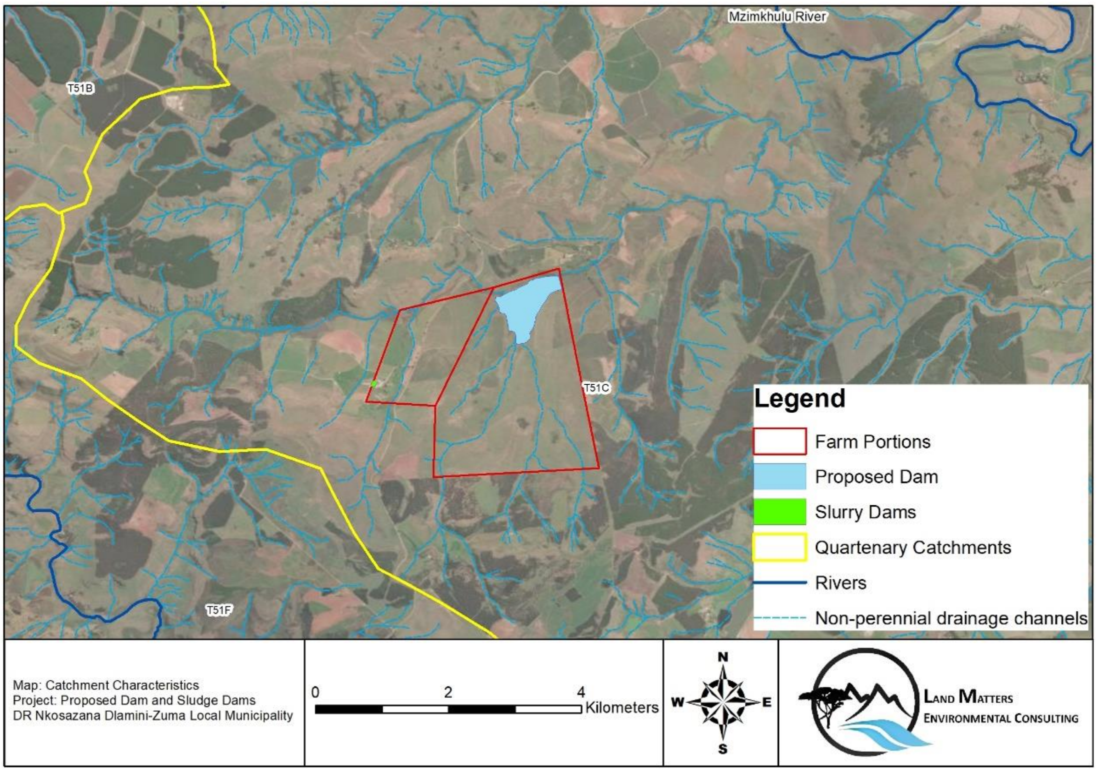

Figure 6-3: Catchment characterisitics of the study site

6.5. Review of Available Data

A review of the wetland impact assessment report and the hydrological assessment was undertaken as part of the desktop component of the hydropedology assessment.

The wetland impact assessment report identified four wetland systems within the study site. These were classified as three seep systems and one floodplain system associated with the Ekamanzi River. The three seep systems will be directly impacted by the proposed dam. The proposed dam wall is to be constructed in the Ekamanzi River and a portion of one of the seep systems (HGM 2). When the dam is at full capacity there will be a loss of 26.94 ha of wetland habitat from the three seep systems (HGM 1, HGM 2 and HGM 3) (Figure 6-4).

The HGM units were assessed with regards to their health according to the Wet-Health methodology. HGM units were classified as Moderately Modified (PES Category C), and Largely Modified (PES Category D). A number of impacts have occurred within the wetland systems as well as their respective catchments as a result of various historic and current agricultural activities within the area. These impacts include cultivation practices, the presence of dams, tree plantations, and the construction of dirt roads to access cultivated fields.

The wetland systems provide ecosystem goods and services to their respective catchments including flood attenuation, streamflow regulation, sediment trapping, filtration, and erosion control. All wetland systems provide ecosystem services for the maintenance of biodiversity within the agricultural landscape. The wetlands provide habitat for faunal, avifaunal and semi-aquatic species for feeding, breeding and foraging.

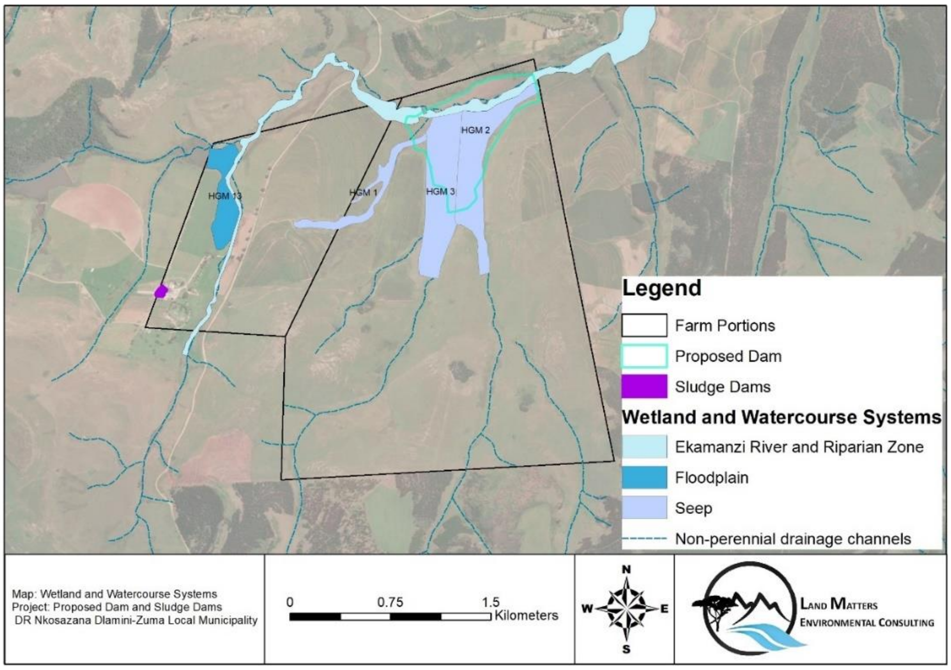

Figure 6-4: Wetlands delineated within the study site

The hydrological assessment indicated a Mean Annual (adjusted) Runoff into the proposed dam of 5.2 Mm^3/annum. The irrigation requirement of perennial pastures is estimated to be approximately 570 mm. The average annual dam yield to irrigate an area 155 ha of pastures was calculated at 860 500 m^3. The dam simulation accounts for 90 mm per month (190 ha) released during summer, which would contribute to the irrigation of undefined vegetable crops below the dam. These water demands are met by the proposed dam with an Assurance of Supply of 70%. There is more than enough water available in the river and from the proposed storage dam to justify granting the proposed licence.

Furthermore, a stormwater management of the sludge dams was undertaken in the hydrological assessment. The sludge originates from the dairy and consists of a mixture of wash water, dung, and urine. Sludge inputs from the dairy are estimated at 20-25 m^3 per day. The sludge ponds store between 3700 and 4000 m^3 of dairy waste-water in earth dams, and this is then used to irrigate pastures through an existing center pivot and slurry spreader. The stormwater management on the farm is adequate and there are no concerns with pollution of nearby watercourses. Any spillages that occur would be limited to overland flow, with minimal contribution to the rivers, which are situated approximately 300 to 400 m away from the ponds. Soils adjacent to the sludge ponds are deep, well drained hutton soils, and most of the nutrient-rich overland flows from any sludge spillages would infiltrate into the soils. No significant impacts to the environment or downstream users are anticipated in the event of spillages.

7. RESULTS

7.1. Land Type Data

Land type data for the site was obtained from the Agricultural Research Council (ARC). The land type data is presented at a scale of 1:250 000 and entails the division of land types, typical terrain cross sections for the land type and the presentation of dominant soil types for each of the identified terrain units (in the cross section). The soil data is classified according to the Binomial System. The soil data was interpreted and re-classified according to the Taxonomic System (Land Type Survey Staff, 1972-2006).

The study site and catchment are situated within the Ac373, and Ac376 Land Types (Figure 7-1). Ac indicates land with red and yellow soils each of which covers more than 10 % of the area while dystrophic and/or mesotrophic soils occupy a larger area than high base status red and yellow apedal soils. Soil forms are therefore represented by either a red apedal (structureless) or yellow-brown apedal horizons. These soils are classified as the Hutton, Clovelly and Griffin soil forms. They are regarded as mature soils which are deep and have a high infiltration rate. They generally have an increase in clay content with depth in the profile. Shallow soils on steeper slopes are classified as the Mispah and Glenrosa soil forms, while the Dundee soil form is generally associated with streams and riverbeds.

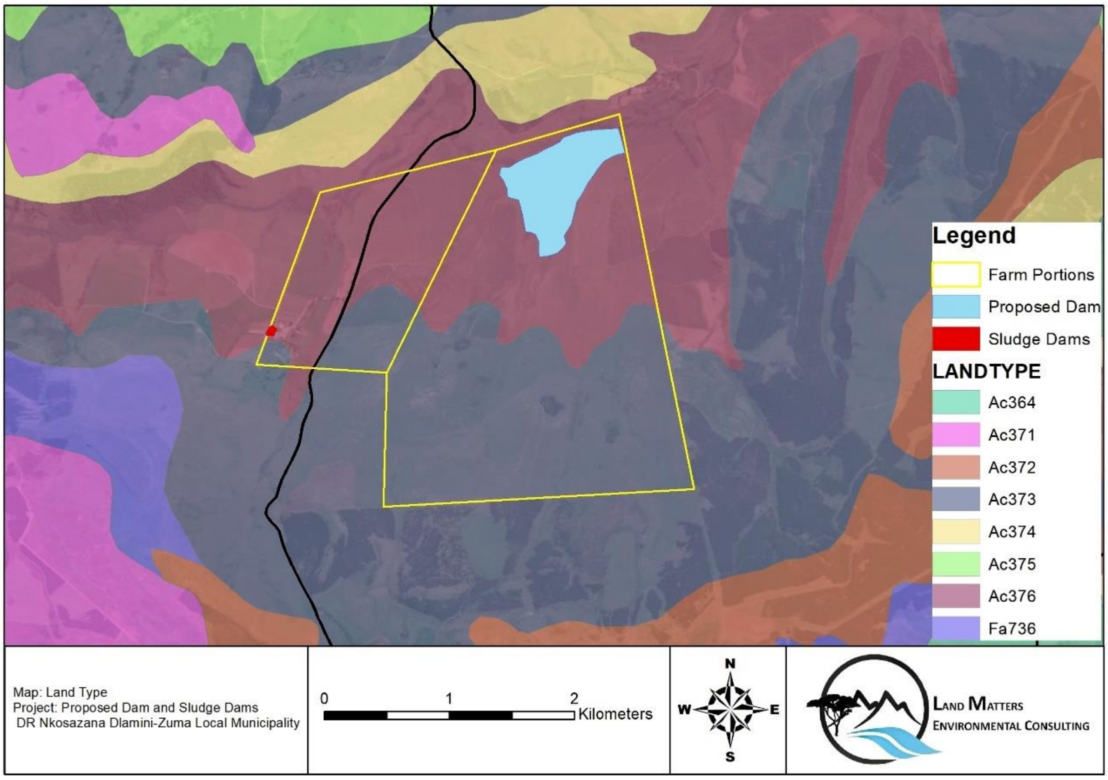

Figure 7-1: Land type data of the study area

7.2. Soil forms of the assessment area

Soil sampling was undertaken throughout the site, and classified to form level. The soils identified in the site are typical of the land types and are classified as the Hutton, Clovelly, Bloemdal, Pinedene, Glenrosa, Katspruit and Alluvial soil forms.

The Hutton/Nkonkoni, Clovelly, Bloemdal, and Pinedene soils are described as oxidic soils as they have a B horizon that is uniformly coloured with red (Hutton and Bloemdal) or yellow (Clovelly and Pinedene) iron (Fe) oxides. These are mature soils coupled with free drainage and aeration, particularly in the upper solum. These soils were furthermore classified as having an increase in clay percentage with depth in the profile, known as a luvic profile. The Pinedene and Bloemdal soil forms were identified in the more seasonal to temporary zones of the seepage wetlands as well as outside of the wetlands depending on the depth of the gleyic horizon. These soil forms are similar to the Clovelly and Hutton soil forms respectively but are identified through the presence of a gleyic horizon in the lower reaches of their profiles.

The Glenrosa soils were identified in the steeper areas of the study site. The soils are described as lithic soils and are characterised by an orthic topsoil underlain by a lithic B horizon. This makes these soil forms generally shallow, with associated increases in overland flow in areas where these soils are located.

In the valley bottoms and seepage areas the soils were classified as the Katspruit soil form. This soil form is characterised as a gley soil and displays reduction conditions leading to a gleyed soil matrix. The gley horizon forms with continuous to long durations of saturation with stagnant water and reduced (anaerobic) environments. Alluvial soils were identified in the Ekamanzi River and associated riparian zone. A description of each soil form identified is detailed in Table 7-1 and their locations are displayed in Figure 7-2.

Table 7-1: Soils identified in the study area

Soil Form	**Horizon**	**Photograph**
Terrestrial Soils		
Hutton/ Nkonkoni	Orthic A	
	Red Apedal	
	Lithic (Nkonkoni)	
Clovelly	Orthic A	

SOIL FORM	HORIZON	PHOTOGRAPH
	Yellow Brown Apedal	
	Lithic	
Glenrosa	Orthic A	
	Lithic	
HYDRIC SOILS		

Soil Form	Horizon	Photograph
Katspruit	Orthic A	
	Gley	
Pinedene	Orthic A	
	Yellow Brown Apedal	
	Gleyic	

Soil Form	**Horizon**	**Photograph**
Bloemdal	Orthic A	
	Red Apedal	
	Gleyic	
Alluvial Soil Deposits		

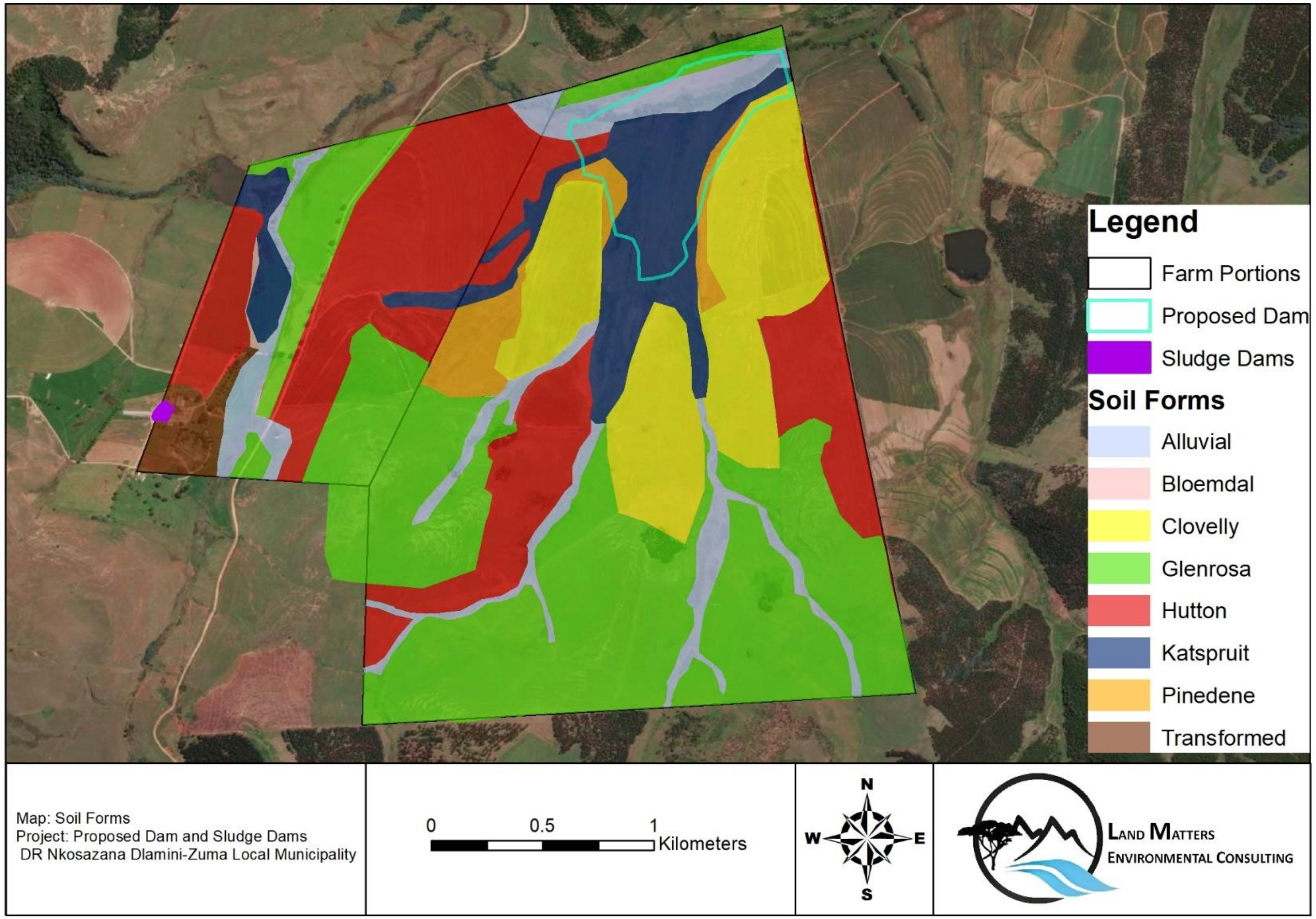

Figure 7-2: Soil form map for the study site

7.3. Hillslope catenas

The wetland systems which were identified and delineated within the study site are impacted by smaller landscape units known as hillslope catenas. A soil hillslope catena sequence is a description of a sequence of soils in a landscape and how the soils change down a slope. The sequence is ascribed to a colluvial (gravity fed) movement down slope (Cornel and Schwertmann, 2003).

The hillslope catenas were mapped taking into account the 5m contour data for the site as well as the soil form. Six hillslope catenas were mapped within the study site and associated with the four wetland systems (Figure 7-3).

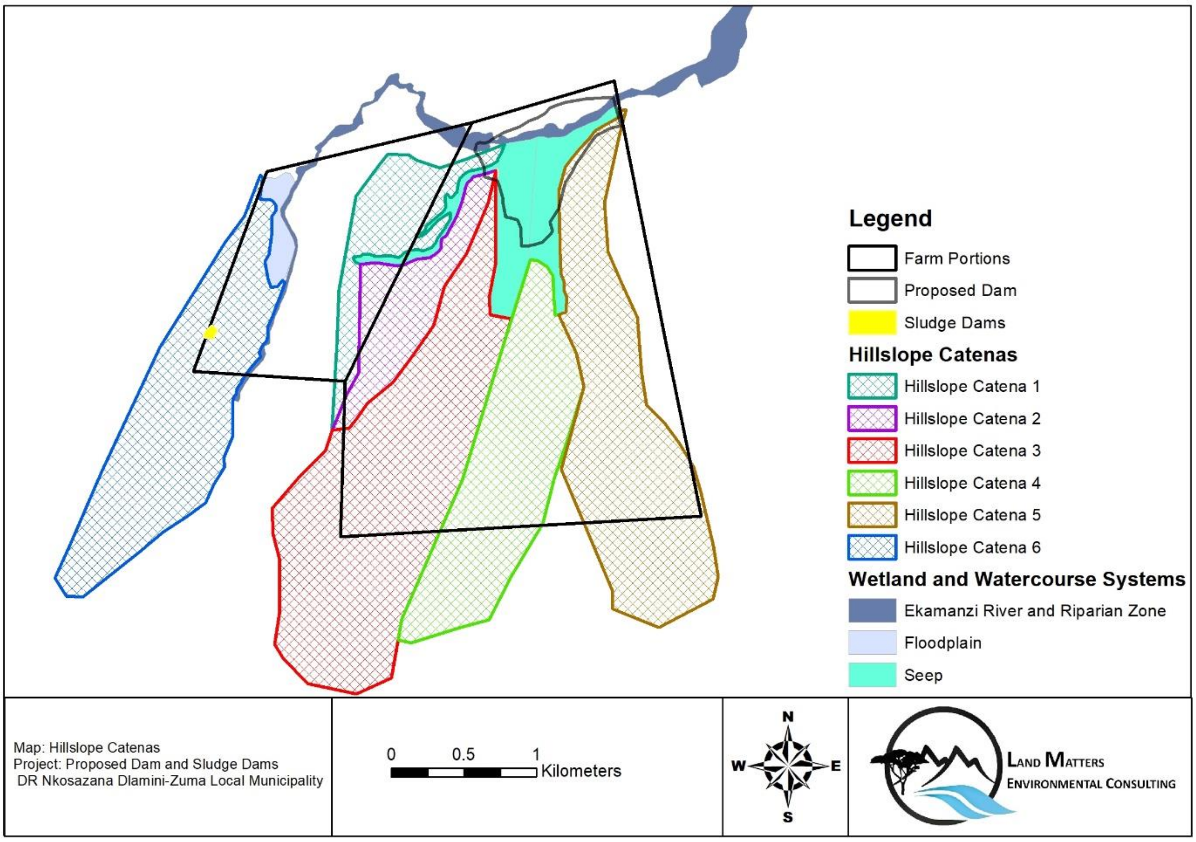

Figure 7-3: Hillslope catenas delineated within the site

Based on the 5m contours of the area, the delineated wetlands and watercourses and the soil samples taken within the site, four types of hillslope catenas were identified. The following hillslope catena sequence is described for hillslope 1. The soils grade from soils which are shallow and consist of a lithic horizon (Glenrosa soils) to a red apedal soil (Hutton soils) in the mid position of the landscape straight through to the saturated soils associated with Katspruit soil form or the alluvial soils of the Ekamanzi River (Figure 7-4). This is due to the micro-topography of the site which influences the flow dynamics of these soils.

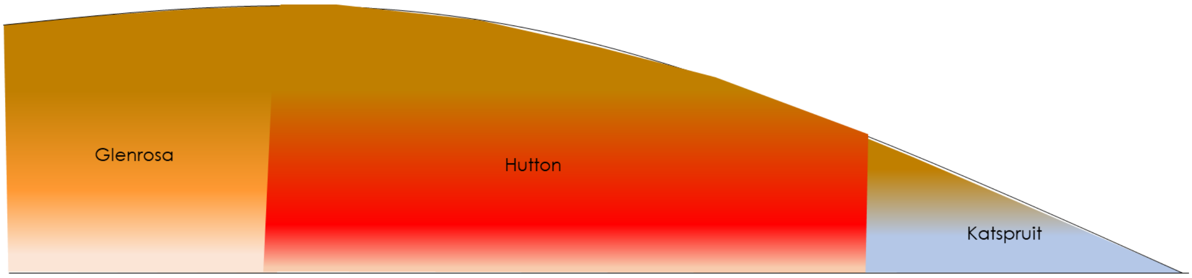

Figure 7-4: Soil catena identified within hillslope catena 1

With regards to hillslope catena 2 and 4 (**Figure 7-5**), the Glenrosa soils are described at the top of the position of the catena, with this soil grading into a yellow-brown apedal soil (Clovelly) in the mid slope position as the landscape has a gentler topography. As one moves down the catena the Clovelly soil starts to show signs of saturation in the lower profile in the form of a gleyic horizon. These soils are then classified as the Pinedene soil form. The Pinedene soils then grade into the more permanently saturated soils classified as the Katspruit soil form and associated with the wetland and watercourse systems.

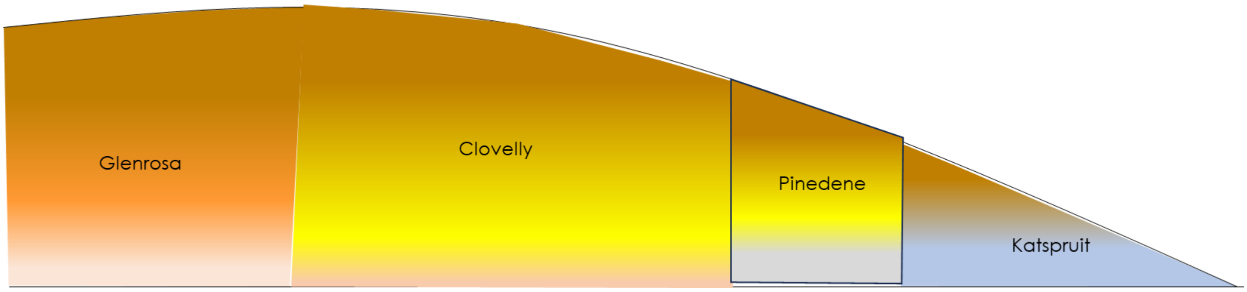

Figure 7-5: Soil catena identified within hillslope catenas 2 and 4

Hillslope catenas 3 and 5 are similar to catenas 1, 2 and 4. The soils grade from shallow Glenrosa soils to the deeper Hutton soils in the mid position of the landscape and then to the yellow-brown Clovelly soils. Water then moves into the Pinedene soils, which show signs of saturation in the gleyic horizon. Water then finally exits the catena through the permanently saturated soils of the Katspruit soil form or the alluvial soils of the Ekamanzi River (**Figure 7-6**).

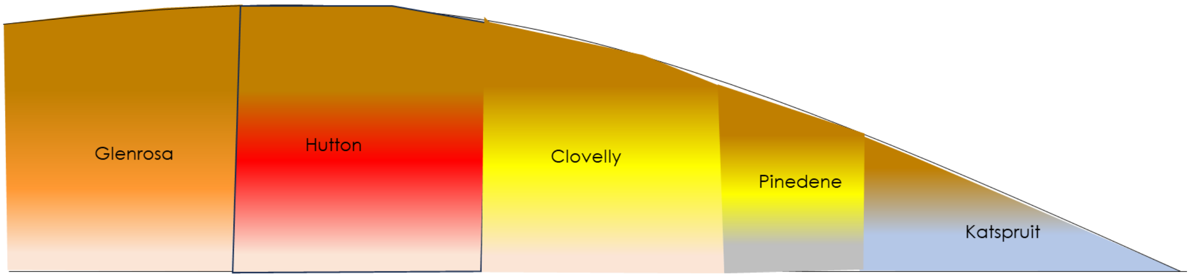

Figure 7-6: Soil catena identified within hillslope catenas 3 and 5

Lastly hillslope catena 6 (Figure 7-7) consists of a more transformed soil type as a result of the development of the farm at the top of the hillslope. This soil was most likely a combination of Glenrosa and Hutton before development took place. The soil then grades into the Hutton soil form and then into the Bloemdal soil form as signs of saturation start to show in the form of a gleyic horizon. This soil form then grades into the more permanently saturated Katspruit soil form in the floodplain wetland system.

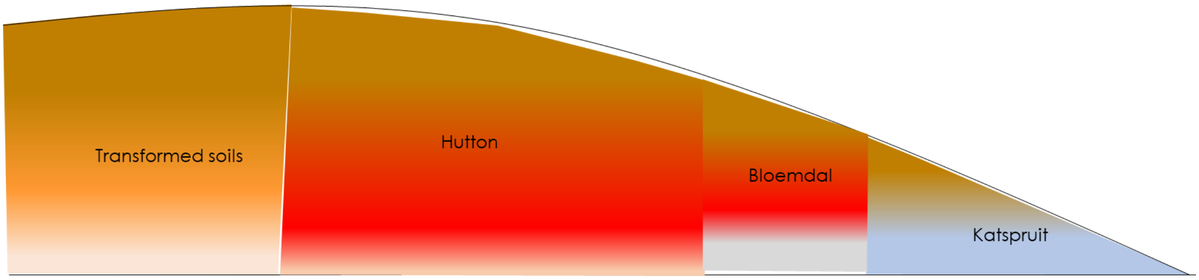

Figure 7-7: Soil catena identified within hillslope catena 6

7.4. Hydropedological characterisitcis of the soil forms associated with the assessment area

Soil types are not randomly distributed in a catchment and therefore hydrological soil types typically occupy specific positions in the hillslope and thus can play more of a releasing or receiving role related to hillslope position. By implication pedogenetically different soils (i.e., various soil forms) may be grouped in the same hydrological functional class (Le Roux et al., 2015).

The division of soils into different hydrological response classes can therefore be used as building blocks of the spatial systematic variation in a hillslope. Six different hydrological classes have been assigned to the soils in the study of hillslopes. The classification largely considers the flow drivers during a peak rainfall event and the associated flow paths of water through the soil. The hillslope classes are:

- Class 1 – Interflow (Soil/Bedrock Interface).

- Class 2 – Shallow responsive.
- Class 3 – Recharge to groundwater (Not connected).
- Class 4 – Recharge to wetland.
- Class 5 – Recharge to midslope; and
- Class 6 – Quick interflow.

A brief description of the properties of these soils is presented in Figure 7-2 (Le Roux et al., 2015). The flow paths from the crest of a slope to the valley bottom is assessed and classified.

Table 7-2: Soil Hydrological soil type classes (Le Roux et al., 2015)

Hydrological Soil Type	Description	Symbol
Recharge	Soils without any morphological indication of saturation. Vertical flow through and out of the profile into the underlying bedrock is the dominant flow direction. These soils can either be shallow on fractured rock with limited contribution to evapotranspiration or deep freely drained soils with significant contribution to evapotranspiration.	▥
Interflow (A/B)	Duplex soils where the textural discontinuity facilitates build-up of water in the topsoil. Duration of drainable water depends on rate of ET, position in the hillslope (lateral addition/release) and slope (discharge in a predominantly lateral direction).	▤
Interflow (soil/bedrock)	Soils overlying relatively impermeable bedrock. Hydromorphic properties signify temporal build of water on the soil/bedrock interface and slow discharge in a predominantly lateral direction.	≋
Responsive (shallow)	Shallow soils overlying relatively impermeable bedrock. Limited storage capacity results in the generation of overland flow after rain events.	⁙

Hydrological Soil Type	Description	Symbol
Responsive (saturated)	Soils with morphological evidence of long periods of saturation. These soils are close to saturation during rainy seasons and promote the generation of overland flow due to saturation excess.	▦

Soil acts as the transport median between the surface water and the groundwater. Water movement in soils is mainly caused by the force of gravity, capillarity, and osmosis. Based on the information obtained during the field investigation, the following hydrological soil type classes are associated with the different hillslope catenas identified throughout the site.

Hillslope Catena 1:

- Recharge (shallow) – Glenrosa
- Recharge (deep) - Hutton
- Responsive soils (saturated) – Katspruit

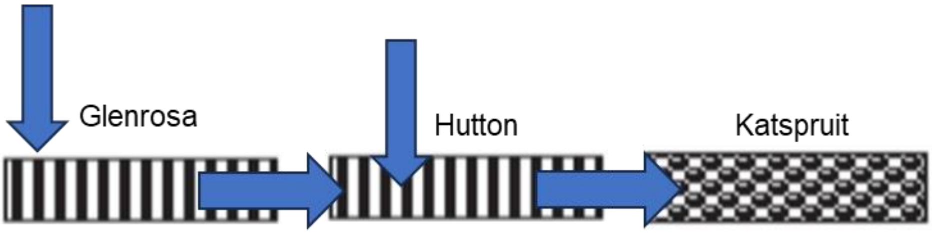

Figure 7-8: Hydrological soil types associated with hillslope catena 1 delineated within the site

Figure 7-8 shows a broad scale depiction of the hydrological flowpaths of the soils associated with hillslope catena 1 which are associated with a seep system. When precipitation occurs, water quickly infiltrates the shallow recharge Glenrosa soils and then moves into the deeper recharge soils of the Hutton soil form. The dominant flow direction in recharge soils is the vertical flow of water through and out of the profile into the underlying bedrock. The freely drained topsoil and/or B horizon of the Hutton soil form merges with the lithic horizon. Water that moves through these soils would recharge the deeper aquifers associated with the catchment areas, or if it encounters less permeable rock such as non-weathered and compacted sandstone outcrops; it will flow laterally, and recharge shallow aquifers associated with seasonal hillslope seepage areas. Water then moves out of the recharge soil group and into the responsive saturated soils or Katspruit soil form. The responsive saturated soils are located in the permanently saturated wetlands of the catchment areas. These soils show morphological evidence of long periods of saturation such as a gleyed matrix as well as mottling. They are close to saturation, particularly during the wet season, and once saturated, and incapable of attenuating any more water, they will generate overland flow to the stream network.

Hillslope catenas 2, and 4 :

- Responsive (shallow) – Glenrosa
- Responsive (deep) - Clovelly
- Interflow (soil/bedrock) –Pinedene
- Responsive soils (saturated) – Katspruit

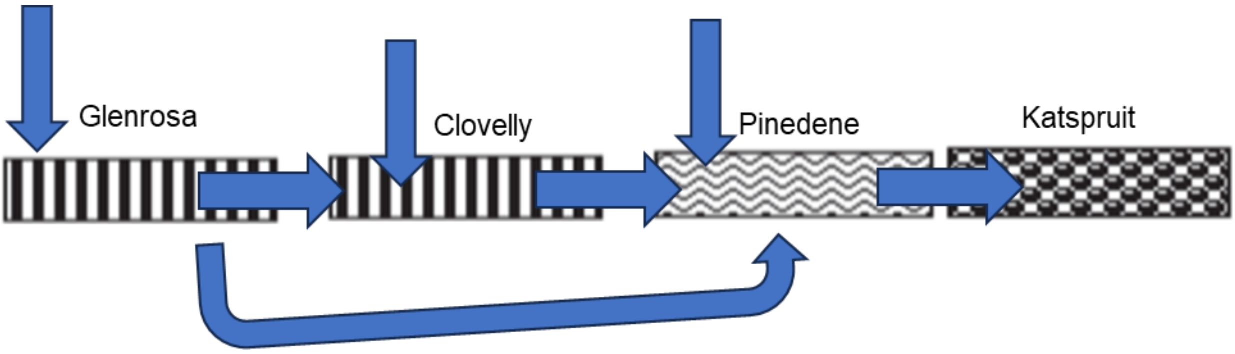

Figure 7-9: Hydrological soil types associated with hillslope catenas 2, and 4

Hillslope catenas 3 and 5 :

- Recharge (shallow) – Glenrosa
- Recharge (deep) – Hutton
- Recharge (deep) - Clovelly
- Interflow (soil/bedrock) – Pinedene
- Responsive soils (saturated) – Katspruit

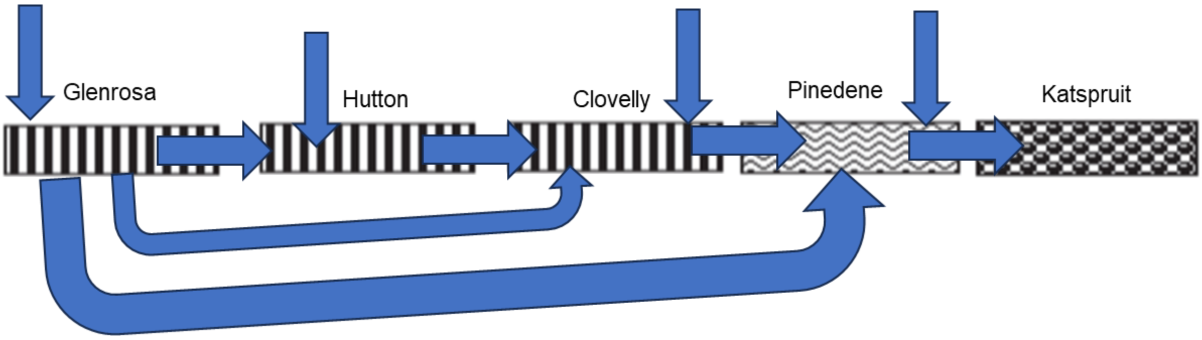

Figure 7-10: Hydrological soil types associated with hillslope catenas 3, and 5

Similar flow dynamics occur in the hillslope catenas 2 and 4 (Figure 7-9) and hillslope catenas 3 and 5 (Figure 7-10). Precipitation will enter into the shallow recharge Glenrosa soil and the deep recharge Hutton and Clovelly soils. Again the dominant flow direction in these soils is the vertical movement of water through the soil profile and into the bedrock. The bedrock can be lithic (particularly in the case of the Glenrosa soils) and water will infiltrate this bedrock and recharge deeper aquifers associated with the catchment area. If it encounters less permaeable bedrock, water will flow laterally along the interface between the soil profile and the rock. Water also flows out of the recharge soils (Hutton and Clovelly) in a lateral direction and enters the interflow soils. This soil is classified as the Pinedene soil form. Here water will move both vertically as well as laterally where there is non-permeable bedrock. At this interface a build up of saturated conditions occur and this is displayed in the soil profile as mottling or a gleyic horizon. In the Pinedene soils identified on site, the saturated gleyic horizon was identified both within the first 50cm of the profile (and thus within the seep systems) as well as deeper than 50cm (and thus outside of the seep systems). Water will then move out of the interflow soils and into the responsive saturated soils of the Katspruit soil form identified in the more permanently saturated areas of the seep systems.

Hillslope catenas 6

- Responsive (shallow) – transformed area
- Recharge (deep) – Hutton
- Interflow (soil/bedrock) – Bloemdal
- Responsive soils (saturated) – Katspruit

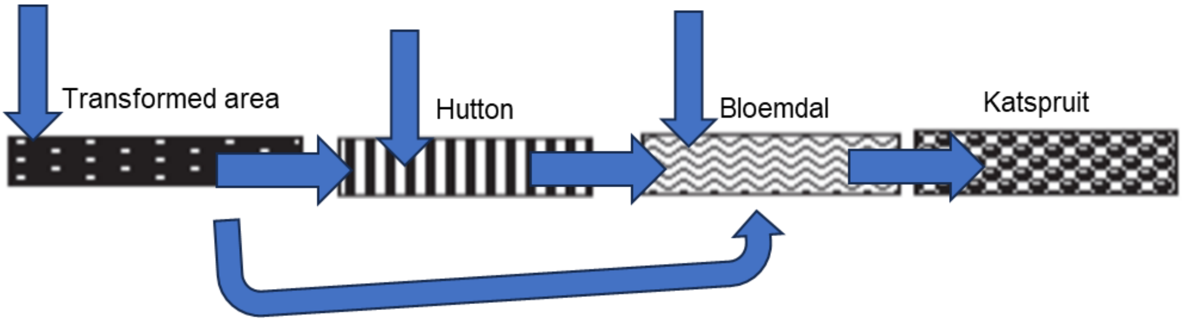

Figure 7-11: Hydrological soil types associated with hillslope catena 6

In hillslope catena 6 (Figure 7-11) a transformed area replaces the original soil profile, which would have most likely been the Glenrosa and Hutton soil forms. Due to the transformed nature of the top of the catena and the associated compaction of soils, a smaller quantity of water will infiltrate the soil profile thus increasing the responsive nature of the soils of this site and creating more overland flow. This overland flow will quickly enter into the deep recharge soils of the Hutton soil form, where it will infiltrate the soil profile and recharge deeper aquifers of the catchment area. Water will also move out of the recharge soils and into the interflow soil type (Bloemdal soil form) where it will move laterally along the interface between the soil profile and impermeable bedrock. This lateral flow causes a build up of saturation at this point and this is displayed in the gleyic horizon identified in the Bloemdal soils on site. Water will then enter into the responsive saturated soils of the Katspruit soil form which dominate the floodplain wetland associated with the Ekamanzi River. Once the responsive saturated soils have reached capacity and can not attenuate any more water they will move water as overland flow into the Ekamanzi River.

7.5. Particle Size Analysis

As part of the hydropedology assessment soil samples from the dominant soil forms identified within the site were collected. These samples included each horizon of the soil profiles. A sample of each of the horizons of the Glenrosa, Katpsruit, Clovelly, Pinedene and Hutton soil forms was collected and sent for analysis at the Talbot Laboratories (Pty) Ltd. Particle Size Analysis was conducted on each of the samples and the results displayed in Table 7-3.

Table 7-3: Results of the Particle Size Analysis of each of the samples collected

Soil Form	Horizon	Sand (%)	Silt (%)	Clay (%)	Texture
Glenrosa	Orthic A	40.0	54.9	5.1	Silt Loam
	Lithic	43.7	51.5	4.8	

Soil Form	Horizon	Sand (%)	Silt (%)	Clay (%)	Texture
Hutton	Orthic A	43.8	52.8	3.4	Silt Loam to Loam
	Red Apedal B	50.8	41.0	8.2	
Clovelly	Orthic A	40.0	48.3	11.7	Loam
	Yellow-Brown Apeal	43.0	41.8	15.2	
Pinedene	Orthic A	40.0	50.8	9.2	Silt Loam to Loam
	Yellow-Brown Apedal B	43.0	41.0	16.0	
	Gleyic	45.9	35.0	19.1	
Katspruit	Orthic A	37.0	47.0	16.0	Clay Loam
	Gley	33.0	34.0	33.0	

All soil samples have a higher percentage of sand and silt as compared to clay and are classified in the silt loam to clay loam texture range. There is an increase in clay with depth in the soil profile and gleyic and gleyed horizons have a higher percentage of clay compared to other horizons. This clay aids in the attenuation of water within these horizons adding to the creation of the wetland systems.

7.6. Quantification of Hydropedological fluxes

Development within a catchment has a profound effect on the flow dynamics of soils and changes the rate of recharge, the rate of interflow and as well as their responsive nature. Changes to the flow dynamics can be seen if there is an increase in hardened surfaces, changes to topography, changes to flow dynamics, as well as a decrease in vegetation which acts as a barrier to allow for stormwater infiltration into the soil profile.

To understand the flow dynamics of the Underberg Farm site and the impacts of the proposed dam as well as the continued use of the sludge dams, the use of the Soil Water Atmosphere Terrain (SWAT+) model was incorporated into this study. SWAT+ is a small watershed to river basin-scale model to simulate the quality and quantity of surface and ground water and predict the environmental impact of land use, land management practices, and climate change. It incorporates land processes including plant growth and detailed land management with channel processes as well as the integration of multiple environmental processes to simulate water fluxes and flow dynamics within a defined watershed area (Bieger et al., 2017).

Inputs into the model include a digital elevation model (DEM), the defined landcover for the area as well as the soil form and soil characteristic information.

Watersheds were defined for the site and include the four wetland systems that were delineated (Figure 7-12). A watershed includes the flowpaths of the seeps and the Ekamanzi River and how these move water downslope of the catchment area into the downstream receiving environment. The watersheds were first defined for the study site and are based on an outlet point downstream of the dam site, which incorporates the entire study site. The watershed therefore includes both upstream features of the study site as well as the boundary of the site.

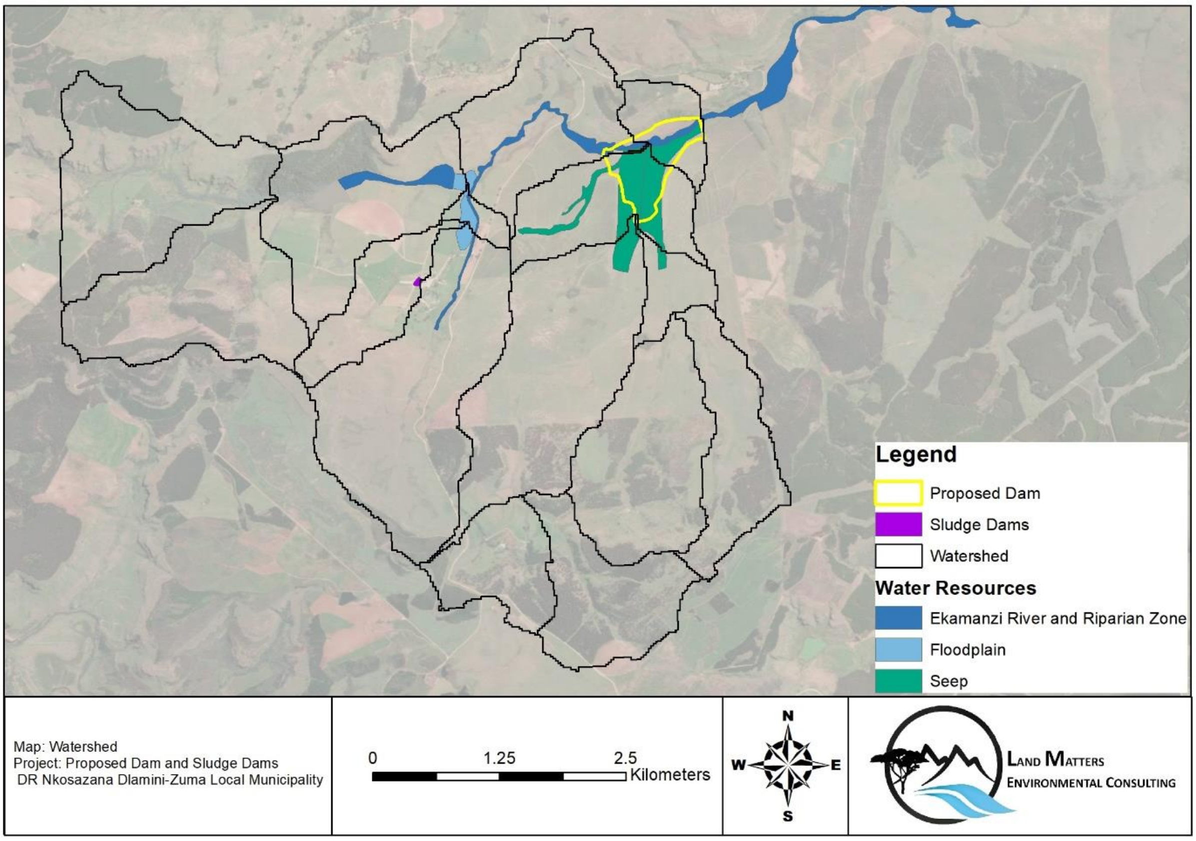

Figure 7-12: Delineated watersheds associated with the project site

Based on these watersheds, detailed soil information gathered during the field assessment, the laboratory analysis, the information from the surface hydrology assessment, and the wetland impact assessment, the flow dynamics, water fluxes and inputs into the watersheds were simulated. Water fluxes are dependent on the land cover of the watershed, the seasonality of precipitation events and the soil types and characteristics.

Based on the available climatic data for the area a simulation from 2014 to 2021 was conducted through the SWAT+ model.

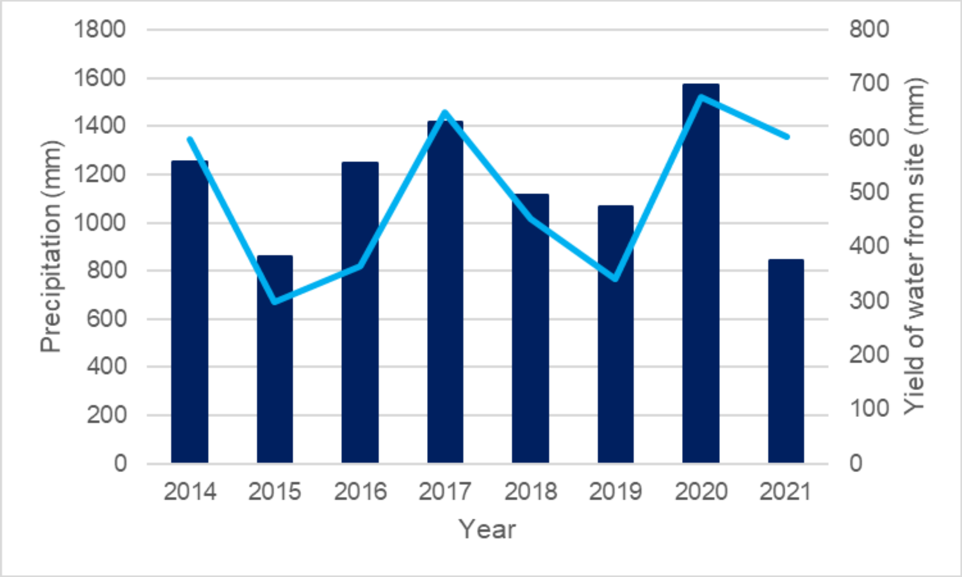

Figure 7-13: Water fluxes from the watersheds associated with the study site

As shown in Figure 7-13, the water fluxes from the site follow the climatic conditions (and specifically the precipitation) for the time period simulated, with fluxes peaking during the summer months (November to March) when rainfall events occur and dropping during the drier winter months. Furthermore, wetter years (e.g., 2014, 2017 and 2020) produce greater water fluxes passing through the wetland systems, the Ekamanzi River and out of the site. Baseflows from the watershed are constant, even in the drier winter months, and this allows for a continuous flow of water through the wetland systems as well as Ekamanzi River year-round. The fluxes are impacted from the land use of the entire watershed area, including existing agricultural activities, grasslands, and existing Tree (Eucalyptus and Wattle) plantations.

The site currently has both contributions from interflow as well as surface flow contributing to the total overall flow of water coming from the site and entering into the downstream environment (Figure 7-14). The interflow dominates the flow paths of the soils of the site. This is due to the soil types which occur within the area, including the shallow and deep recharge soils of the Glenrosa, Hutton and Clovelly soil forms as well as the interflow soils including the Pinedene and Bloemdal soil forms. Surface flow is minor and occurs through the saturated Katspruit soils (classified as the saturated responsive soils) as well as the more compacted developed areas of the site.

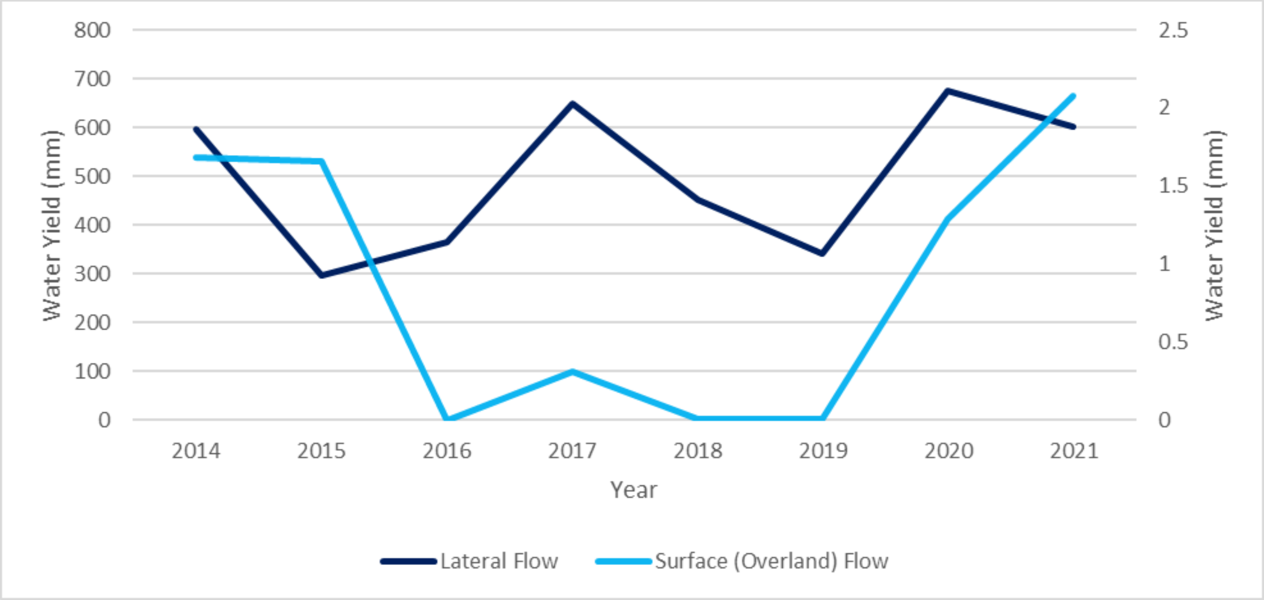

Figure 7-14: Contribution of lateral flow and surface flow to the overall flow from the site

The proposed dam will change the flow dynamics of the seep wetlands in which it will be situated, including an increase in satuarated conditions at this point. The increase in saturation levels will change the current interflow soils of the Pinedene soil form to responsive saturated soils and create more overland (surface) flow. The design of the dam will be important in mitigating this increase in overland flow so as not to cause erosion downstream of the site. The use of the sludge dams for irrigation water does not have a significant impact on the flow dynamics of the site. This is due to the irrigation water being used in the deep recharge soils (Hutton soil form) and this water infiltrating quickly into the soil profile. Within the area where the irrigation takes place, no erosion was noted allowing one to come to conclusion that irrigation levels take place at a sustainable rate.

8. Identification of Impacts

Any activities associated with a natural system, whether historic, current, or proposed, will impact on the surrounding environment, usually in a negative way. In order to minimise these impacts development planning should be based on ecological principles that promote sustainable development. The purpose of this phase of the study was to identify and assess the significance of the potential impacts caused by the proposed dam and the continued use of the sludge dams for irrigation purposes. Furthermore, this section aims to provide a description of the mitigation required to limit the perceived impacts on the natural environment.

This project includes the construction of a storage dam with a capacity of 1 500 000 m^3 to be used for the irrigation of existing cultivation fields. Furthermore, the applicant currently utilises two sludge dams for irrigation purposes and these form part of the WUL application. The proposed dam will have a direct impact on three seep systems and change the flow dynamics of these systems. The sludge dams are however located outside of all wetland systems, with the sludge used for irrigation on deep well drained recharge soils.

A number of potential impacts on the receiving environment have been identified. These relate to the potential for soil erosion and sedimentation as a result of the construction of the dam wall and the floding of the seep systems; and the potential for pollution of the receiving environment is increased if fertilisers and/or herbicides/pesticides are utilised on the cultivation fields and the sludge is not continuously applied at the current rate that it is. Mitigation measures must therefore be aimed at the protection of the current services provided by the catchment areas including the deep recharge soils as well as the water resources.

8.1. Impact Assessment Criteria

Potential impacts of the proposed project on the receiving environment were assessed in terms of a formalised method, whereby a typical risk assessment process was undertaken in order to determine the significance of the potential impacts without the application of mitigation/management measures (WOMM). Once the significance of the impacts without the application of mitigation/management measures was known, the impacts were then re-evaluated, taking cognisance of the application of proposed mitigation/management measures provided in order to reduce the impact (WMM), thus enabling an understanding of the overall impact after the implementation of mitigation/management measures.

The **Nature** of an impact refers to a description of the activity, inherent features, characteristics and/or qualities of the impact. Thus, each impact will be comprehensively detailed and contextualised prior to being assessed.

The **Extent** refers to the impact footprint. What that means is that if a species were to be lost then the extent would be global because that species would be lost to the world. If human health is threatened, then the impact is likely to be no more than local and possibly (in the case of a nuclear power station) regional.

Table 8-1: Descriptors and scoring for the Extent of an impact

Descriptors	Definitions	Score
Site only	The impact remains within the footprint or cadastral boundary of the site.	1
Local	The impact extends beyond the footprint or cadastral boundary of the site, to include the immediately adjacent and surrounding areas.	2
Regional	The impact includes the greater surrounding area within which the site is located.	3
National	The scale/extent of the impact is applicable to the Republic of South Africa.	4
Global	The scale /extent of the impact is global (i.e. world-wide).	5

The **Duration** is the period of time for which the impact would be manifest. Importantly, the concept of reversibility is taken into consideration in the scoring. In other words, the longer the impact endures, the less likely is the reversibility of the impact.

Table 8-2: Descriptors and scoring for the Duration of an impact

Descriptors	Definitions	Score
Temporary	The impact endures for only a short period of time (0-1 years).	1
Short term	The impact continues to manifest for a period of between 1-5 years.	2
Medium term	The impact continues to manifest for a period of 5-15 years.	3
Long term	The impact will cease after the operational life of the activity.	4
Permanent	The impact will continue indefinitely.	5

The **Magnitude** is the measure of the potential severity of the impact on the associated environment. As with duration, the concept of reversibility should be taken into account when considering the magnitude of the potential impact.

Table 8-3: Descriptors and scoring for the Magnitude of an impact

Descriptors	Definitions	Score
Negligible	The ecosystem pattern, process and functioning are not affected, although there is a small negative impact on quality of the ecosystem.	1
Minor	Minor impact - a minor impact on the environment and processes will occur.	2
Low	Low impact - slight impact on ecosystem pattern, process and functioning.	4
Moderate	Valued, important, sensitive or vulnerable systems or communities are negatively affected, but ecosystem pattern, process and functions can continue albeit in a slightly modified way.	6
High	The environment is affected to the extent that the ecosystem pattern, process and functions are altered and may even temporarily cease. Valued, important, sensitive or vulnerable systems or communities are substantially affected.	8
Very High	The environment is affected to the extent that the ecosystem pattern, process and functions are completely destroyed and may permanently cease.	10

The **Probability** is the likelihood of the impact manifesting. Although likelihood and probability may be considered interchangeable, the term likelihood is preferred as probability has a very specific mathematical and/ or statistical connotation. As such the expectation created by the term probability is that there will be an accurate empirically or mathematically defined expression of risk, which is not necessarily required.

Table 8-4: Descriptors and scoring for the Probability of an impact

Descriptors	Definitions	Score
Very improbable / Rare	Where it is highly unlikely that the impact will occur, either because of design or because of historic experience	1
Unlikely	Improbable – where the impact is unlikely to occur (some possibility), either because of design or historic experience.	2
Probable	there is a distinct probability that the impact will occur (< 50% chance of occurring)	3
Highly Probable	Most likely that the impact will occur (50 – 90% chance of occurring)	4
Definite	The impact will occur regardless of any prevention or mitigating measures (>90% chance of occurring).	5

The **Significance** of impacts will be derived through a synthesis of ratings of all criteria in the following calculation:

(Extent + Duration + Magnitude) x Probability = Significance

Table 8-5: Descriptors for the significance score of an impact

Descriptors	Definitions	Score
Low	The perceived impact will not have a noticeable negative influence on the environment and is unlikely to require management intervention that would incur significant cost.	**0 – 19**
Low to Moderate	The perceived impact is considered acceptable, and application of recommended mitigation measures recommended.	**20 – 39**
Moderate	The perceived impact is likely to have a negative effect on the receiving ecosystem and is likely to influence the decision to approve the activity. Implementation of mitigation measures is required, as is routine monitoring to ensure effectiveness of recommended mitigation measures.	**40 – 59**
Moderate to High	The perceived impact will have a significant impact on the receiving ecosystem and will likely have an influence on the decision-making process. Strict implementation of mitigation measures as provided is required, and strict monitoring and high levels of compliance and enforcement in respect of the impact in question are required.	**60 – 79**
High	The impact on the receiving ecosystem is considered of high significant and likely to be irreversible, and therefore highly likely to result in a fatal flaw for the project. Alternatives to the proposed activity are to be investigated as impact will have an influence on the decision-making process.	**80 - 100**

8.2. Soil erosion and degradation of receiving environment

IMPACTS ASSOCIATED WITH SOIL EROSION AND DEGRADATION OF THE RECEIVING ENVIRONMENT										
Potential impact	Extent		Duration		Magnitude		Probability		Significance scoring without mitigation	Significance scoring with mitigation
	Without	With	Without	With	Without	With	Without	With		
CONSTRUCTION PHASE										
Soil erosion, sedimentation, and degradation of the receiving environment.	2	1	1	1	6	4	4	3	36 (Low to Moderate)	18 (Low)
OPERATIONAL PHASE										
Ongoing soil erosion and degradation of the receiving environment.	2	1	5	5	6	4	4	3	52 (Moderate)	30 (Low to Moderate)

Description of impact

The construction of the dam wall will result in the alteration of the soil profile and expose soils to environmental factors including rainfall and wind. The exposure to these factors will result in the removal of sediment and the deposition of this sediment into the seep systems. Sedimentation of the deposited soil poses a risk to the geomorphological/functional integrity of the seeps and the Ekamanzi River as it increases the turbidity of water within these water resources as well as the compaction of the soil profile. Compaction of the soil changes the flow dynamics of the water within the soil profile from subsurface flow to overland flow as water does not infiltrate into the soil profile quickly. This change often impedes hydrological flow and leads to wetland degradation.

In the long term, the formation of a dam commonly impacts the frequency of downstream flooding and sediment cycling. This includes the timing; water quantity; and chemical composition of the water associated with the flow of water into and through the river system as well as the seep systems. An increase in the flooded area of the dam will hold back a greater quantity of water and sediments that would naturally replenish the downstream ecosystems, particularly the Ekamanzi River.

With regards to the use of the sludge dam for irrigation purposes, potential impacts can occur if there is oversaturation of the fields. This does not appear to be the case at present. Any excess water will runoff the area as overland flow once the soil profile is saturated and this leads to the erosion of topsoil.

8.3. Pollution of water resources and soil

IMPACTS ASSOCIATED WITH POLLUTION										
Potential impact	Extent		Duration		Magnitude		Probability		Significance scoring without mitigation	Significance scoring with mitigation
	With out	With	With out	With	With out	With	With out	With		
CONSTRUCTION PHASE										
Pollution of water resources and soil	2	1	1	1	6	4	4	2	36 (Low to Moderate)	12 (Low)
OPERATIONAL PHASE										
Pollution of water resources and soil	2	1	5	5	6	4	4	3	52 (Moderate)	30 (Low to Moderate)

<u>Description of the impact</u>

Sediment release into the downstream aquatic environment is one of the most common forms of waterborne pollution. Sediment will be released into the wetland and river system during the construction of the dam wall. Furthermore, mismanagement of waste and pollutants including hydrocarbons, construction waste, and other hazardous chemicals from any heavy machinery used to construct the dam wall result in these substances entering and polluting the water resources either directly through surface runoff during rainfall events, or subsurface water movement. The linked nature of these systems to downstream water resources will result in pollutants being carried downstream from the construction site having consequences on further downstream users. An increase in pollutants will lead to changes in the water quality of the water resources affecting their ability to maintain biodiversity and act as ecological corridors in the larger landscape.

Furthermore, agricultural practices including using the slude water for irrigation can lead to increased levels of nutrients and pollutant loads. This is not expected to be the case at the moment. An increased load will result in changes to the nutrient and pollutant levels of the soils and waters of the wetland and river systems. Given the linked nature of the wetlands to downstream water resources, these pollutants have the means to affect the downstream receiving environment if not managed. This will lead to a decline in the water quality of the affected water resources.

8.4. General Recommendations

Mitigation measures which can reduce overland flow, encourage the recharge of the soils, and stop soil contamination must be encouraged. These include:

- The use of sediment traps downstream of the dam wall area to minimise the flow of sediment into the wetland and river areas outside of the dam.
- Do not allow surface water from over-irrigation to be concentrated, or to flow down slopes created within any pivot areas without erosion protection measures being in place.
- Erosion control measures must be implemented throughout areas susceptible to erosion. These measures include but are not limited to - sand bags, hessian sheets, silt fences, retention or replacement of vegetation and geotextiles such as soil cells which must be used in the protection of slopes.
- Any vegetation clearance, soil preparation and planting must be scheduled to coincide with the low rainfall season such that surface runoff and erosion are minimal.
- Soil compaction (where encountered) can be alleviated by lightly ripping the soils to at least 45 cm below ground surface to physically loosen the soil prior to re-vegetating the soil.
- No release of any substance i.e. cement, oil, fertilisers or pesticides that could be toxic to fauna or faunal habitats. Furthermore, the washing of any containers, wheelbarrows, spades, picks or any other equipment that may be used and that has been contaminated with cement or chemicals within any of the wetland and river systems or dams must be strictly prohibited.
- Spillages of fuels, oils and other potentially harmful chemicals must be cleaned up immediately and contaminants properly drained and disposed of using proper solid/hazardous waste facilities (not to be disposed of within the natural environment). Any contaminated soil must be removed, and the affected area rehabilitated immediately – consult with a wetland/aquatic specialist if spills occur.
- The duration of the irrigation cycles should be monitored to establish a baseline timing according to soil type in order to avoid excessive saturation and surface runoff, which would increase the erosion hazard and sedimentation of downstream wetlands as well as release of excess nutrients/pollutants.

- Should any waste be generated during day-to-day agricultural activities, these must be disposed of and not dumped in open land. Monitor all sites disturbed by construction activities for colonisation by exotics or invasive plants and control these as they emerge. This requirement is in fulfilment of the terms of the National Environmental Management: Biodiversity Act (Act 10 of 2004).

9. Conclusions

Soil sampling was undertaken throughout the sudy site and the soils classified to form level. The soils are typical of the land type data for the area and were classified as Hutton, Clovelly, Pinedene, Bloemdal, Glenrosa and Katspruit soils.

Based on the 5m contours of the area, as well as the delineated wetland and watercourse systems, six hillslope catenas were delineated. A soil hillslope catena sequence is a description of a sequence of soils in a landscape and how the soils change down a slope. The wetland and watercourse systems located in the site were considered the end points of the hillslope catenas. From the soil samples taken within the site, the six catenas were then classified as per hydrological soil groups. Based on the information obtained during the field investigation, the following hydrological soil type classes are associated with the hillslope catenas identified throughout the site.

Hillslope catena 1:

- Recharge (shallow) – Glenrosa
- Recharge (deep) - Hutton
- Responsive soils (saturated) – Katspruit

Hillslope catenas 2, and 4 :

- Responsive (shallow) – Glenrosa
- Responsive (deep) - Clovelly
- Interflow (soil/bedrock) –Pinedene
- Responsive soils (saturated) – Katspruit

Hillslope catenas 3 and 5 :

- Recharge (shallow) – Glenrosa
- Recharge (deep) – Hutton
- Recharge (deep) - Clovelly
- Interflow (soil/bedrock) – Pinedene
- Responsive soils (saturated) – Katspruit

Hillslope catenas 6

- Responsive (shallow) – transformed area
- Recharge (deep) – Hutton
- Interflow (soil/bedrock) – Bloemdal
- Responsive soils (saturated) – Katspruit

Development within a catchment has a profound effect on the flow dynamics of soils and changes the rate of recharge, the rate of interflow as well as their responsive nature. Changes to the flow dynamics can be seen if there is an increase in hardened surfaces, changes to topography, changes to flow dynamics, as well as a decrease in vegetation which acts as a barrier to allow for stormwater infiltration into the soil profile. To understand the flow dynamics of the site and the impacts of the proposed dam as well as the continued use of the sludge dams, the use of the SWAT+ model was incorporated into this study and the fluxes from the site simulated.

The simulation shows that water fluxes from the site follow the climatic conditions (and specifically the precipitation) for the time period simulated, with fluxes peaking during the summer months (November to March) when rainfall events occur and dropping during the drier winter months. Furthermore, wetter years (e.g., 2014, 2017 and 2020) produce greater water fluxes passing through the water resource systems and out of the site. Baseflows from the watershed are constant, even in the drier winter months, and this allows for a continuous flow of water through the wetland systems as well as Ekamanzi River year-round. The fluxes are impacted from the land use of the entire watershed area, including existing agricultural activities, grasslands, and existing Tree plantations.

The site currently has both contributions from interflow as well as surface flow contributing to the total overall flow of water coming from the site and entering into the downstream environment. The interflow dominates the flow paths of the soils of the site. This is due to the soil types which occur within the area, including the shallow and deep recharge soils of the Glenrosa, Hutton and Clovelly soil forms as well as the interflow soils including the Pinedene and Bloemdal soil forms. Surface flow is minor and occurs through the saturated Katspruit soils (classified as the saturated responsive soils) as well as the more compacted developed areas of the site.

The proposed dam will change the flow dynamics of the seep wetlands in which it will be situated, including an increase in satuarated conditions at this point. The increase in saturation levels will change the current interflow soils of the Pinedene soil form to responsive saturated soils and create more overland (surface) flow. The design of the dam will be important in mitigating this increase in overland flow so as not to cause erosion downstream of the site. The use of the sludge dams for irrigation water does not have a significant impact on the flow dynamics of the site. This is due to the irrigation water being used in the deep recharge soils (Hutton soil form) and this water infiltrating quickly into the soil profile. Within the area where the irrigation takes place, no erosion was noted allowing one to come to conclusion that irrigation levels take place at a sustainable rate.

It is therefore recommended that should the mitigation measures outlined in this report be adhered too, long-term impacts can be minimised on both the wetlands and river system. Should all mitigation measures including any required monitoring be implemented it is the author’s opinion that the project be authorised.

10. Details of Specialist

This Specialist Report has been compiled by the following specialists:

Table 10-1: Details of the Specialist(s) who prepared this Report

Responsibility	Report Writing
Full Name of Specialist	Rowena Harrison
Highest Qualification	PhD – Soil Science
Professional Accreditation	Pr. Sci. Nat. Reg. Number 400715/15
Years of experience in specialist field	>10

Declaration of Specialist

I, **Rowena Harrison**, as the appointed specialists hereby declare/affirm the correctness of the information provided or to be provided as part of the application, and that I:

- in terms of the general requirement to be independent:
- other than fair remuneration for work performed/to be performed in terms of this application, have no business, financial, personal or other interest in the activity or application and that there are no circumstances that may compromise my objectivity; or
- am not independent, but another specialist that meets the general requirements set out in Regulation 13 have been appointed to review my work (Note: a declaration by the review specialist must be submitted);
- in terms of the remainder of the general requirements for a specialist, am fully aware of and meet all of the requirements and that failure to comply with any the requirements may result in disqualification;
- have disclosed/will disclose, to the applicant, the Department and interested and affected parties, all material information that have or may have the potential to influence the decision of the Department or the objectivity of any report, plan or document prepared or to be prepared as part of the application;

- have ensured/will ensure that information containing all relevant facts in respect of the application was/will be distributed or was/will be made available to interested and affected parties and the public and that participation by interested and affected parties was/will be facilitated in such a manner that all interested and affected parties were/will be provided with a reasonable opportunity to participate and to provide comments;
- have ensured/will ensure that the comments of all interested and affected parties were/will be considered, recorded and submitted to the Department in respect of the application;
- have ensured/will ensure the inclusion of inputs and recommendations from the specialist reports in respect of the application, where relevant;
- have kept/will keep a register of all interested and affected parties that participate/d in the public participation process; and
- I am aware that a false declaration is an offence in terms of regulation 48 of the 2014 NEMA EIA Regulations.

Rowena Harrison Pr. Sci. Nat. No. 400715/15

Signature of the specialist

Rowena Harrison

Full Name and Surname of the specialist

Land Matters on behalf of Hunts Green Consulting

Name of company

January 2024

Date

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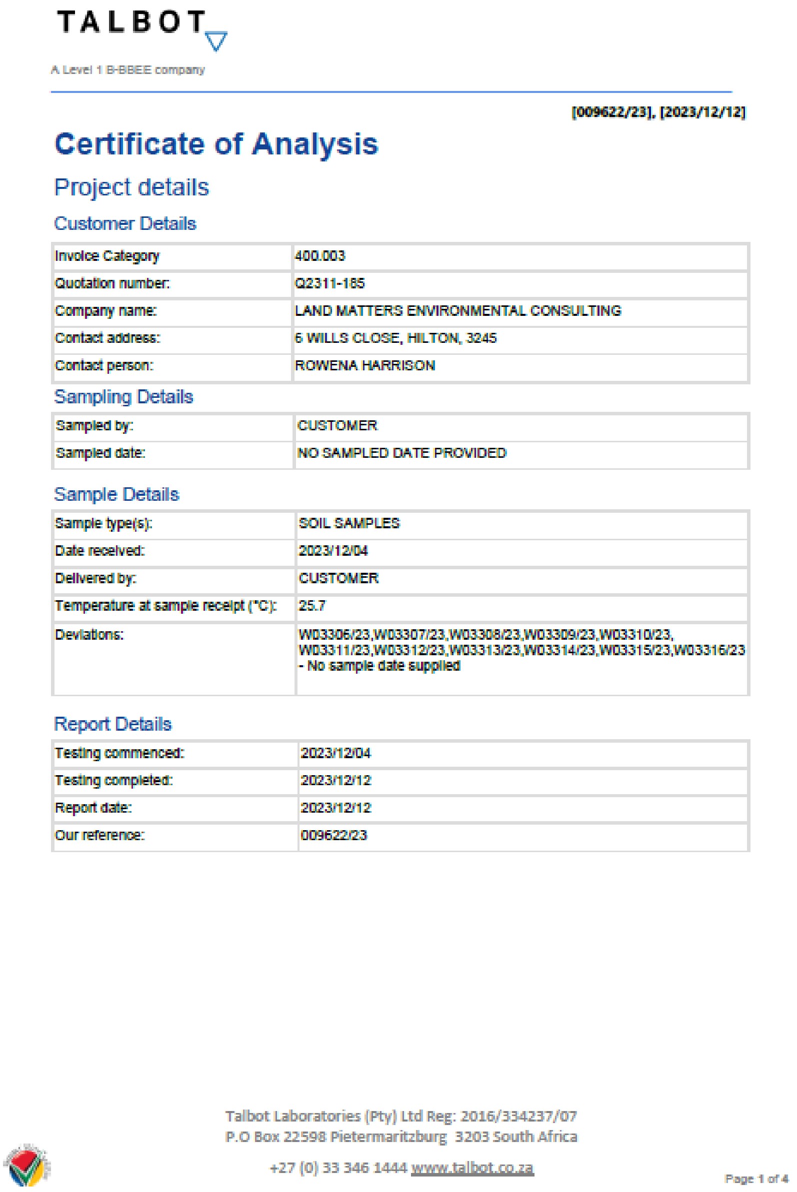
12. Appendix A: Talbot Laboratory Analysis Results



TALBOT

A Level 1 B-BBEE company

[009622/23], [2023/12/12]

Certificate of Analysis

Project details

Customer Details

Invoice Category	400.003
Quotation number:	Q2311-185
Company name:	LAND MATTERS ENVIRONMENTAL CONSULTING
Contact address:	6 WILLS CLOSE, HILTON, 3245
Contact person:	ROWENA HARRISON

Sampling Details

Sampled by:	CUSTOMER
Sampled date:	NO SAMPLED DATE PROVIDED

Sample Details

Sample type(s):	SOIL SAMPLES
Date received:	2023/12/04
Delivered by:	CUSTOMER
Temperature at sample receipt (°C):	25.7
Deviations:	W03306/23,W03307/23,W03308/23,W03309/23,W03310/23, W03311/23,W03312/23,W03313/23,W03314/23,W03315/23,W03316/23 - No sample date supplied

Report Details

Testing commenced:	2023/12/04
Testing completed:	2023/12/12
Report date:	2023/12/12
Our reference:	009622/23

Talbot Laboratories (Pty) Ltd Reg: 2016/334237/07
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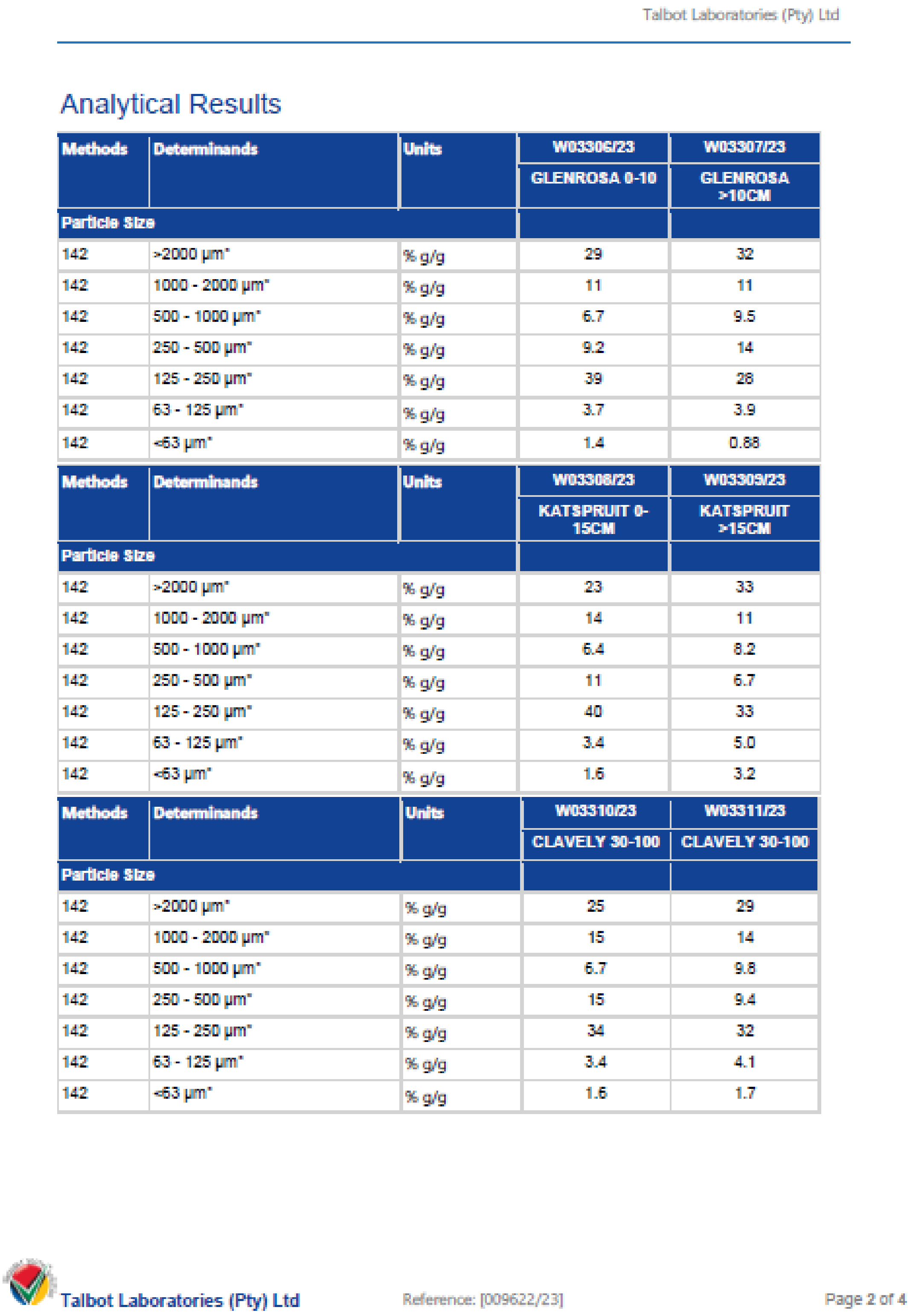
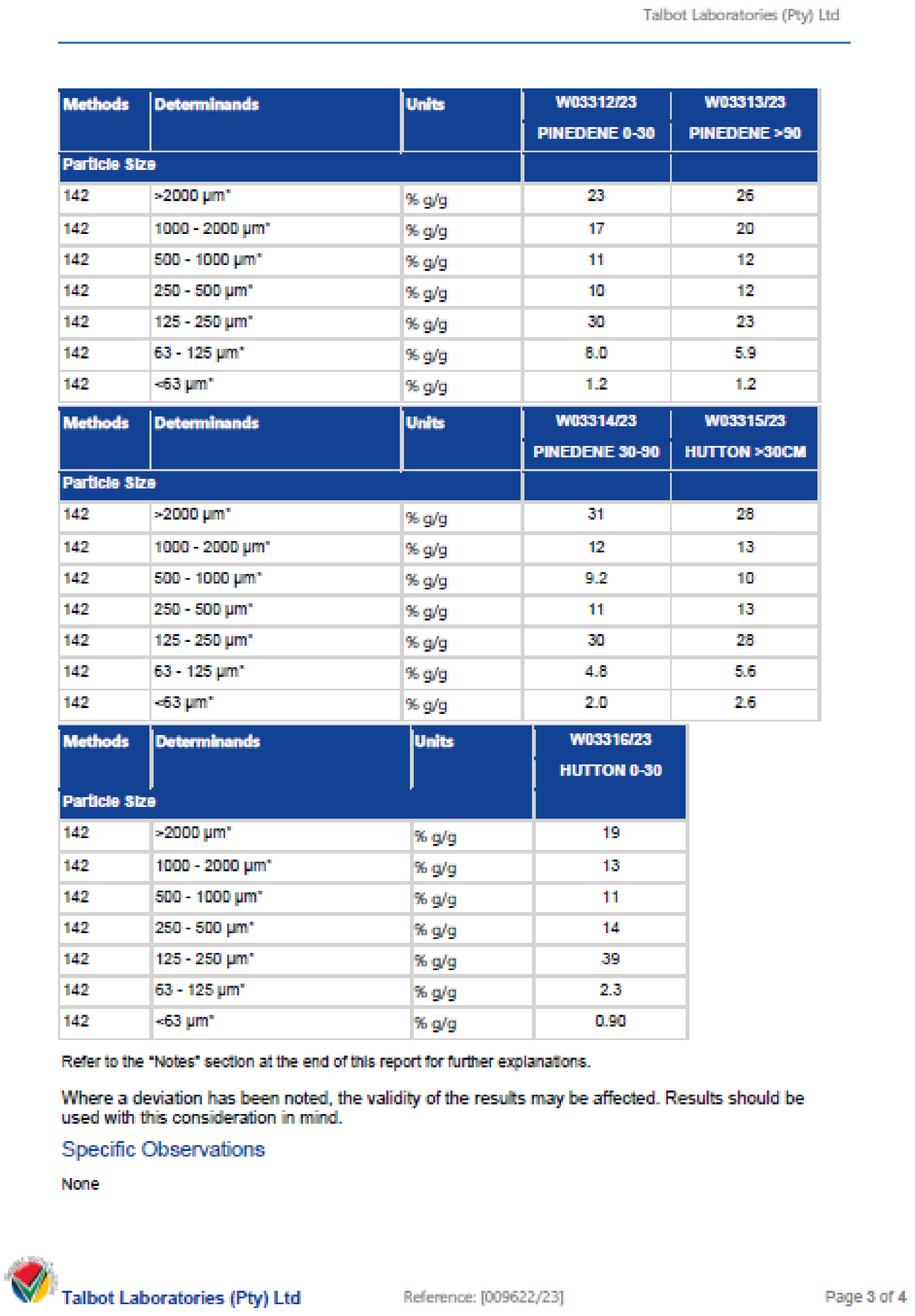


Analytical Results

Methods	Determinands	Units	W03306/23	W03307/23
			GLENROSA 0-10	GLENROSA >10CM
Particle Size				
142	>2000 µm*	% g/g	29	32
142	1000 - 2000 µm*	% g/g	11	11
142	500 - 1000 µm*	% g/g	6.7	9.5
142	250 - 500 µm*	% g/g	9.2	14
142	125 - 250 µm*	% g/g	39	28
142	63 - 125 µm*	% g/g	3.7	3.9
142	<63 µm*	% g/g	1.4	0.88

Methods	Determinands	Units	W03308/23	W03309/23
			KATSPRUIT 0-15CM	KATSPRUIT >15CM
Particle Size				
142	>2000 µm*	% g/g	23	33
142	1000 - 2000 µm*	% g/g	14	11
142	500 - 1000 µm*	% g/g	6.4	8.2
142	250 - 500 µm*	% g/g	11	6.7
142	125 - 250 µm*	% g/g	40	33
142	63 - 125 µm*	% g/g	3.4	5.0
142	<63 µm*	% g/g	1.6	3.2

Methods	Determinands	Units	W03310/23	W03311/23
			CLAVELY 30-100	CLAVELY 30-100
Particle Size				
142	>2000 µm*	% g/g	25	29
142	1000 - 2000 µm*	% g/g	15	14
142	500 - 1000 µm*	% g/g	6.7	9.8
142	250 - 500 µm*	% g/g	15	9.4
142	125 - 250 µm*	% g/g	34	32
142	63 - 125 µm*	% g/g	3.4	4.1
142	<63 µm*	% g/g	1.6	1.7



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Methods	Determinands	Units	W03312/23 PINEDENE 0-30	W03313/23 PINEDENE >90
Particle Size				
142	>2000 µm*	% g/g	23	26
142	1000 - 2000 µm*	% g/g	17	20
142	500 - 1000 µm*	% g/g	11	12
142	250 - 500 µm*	% g/g	10	12
142	125 - 250 µm*	% g/g	30	23
142	63 - 125 µm*	% g/g	8.0	5.9
142	<63 µm*	% g/g	1.2	1.2

Methods	Determinands	Units	W03314/23 PINEDENE 30-90	W03315/23 HUTTON >30CM
Particle Size				
142	>2000 µm*	% g/g	31	28
142	1000 - 2000 µm*	% g/g	12	13
142	500 - 1000 µm*	% g/g	9.2	10
142	250 - 500 µm*	% g/g	11	13
142	125 - 250 µm*	% g/g	30	28
142	63 - 125 µm*	% g/g	4.8	5.6
142	<63 µm*	% g/g	2.0	2.6

Methods	Determinands	Units	W03316/23 HUTTON 0-30
Particle Size			
142	>2000 µm*	% g/g	19
142	1000 - 2000 µm*	% g/g	13
142	500 - 1000 µm*	% g/g	11
142	250 - 500 µm*	% g/g	14
142	125 - 250 µm*	% g/g	39
142	63 - 125 µm*	% g/g	2.3
142	<63 µm*	% g/g	0.90

Refer to the "Notes" section at the end of this report for further explanations.

Where a deviation has been noted, the validity of the results may be affected. Results should be used with this consideration in mind.

Specific Observations

None

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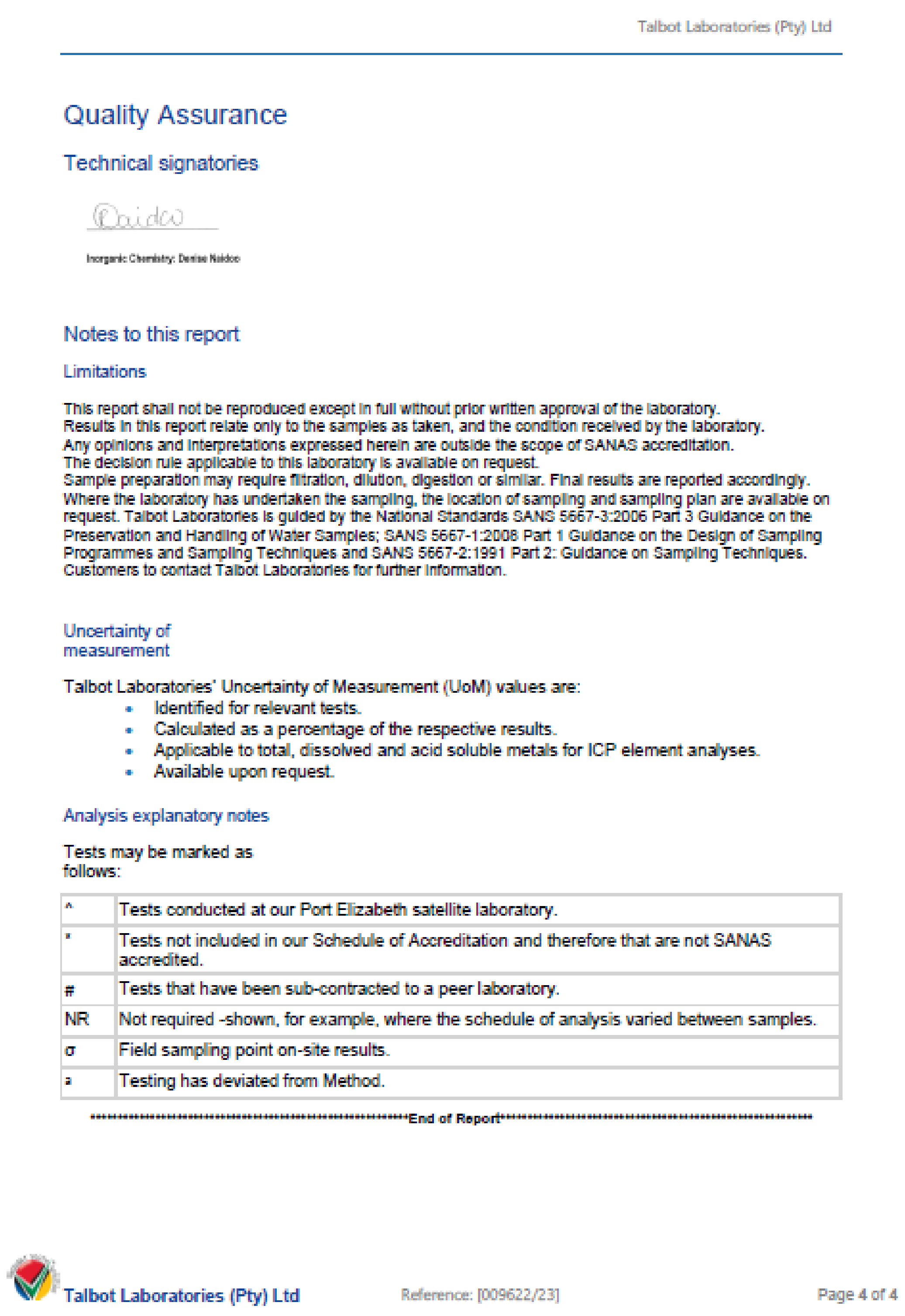

Quality Assurance

Technical signatories

Naidoo

Inorganic Chemistry: Denise Naidoo

Notes to this report

Limitations

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Sample preparation may require filtration, dilution, digestion or similar. Final results are reported accordingly.
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Uncertainty of measurement

Talbot Laboratories' Uncertainty of Measurement (UoM) values are:

- Identified for relevant tests.
- Calculated as a percentage of the respective results.
- Applicable to total, dissolved and acid soluble metals for ICP element analyses.
- Available upon request.

Analysis explanatory notes

Tests may be marked as follows:

^	Tests conducted at our Port Elizabeth satellite laboratory.
*	Tests not included in our Schedule of Accreditation and therefore that are not SANAS accredited.
#	Tests that have been sub-contracted to a peer laboratory.
NR	Not required -shown, for example, where the schedule of analysis varied between samples.
σ	Field sampling point on-site results.
a	Testing has deviated from Method.

End of Report