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HYDROPEDOLOGICAL IMPACT ASSESSMENT FOR THE PROPOSED CONSTRUCTION OF A DONOR HOUSE AND ASSOCIATED INFRASTRUCTURE AT THE UKUWELA NATURE RESERVE, HLUHLUWE, KZN

Date
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Client
SiVEST SA (Pty) Ltd

SPECIALIST ASSESSMENT DETAILS & DECLARATION OF INDEPENDENCE

Document Title	**HYDROPEDOLOGICAL IMPACT ASSESSMENT FOR THE PROPOSED CONSTRUCTION OF A DONOR HOUSE AND ASSOCIATED INFRASTRUCTURE AT THE UKUWELA NATURE RESERVE, HLUHLUWE, KZN**	
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Client	**SiVEST SA (Pty) Ltd**	
Fieldwork and Report Writing	**Wayne Jackson**	

I, Wayne Jackson, hereby declare that this report has been prepared independently of any influence or prejudice as may be specified by the Department of Environmental Affairs.

Wayne Jackson

Soils & Wetland Specialist

Eco-Assist

16th March 2022

Specialist Details

The relevant experience of specialist team members involved in the compilation of this report are briefly summarized above. Curriculum Vitae's of the specialist team are available on request.

Specialist	Role	Details
Wayne Jackson *Cert.Sci.Nat. (Registration 119037)*	**Field work and author (Soils)**	Wayne Jackson graduated from the University of KwaZulu-Natal, Pietermaritzburg, with a BSc. degree in Soil Science & Hydrology. Wayne has 13 years' experience in Wetlands & Soils Scientist with a demonstrated history of working in the environmental services industry. He is skilled in Soil Classification, Wetlands, Hydropedology, and Surface Water Hydrology. He has a strong Environmental mitigation and rehabilitation knowledge. He has also gained experience in large post-mining rehabilitation projects, providing specialist inputs on land capability and soil utilisation. He has extensive exposure to a wide range of projects in many sectors across South Africa, and parts of Africa. He is knowledgeable on how soils, wetlands, and hydrological systems are linked in the landscape and how activities could impact all these aspects. Wayne is a registered Natural Scientist with the South African Council for Natural Scientific Professionals (SACNASP) – Registration No. 119037.

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1 INTRODUCTION

Eco-Assist Environmental Consultants (here after Eco-Assist) were appointed by SiVEST SA (Pty) Ltd (hereafter SiVEST) to conduct the Hydropedological Impact Assessment in relation to the development of the Greater Ukuwela Nature Reserve (GUNR) located in the Big 5 False Bay Local Municipality (KZN273) section of the Umkhanyakude District Municipality (DC27) near the town of Hluhluwe, KwaZulu-Natal..

1.1 Background

Wild Tomorrow Fund are proposing the construction of a donor house and associated infrastructure on the GUNR near Hluhluwe, KwaZulu-Natal Province.

The GUNR has been registered as an Ezemvelo KZN Biodiversity Stewardship Site and as such is proclaimed as a Protected Area as defined within the National Environmental Management: Protected Areas Act of 2003 (NEMPAA), as amended.

The proposed development is to include the following components:

- Donor House with associated Decking, Terraces, Landscaping and Walkways
- Managers House
- Reserve Office and FreeMe Complex
- Tented Camp
- Various internal access roads (x3) / tracks for reserve management / game viewing (Gravel Roads Proposed)

In terms of infrastructure requirements, the following is proposed:

- Potable water provision will be via a municipal source;
- On site sewer treatment will be required (Septic Tank and Soakaway System); and
- Electrical supply will be via Eskom.

1.2 Project Locality

The GUNR is approximately 1283,1 hectares and is located just north of the Hluhluwe town in Northern KwaZulu Natal (see Figure 1-1). It falls within the uMkhanyakude District Municipality and the Big Five Hlabisa Local Municipality.

Ukuwela is located in the center of the Maputaland-Pondoland-Albany Hotspot, one of the world's biologically richest and most endangered land-based ecoregions. It is surrounded by prestigious wildlife reserves, including Mkuze, St Lucia, Sodwana Bay, South Africa's first UNESCO World Heritage Site, the iSimangaliso Wetland Park, and the Phinda Private Game Reserve, with which Ukuwela shares a river border (Wild Tomorrow Fund, 2021).

The GUNR is accessed off Road R22 and may be entered from either the southern side near the Zulu Croc Centre, or the northern side on the approach to the Mzinene River crossing. The project footprint and layouts are shown in Figure 1-2 to Figure 1-5.

The GUNR consists of three properties. Note that the original extent of the Mfuleni property includes the FreeMe site although the latter is now a separate subdivision. It is also to be noted that the Phinda game Reserve lies immediately to the north of the area.

The overall GUNR Project consists of developing a stable and functional nature conservation area which will also have educational and training functions. However, the purpose of this investigation is to consider the possible impacts of the proposed project infrastructure on the aquatic environment in its proximity. This infrastructure consists of a donor house, a manager's house, an office complex, a tented camp, and some roads/tracks. In addition, the Fund has offered space to the FreeMe NGO in which to construct and operate a wildlife trauma and rehabilitation centre.

The proposed development is to include the following components:

- ***Donor House (see* Figure 1-4*):*** Donor House with associated decking, terraces, landscaping and walkways. The Fund is a wildlife conservation charity which receives financial donations from hundreds of people each year. These donations fund the conservation work performed on the GUNR. The Fund would like its major donors to experience the reserve firsthand and to share in the conservation achievements that they made possible. The donor house will be a place for them to stay and learn about the Fund's current and future projects. The major donors will have the chance to invite their friends and family to stay with them. The Fund believes the donor house will be an excellent means to deepen relationships with existing and potential donors and that it will ultimately lead to more funding for conservation. Thus the donor house will be an important source of sustainable revenue for the reserve, bringing both invited and paying guests while creating additional employment for people in the area.
- ***Managers House (see* Figure 1-3*):*** The Fund intends to build a simple two-bedroom house in the GUNR for their General Manager. Having the General Manager reside on-site will increase the output and quality of work from this employee and all other staff. An additional person living fulltime on the reserve will also increase the overall security.
- ***A Reserve Office and FreeMe Complex (see* Figure 1-5*):*** FreeMe is a South African wildlife rehabilitation organization based in Howick, SA. The Wild Tomorrow Fund has entered into a legal agreement where FreeMe will lease four hectares of land from the Fund on the GUNR. The purpose is for FreeMe to create a wildlife rehabilitation centre for the indigenous mammals, birds, reptiles, amphibians and invertebrates in accordance with the Ezemvelo KZN Wildlife permit conditions. FreeMe's rehabilitation centre will fill a much-needed void in the area for a reputable place where injured wildlife can be cared for. Adjacent to the FreeMe rehabilitation centre will be the Reserve Office where Fund employees will work. Having the employees working from one location will increase the productivity and quality of conservation work.
- ***A Tented Camp (see* Figure 1-5*):*** The Wild Tomorrow Fund has a paid volunteer program where local and international people take part in conservation activities on the Greater Ukuwela Nature Reserve for two weeks at a time. There are typically two to three volunteer trips each year. To increase the profits the Fund generates from these trips, they would like their guests to stay on reserve, thus eliminating the need to pay for third-party lodging. These savings will be used to fund their conservation and community projects.
- Various internal access roads and tracks for reserve management / game viewing. These roads will have gravel surfaces and will be constructed with appropriate drainage and watercourse crossing structures as may be required.

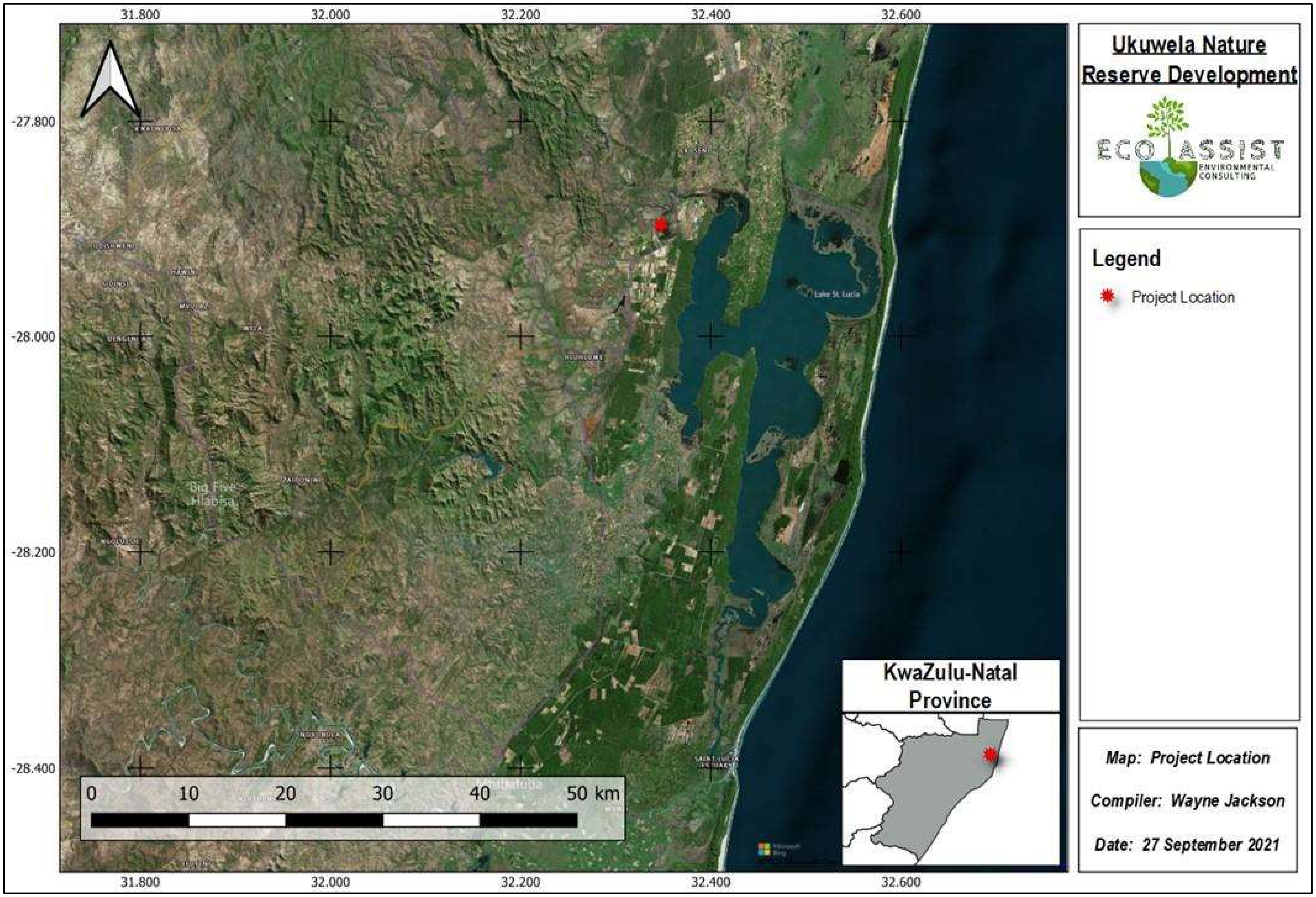

Figure 1-1: Local setting of the study.

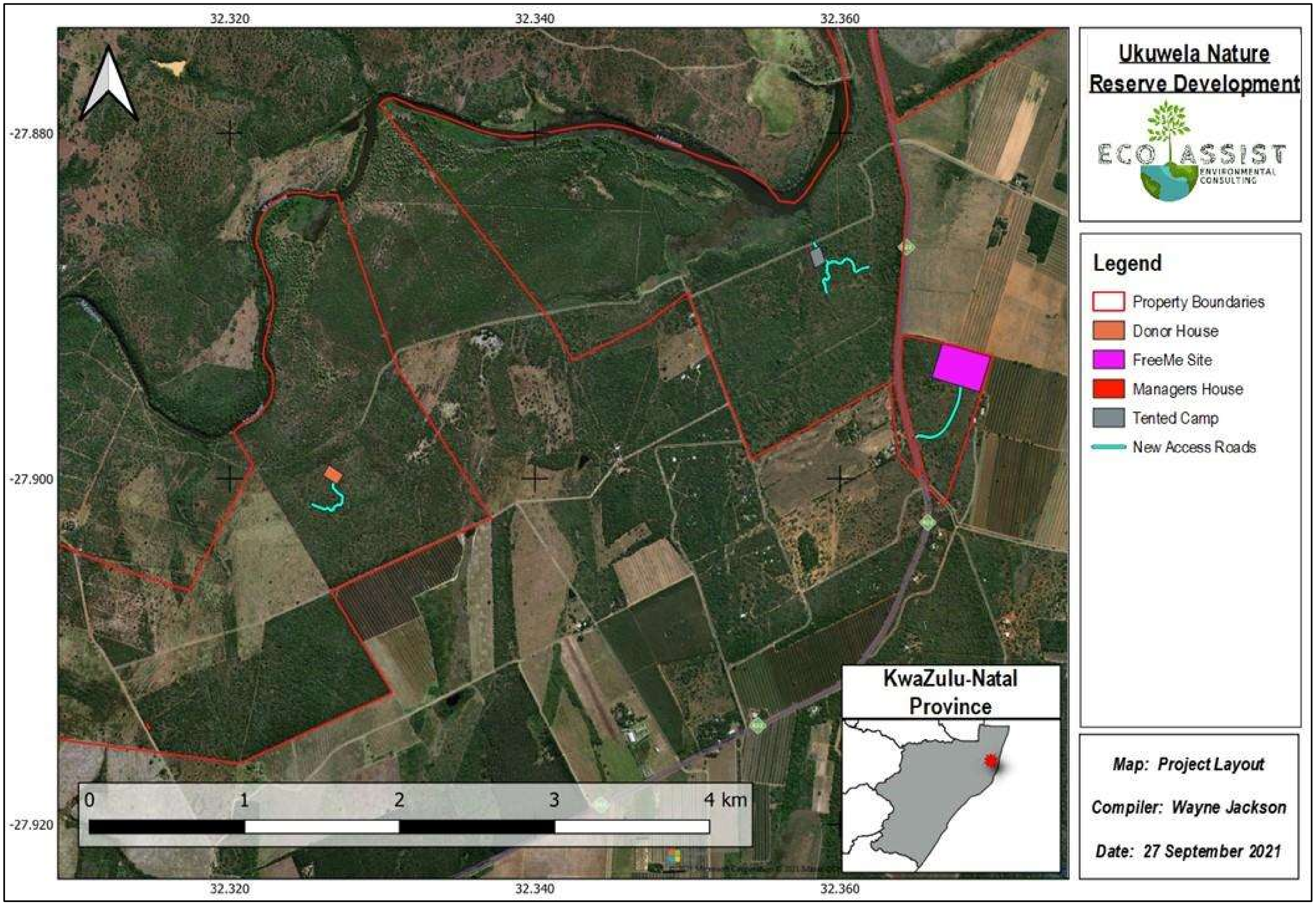

Figure 1-2: Project layout.

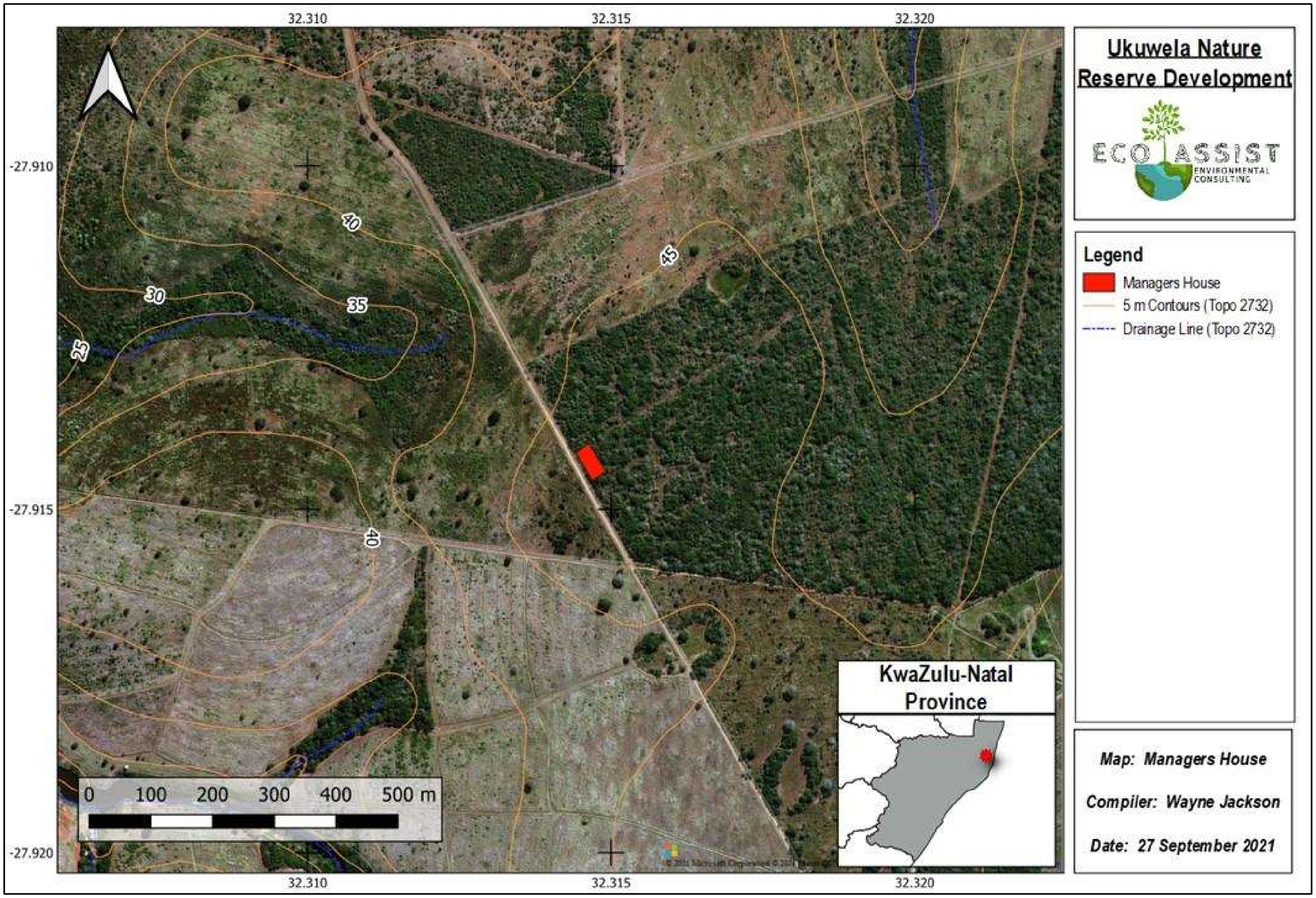

Figure 1-3: Managers house layout.

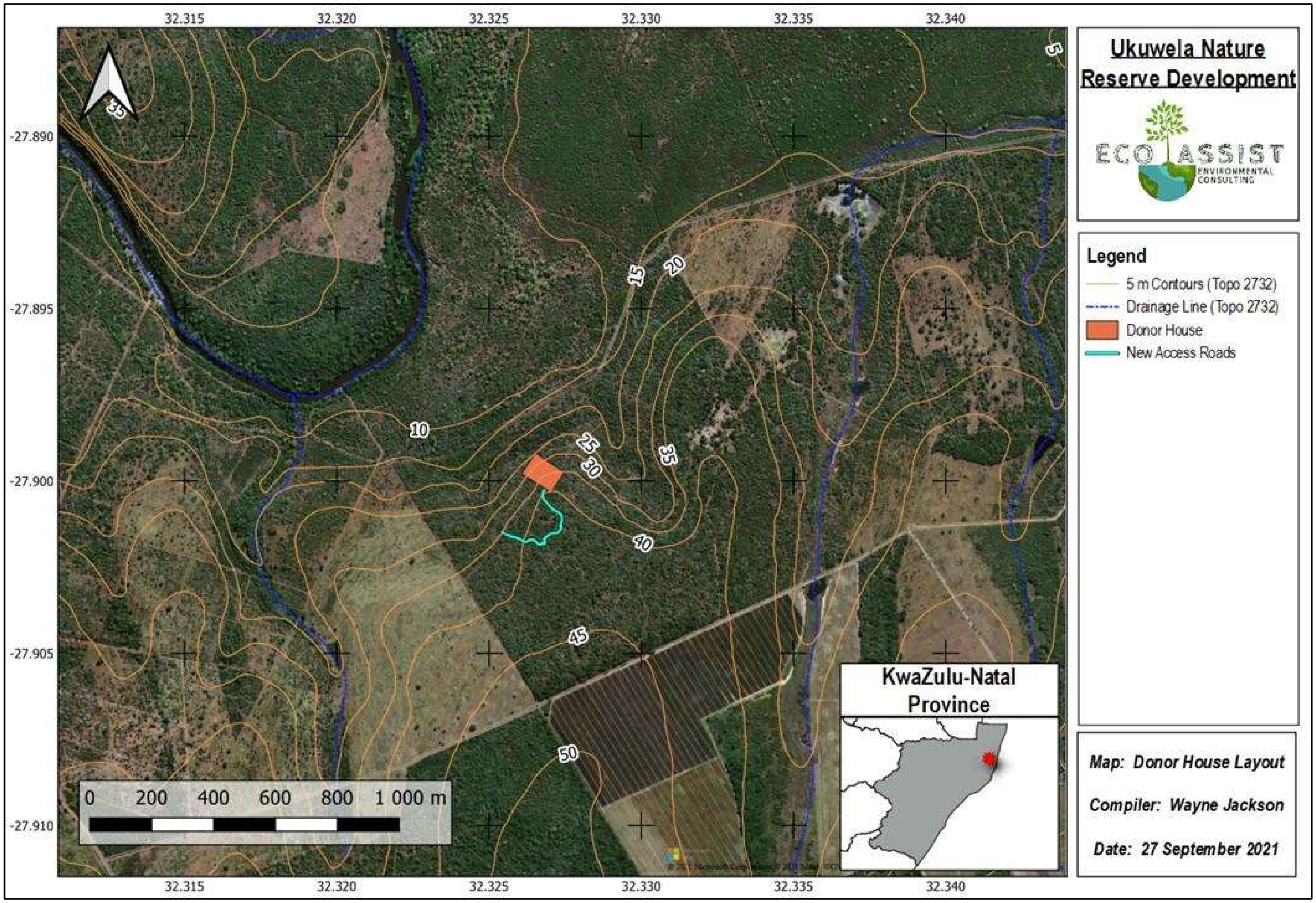

Figure 1-4: Donor house layout.

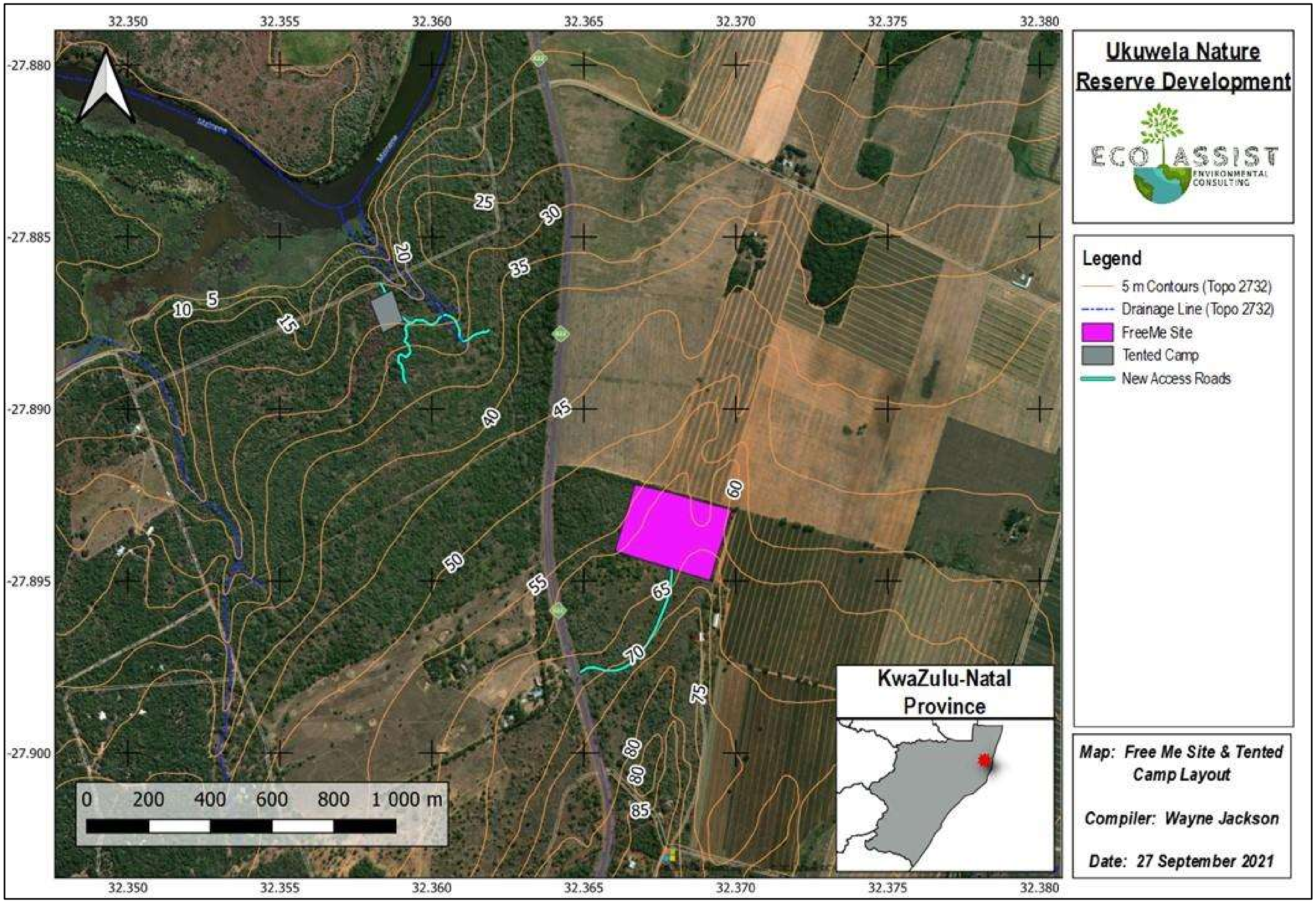

Figure 1-5: Tented camp and Free Me site layout.

2 TERMS OF REFERENCE

Hydropedology Assessment

- Terrain analysis - to identify hillslopes in the study area.
- Landtype disaggregation - These findings will guide the fieldwork and positions of observations.
- Hydropedological survey of representative hillslopes on the site according to the methodology of Le Roux et al., 2011.
- Classify observations according to the Soil Classification Working Group (2018).
- Regrouped soils into hydropedological response of the soils (van Tol and Le Roux, 2019).
- Develop a Conceptual Hydrological Response Model based on morphological properties and their spatial distribution.
- Discussion of land use change impact on flowpaths affected.
- Impact assessment based on the above results.
- Determine best management practices to conserve the water resources:
  - size of buffer zones.
  - identification of hydrological sensitive areas.

3 KEY LEGISLATION

Relevant environmental legislation pertaining to the protection and use of water resources in South Africa has been included in Table 3-1.

Table 3-1: Relevant Legislation.

Legislation	Description of relevant portions
South African Constitution 108 of 1996.	This includes the right to have the environment protected through legislative or other means.
The National Water Act 36 of 1998.	This Act imposes 'duty of care' on all landowners, to ensure that water resources are not polluted. The following Clause in terms of the National Water Act is applicable in this case: **19 (1)** *"An owner of land, a person in control of land or a person who occupies or uses the land on which (a) any activity or process is or was performed or undertaken; which causes, has caused or likely to cause pollution of a water resource, must take all reasonable measures to prevent any such pollution from occurring, continuing or recurring"* Chapter 4 of the National Water Act is of particular relevance to wetlands and addresses the use of water and stipulates the various types of Licenced and unlicensed entitlements to the use water. Water use is defined very broadly in the Act and effectively requires that any activities with a potential impact on wetlands (within a distance of 500m upstream or downstream of a wetland) be authorized.
General Authorisations (GAs).	These have been promulgated under the National Water Act and were published under GNR 398 of 26 March 2004. Any uses of water which do not meet the requirements of Schedule 1 or the GAs, require a Licence which should be obtained from the Department of Water and Sanitation (DWS).
National Environmental Management Act 107 of 1998.	This is a fundamentally important piece of legislation and effectively promotes sustainable development and entrenches principles such as the 'precautionary approach', 'polluter

Legislation	Description of relevant portions
	pays', and requires responsibility for impacts to be taken throughout the life cycle of a project.
Environmental Impact Assessment (EIA) Regulations.	New regulations have been promulgated in terms of Chapter 5 of NEMA and were published on 4 December 2014 in Government Notice No. R. 32828. In addition, listing notices (GN 983-985) lists activities which are subject to an environmental assessment.
National Environmental Management: Biodiversity Act No. 10 of 2004.	The intention of this Act is to protect species and ecosystems and promote the sustainable use of indigenous biological resources. It addresses aspects such as protection of threatened ecosystems and imposes a duty of care relating to listed invasive alien plants.

4 METHODOLOGY

4.1 Desktop Assessment

The following data layers were assessed to determine whether the development could have an impact on important national & provincial feature:

- Aerial imagery (Google Earth™);
- Land Type Data (Land Type Survey Staff, 1972 - 2006);
- Topographical data;
- Contour data (5 m);
- National land capability evaluation raster data layers (Department of Agriculture, Forestry and Fisheries, 2017); and
- Consideration of aquatic environments in relation to proposed infrastructure developments within a nature reserve near Hluhluwe, KwaZulu-Natal, Jake Alletson 2021.

4.2 Literature Review

The literature review lists and discusses other sources of information including previous assessments conducted on the project area (if available).

Hydropedological Flow Paths

Given that hydropedology is a relatively new field, a short literature review has been added on this interdisciplinary research field. This literature is an excerpt from (Van Tol, et al., 2017).

Soil physical properties and hydrology play significant roles in the fundamentals of hydropedology. Physical properties including porosity, hydraulic conductivity, infiltration etc. determine micro preferential flow paths through a soil profile. The hydrology in turn is responsible for the formation of various morphological processes in soil, including mottling, colouration, and the accumulation of carbonate.

These processes are used to construct models illustrating sub-surface flow paths, storage, and interconnection between these flow paths. Hydropedology can therefore be used for a variety of functions. These functions include process-based modelling, digital soil mapping, pollution control management, impact of land use change on water resources, wetland protection, characterising ground, and sub-surface flows as well as wetland protection and rehabilitation, of which the latter will be the focus during this report (see Figure 4-1). The latter mentioned enables effective water resource management regarding wetlands and sub-surface flows in general.

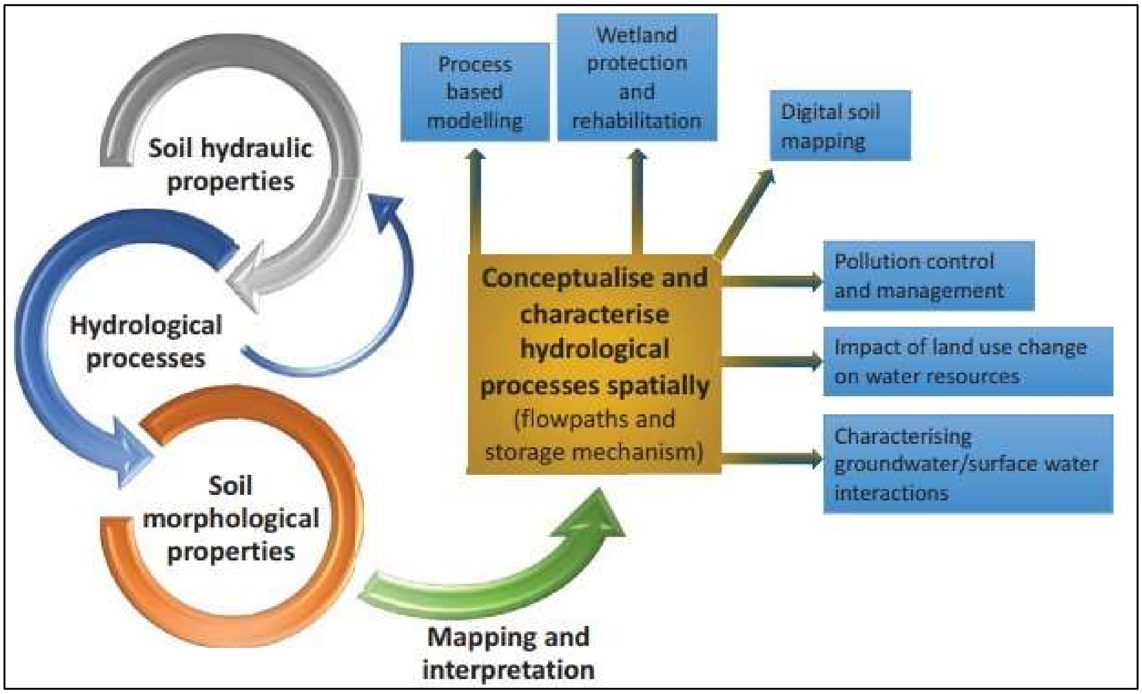

Figure 4-1: Illustration of the interactive nature of hydropedology and its potential applications (Van Tol, et al., 2017).

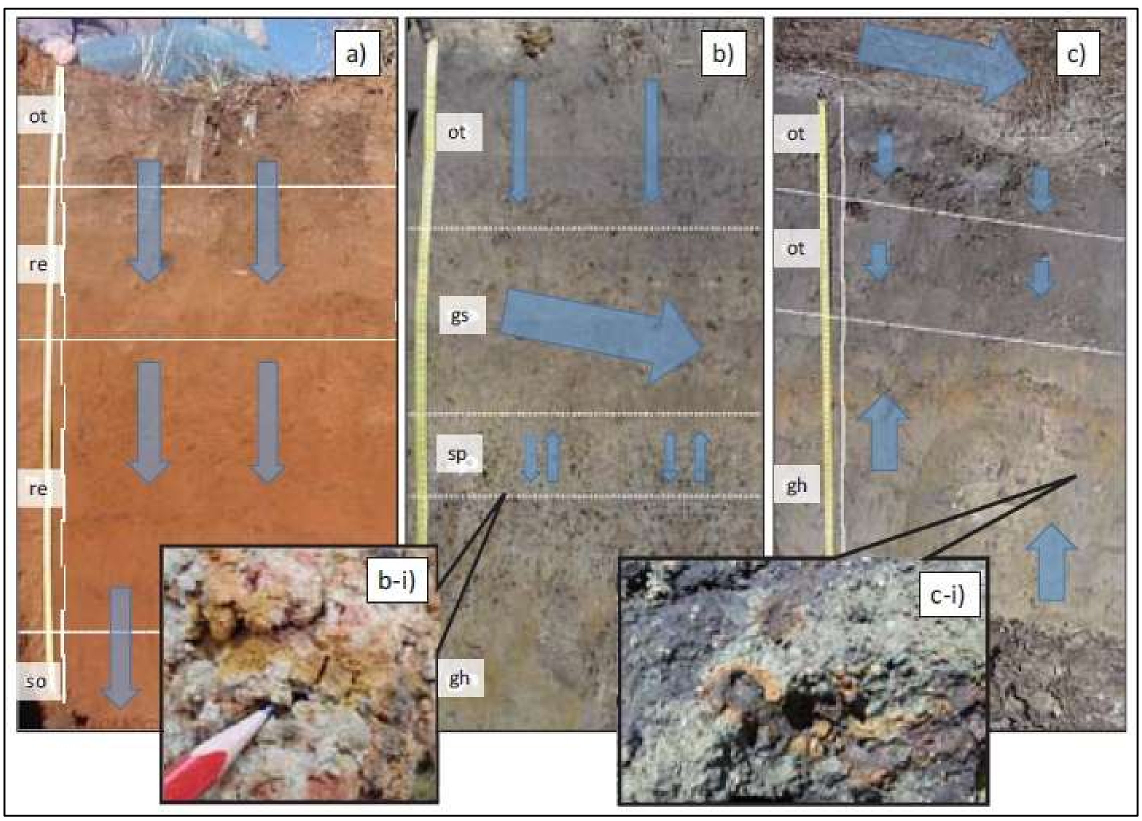

Figure 4-2: Illustration of different hydropedological soil types (Van Tol, et al., 2017).

As can be seen in **Error! Reference source not found.**, the hydropedological behaviour of soil types can differ significantly. **Error! Reference source not found.** (a) illustrates a typical red coloured soil (top- and sub-soil). This soil type will typically have a vertical flow path throughput the soil profile. Water will therefore infiltrate the topsoil and freely drain into the profile to such an extent that the water rapidly reaches the bedrock. After reaching this layer, water will penetrate the ground water source or be transported horizontally towards lower laying areas. This soil type is known as a recharge soil, given its ability to recharge ground and surface water sources.

Error! Reference source not found. (b) illustrates interflow soils. Lateral flows are dominant in this soil type and occurs due to differences in the hydraulic conductivity of soil horizons. The “sp” soil horizon restricts vertical movement and promotes lateral flows at the A/B interface. The lighter colour in this profile indicates leaching which is caused by lateral flows which often occurs on top of a bedrock layer due to the impermeable nature thereof. Mottles often occurs above this impermeable layer due to fluctuating water levels, see the magnified illustration in **Error! Reference source not found.** (b-i).

Error! Reference source not found. (c) illustrates responsive soils. This hydropedological soil type is characterised (in this case) by a dark top-soil and a grey coloured sub-soil. Other indicators include mottling and gleying. These soil types are saturated for very long periods. Therefore, rainfall is unlikely to infiltrate this layer and would likely be carried off via overland flow and are mostly fed by lateral sub-surface flows. Shallow soils are equally responsive in the sense that the soil profile will rapidly be saturated during precipitation, after which rainfall will be carried off by means of overland flows.

A typical example of the hydropedological processes through a hillslope is illustrated in Figure 4-3. In this example, a recharge soil type is located at the upper reaches of the slope. Rainfall infiltrates this soil type and percolates vertically towards the bedrock. Water then, infiltrate into this bedrock given the permeability thereof and could now recharge groundwater or return to the soil in lower lying positions. The second soil type (the interflow zone) indicates lateral flows at the A/B interface and again at the soil/bedrock interface which feeds the responsive zone. The responsive zone is then simultaneously fed by lateral sub-surface flows and ground water recharge.

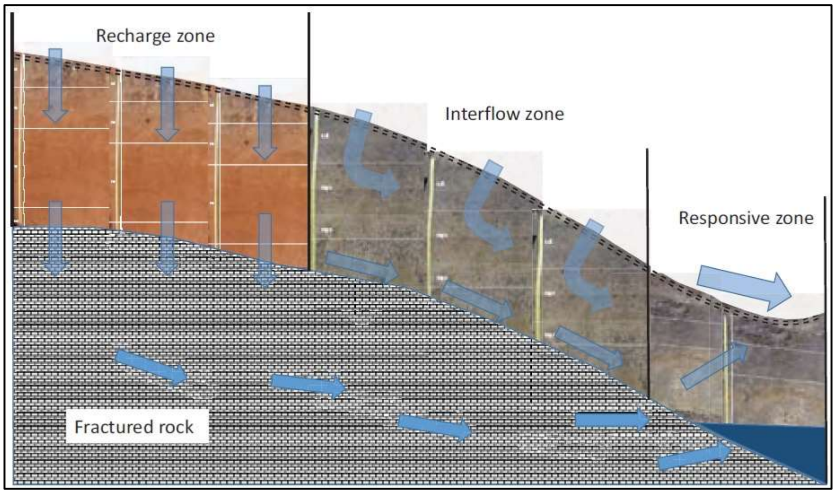

Figure 4-3: Theoretical example of various sub-surface flow paths (Van Tol, et al., 2017).

The methodology of (Van Tol, et al., 2017) has since been updated to include a "stagnant" hydropedological type. According to (Hydropedological grouping of South African soil forms, 2019), four different hydropedological types exist, namely;

- Recharge;
- Interflow;
- Responsive; and
- Stagnating.

These soil types are divided into seven subgroups depending on the morphology of the relevant soil form. The latest addition to this methodology, as mentioned, is known as a stagnating hydropedological type.

This soil type is characterised by restrictive movement of water through profiles (both laterally and vertically) and is dominated by evapotranspiration. The A- and B-horizon of such a soil type usually has a high permeability with morphological indicators, indicating very little movement through the profile. Lime and iron concretions as well as cementation of silica are typical indicators of such a soil form.

4.2.1 Field Procedure

The slopes within the project area have been assessed during the desktop assessment to identify possible transects that will represent typical terrain and soil distribution patterns. These locations were then altered slightly during the survey depending on the extent of vegetation, slopes, access and any features that will improve the accuracy of data acquired.

4.2.2 Identification of Soil Types and Hydrological Soil Types

Soil types have been identified according to the South African soil classification system (Soil Classification Working Group, 1991) after which the link between soil forms and hydropedological response were established (Hydropedological grouping of South African soil forms, 2019), and the soils regrouped into various hydropedological soil types as shown in Table 4-1.

Table 4-1: Hydrological soil types of the studied hillslopes (Hydropedological grouping of South African soil forms, 2019).

Hydrological soil type	Description	Subgroup	Symbol
Recharge	Soils without any morphological indication of saturation. Vertical flow through and out 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.	Shallow	
		Deep	
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).	A/B	
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.	Soil/Bedrock	
Responsive (shallow)	Shallow soils overlying relatively impermeable bedrock. Limited storage capacity results in the generation of overland flow after rain events.	Shallow	
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.	Saturated	
Stagnating	In these soils outflow of water is limited or restricted. The A and/or B horizons are permeable but morphological indicators suggest that recharge and interflow are not dominant. These includes soils with carbonate accumulations in the subsoil, accumulation and cementation by silica, and precipitation of iron as concretions and layers. These soils are frequently observed in climate regions with a very high evapotranspiration demand. Although infiltration occurs readily, the dominant hydrological flow path in the soil is upward, driven by evapotranspiration.	Stagnating	

4.3 Field Procedure

The site was traversed by vehicle and on foot. A soil auger was used to determine the soil form/family and depth. The soil was hand augured to the first restricting layer or 1.5 m. Soil survey positions were recorded as waypoints using a GPS device.

Soils were identified to the soil family level as per the “Soil Classification: A Natural and Anthropogenic System for South Africa” (Soil Classification Working Group, 2018). Landscape features such as existing open trenches were also helpful in determining soil types and depth.

5 LIMITATIONS

The following limitations are applicable to this project:

- It has been assumed that the extent of the development area provided by the applicant is accurate;
- The GPS used for ground truthing is accurate to within five meters. Therefore, the observation site’s delineation plotted digitally may be offset by up to five meters to either side;
- Only the slopes affected by the proposed development have been assessed;

- Only a soil auger was used for this assessment, no open pits were dug, and the hydraulic conductivity of the landscape has been inferred based on the soil properties; and
- The assessment of potential impacts was informed by site-specific environmental conditions at the time of the site visit and ecological concerns based on the investigator's working knowledge and experience with similar projects.

6 RESPONSES TO INTERESTED AND AFFECTED PARTIES

To this point no concerns have been raised as yet. If any concerns are raised with regards to the hydropedology impact assessment it will be addressed in this report.

7 RESULTS FROM DESKTOP ASSESSMENT

7.1 Climate

The climate for the area is mainly summer rainfall with some rain in winter. Mean Annual Precipitation (MAP) is approximately 550–800 mm. Mist of the warm Indian Ocean contributes to precipitation. No incidence of frost occurs in the area. Mean monthly maximum and minimum temperatures were 39.5°C and 3.1°C for January and July, respectively (Mucina, et al., 2006).

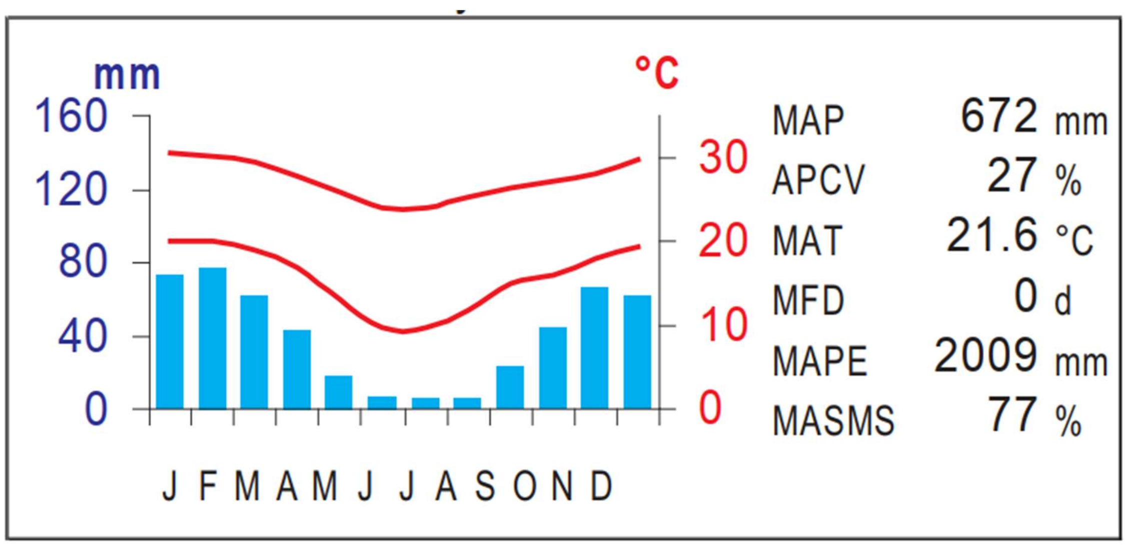

Figure 7-1: Climate summary for the area (Mucina, et al., 2006).

The land capability evaluation 2016 data layer is a refined and updated spatial modelled data layer depicting the land capability evaluation values for the country. The climate capability data layer is a sub-set data layer that contributes to the land capability data layer. It includes both the spatial as well as attributes description of the climate capability values (Department of Agriculture, Forestry and Fisheries, 2017). The climate capability as per Figure 7-2 shows a Moderate-High rating for the project area.

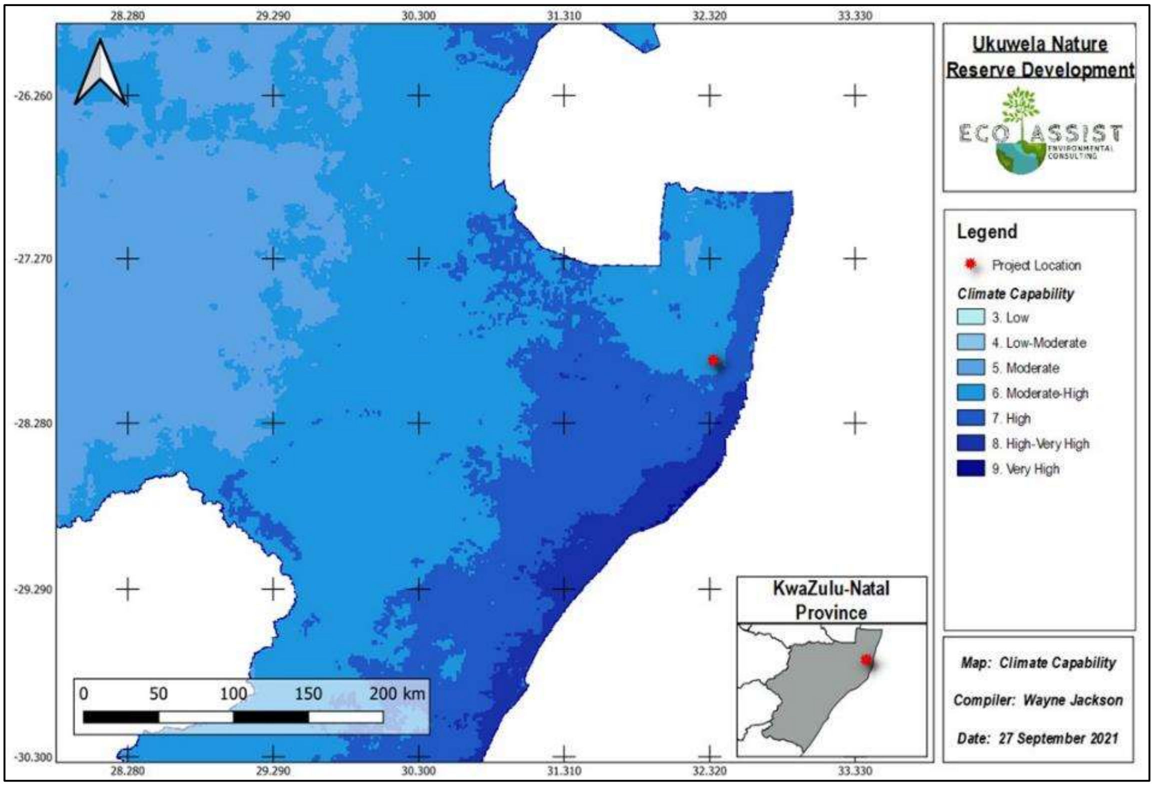

Figure 7-2: Climate capability (Department of Agriculture, Forestry and Fisheries, 2017).

7.2 Terrain

The terrain analysis was conducted using the processing tools within the QGIS mapping software. The SAGA terrain analysis tools were used to determine the Digital Elevation Model (DEM) (see Figure 7-3).

The project relief shows that the elevation ranges from approximately 15 metres above sea level (masl) to about 120 masl. The slopes are shallow ranging between 0% and 15%. The project area is north facing and situated on a midslope landscape unit (Figure 7-4).

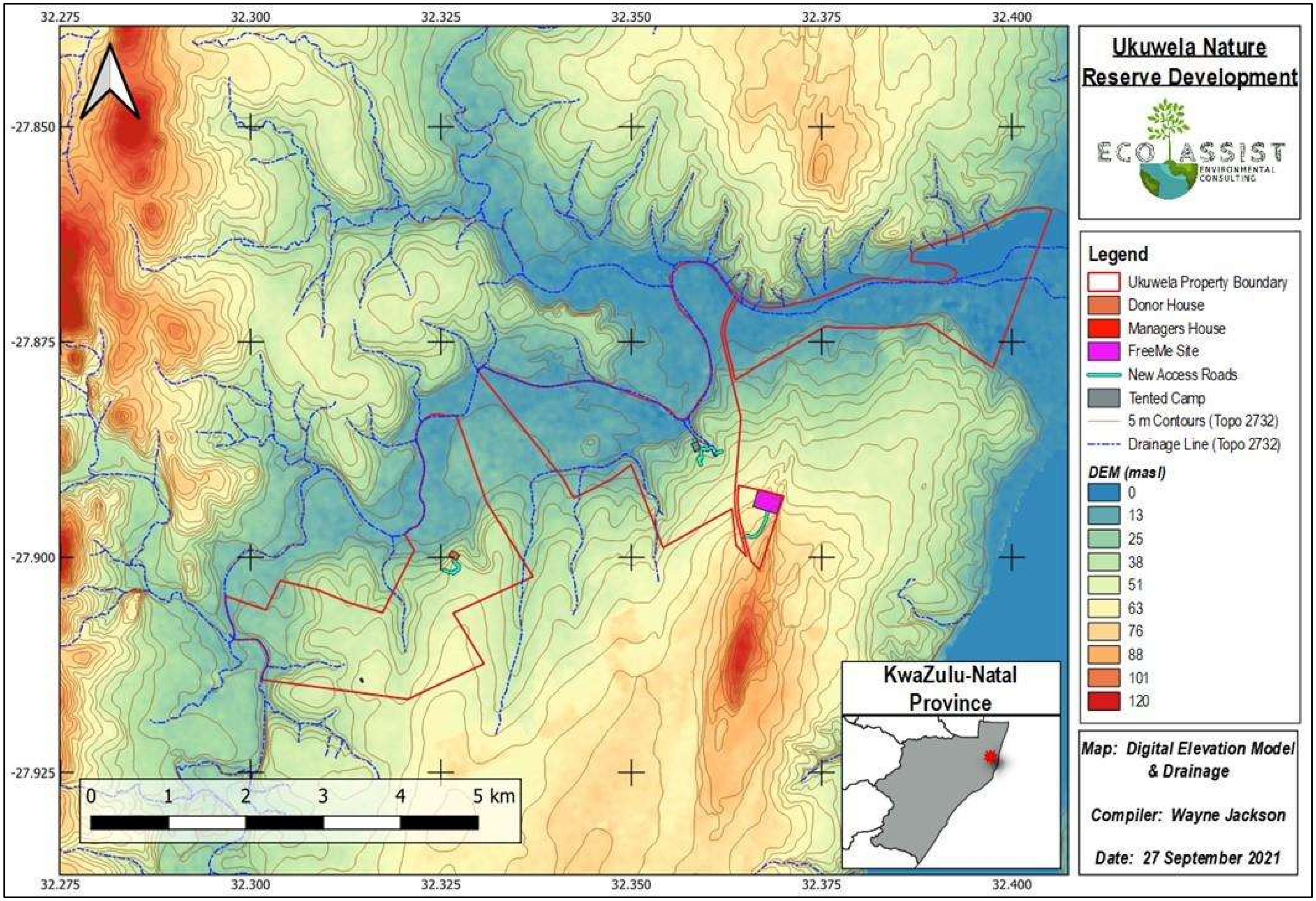

Figure 7-3: The DEM for the project area.

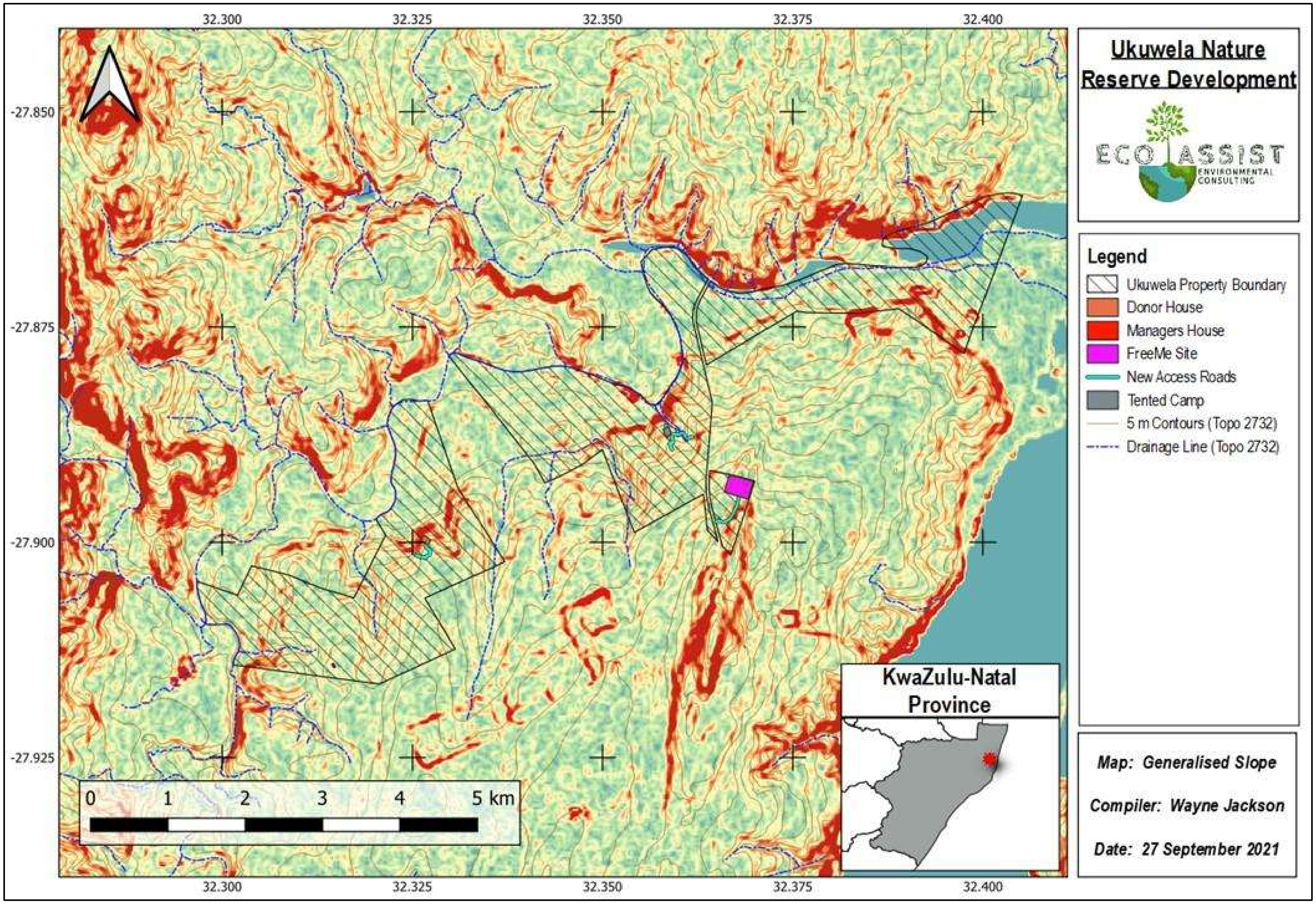

Figure 7-4: The generalised slopes for the project area.

7.3 Desktop Soils & Geology

7.3.1 Geology

The project area (according to Mucina and Rutherford, 2006) has an underlying geology comprising of Cretaceous shallow-marine and coastal sediments, siltstones and conglomerates of the Zululand Group and minor rhyolites of the Jozini Formation (Karoo Supergroup). These geological features are shown in Figure 7-5.

The land type database describes the geology for land types Db113 and Ai9 as siltstone, with concretionary and shelly horizons, of the St. Lucia Formation, marine siltstone with shelly concretions of the Mzinene Formation, Zululand Group, and argillaceous sand of the Muzi Formation. The land type database describes the geology for land type Ae153 as mainly red dune cordon sand of the Berea Formation (Land Type Survey Staff, 1972 - 2006).

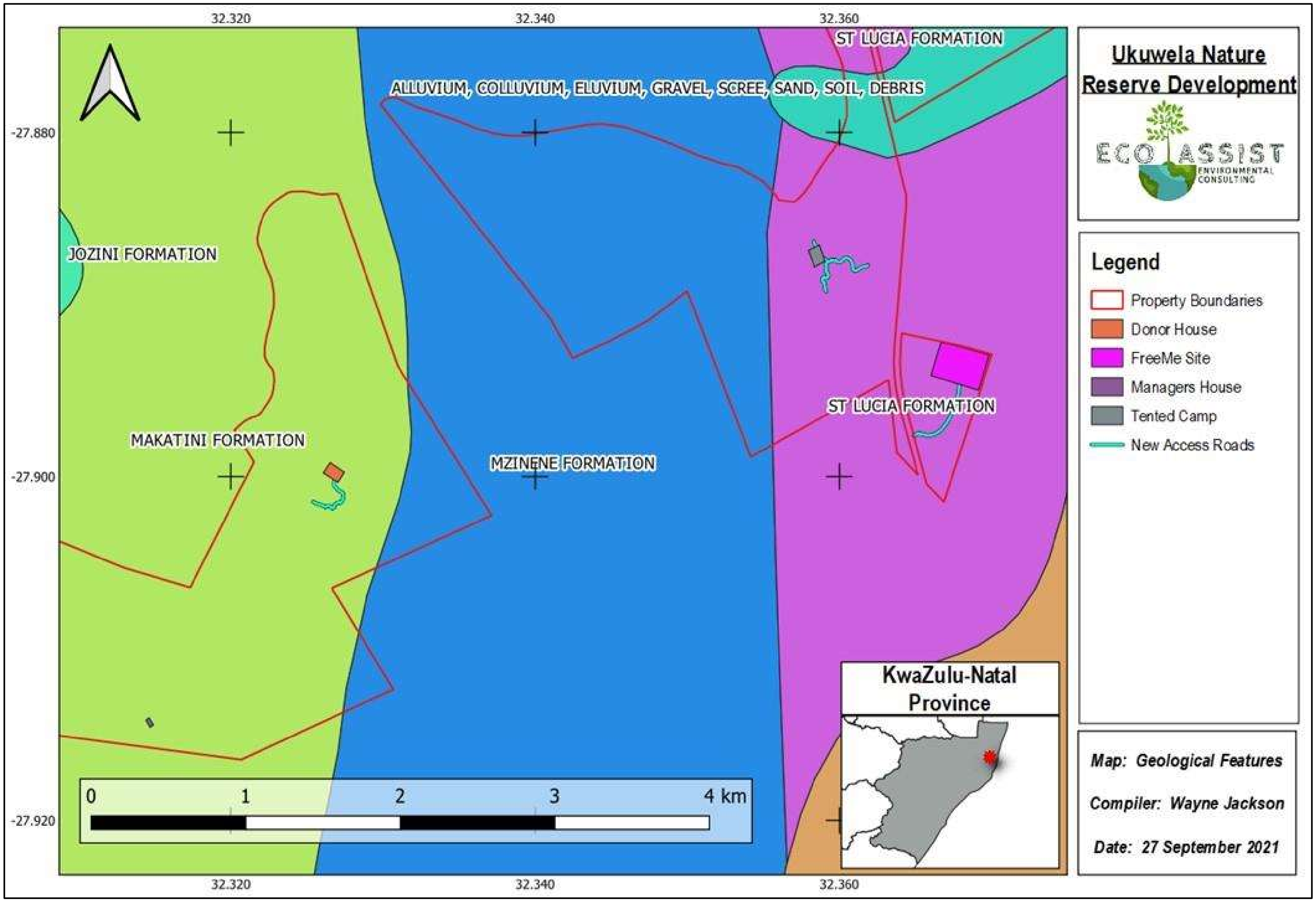

Figure 7-5: Regional geology for the project area.

7.3.2 Land Types

According to Mucina and Rutherford (2006) the Donor house and the Managers house soil attributes are dominated by zonal soils comprising of red sandy clay loam to red clay soils (Hutton, Bainsvlei and Shortlands soil forms) and nonduplex brown calcimorphic soils comprising yellow-brown sandy clay, sandy loam to sandy clay loams (Valsrivier and Avalon soil forms). These are generally fertile soils, characterised by a moderate to high clay content (20–60%) in the A-horizon. Land types Ea, Ae, Dc, Ia and Db (Mucina, et al., 2006).

The eastern sections of the project area according to Mucina and Rutherford (2006), which include the Tented camp and the Free Me site, are mainly dominated by system of old (5–3 million years) and younger (125 000 years) grey regic to reddish redistributed sand dunes of marine origin. Nutritionally the sandy soils are very poor and well leached. In some depressions, duplex soils can be found (Mucina, et al., 2006).

The Land Type data was used to obtain generalised soil patterns and terrain types for the site. Land Type data exists in the form of published 1:250 000 maps. These maps indicate delineated areas of similar terrain types, pedosystems (uniform terrain and soil pattern) and climate (Land Type Survey Staff, 1972 - 2006).

The development footprints fall within three (3) land types;

- Db113 (Managers House & Donor House);
- Ai9 (Tented Camp & Free me site); and
- Ae153 (Free me site).

The Managers house and Donor house sites fall into the Db113 land type (see Figure 7-9). This land type is dominated by the midslope and valley bottom landscape positions (see Figure 7-6) and consists largely of the structured Valsrivier and Sterkspruit soil forms. There are areas with Albic properties which include the Fernwood and Kroonstad soil forms. The average slope for this land type ranges from 1% to 12%. Clay content in the structured soils is estimated to be between 15% and 25% in the A-Horizion and increases to 25% and 55% in the deeper horizons. The Albic soils clay content is slightly lower in the A-Horizon at 6% to 15%. The shape of the landscape catena is shown in Figure 7-6.

The Tented camp and the Free Me sites fall into the Ai9 land type (see Figure 7-9). This land type is dominated by the midslope and valley bottom landscape positions, with some crest landscape positions (see Figure 7-7). The land type consists largely of the sandy Fernwood and Clovelly soil forms. The average slope for this land type is fairly flat and ranges from 0% to 2%. Clay content is estimated to be between 0% and 6% but can be as high as 35 % in areas of clay accumulation. The shape of the landscape catena is shown in Figure 7-7.

The Free Me sites also partially falls into the Ae153 land type (see Figure 7-9). This land type is dominated by the midslope and valley bottom landscape positions, with some crest landscape positions (see Figure 7-8). The land type consists largely of the freely drained Hutton and Fernwood soil forms. The average slope for this land type is fairly flat and ranges from 1% to 4%. Clay content is estimated to be between 0% and 10% but can be as high as 15 % in areas of clay accumulation. The shape of the landscape catena is shown in Figure 7-8.

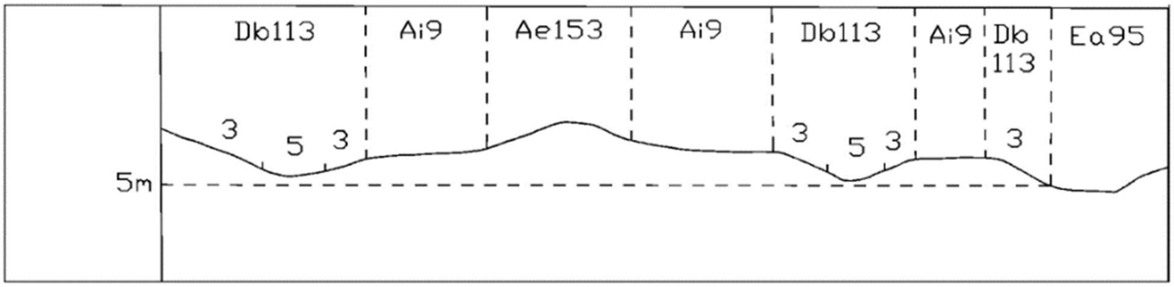

Figure 7-6: Hillslope catena for land type Db113.

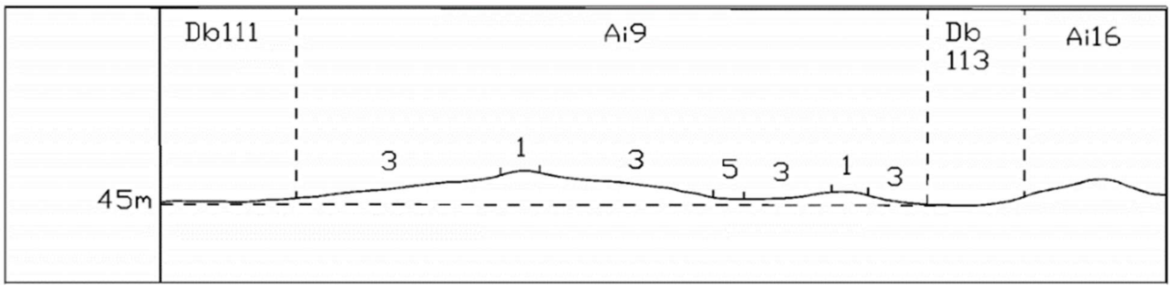

Figure 7-7: Hillslope catena for land type Ai9.

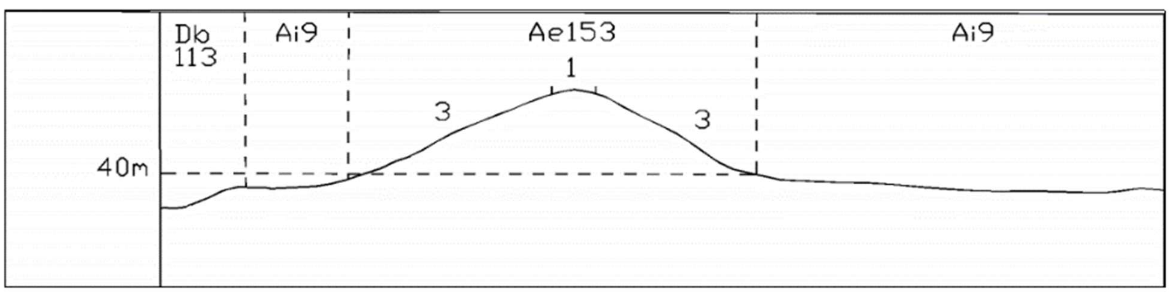

Figure 7-8: Hillslope catena for land type Ae153.

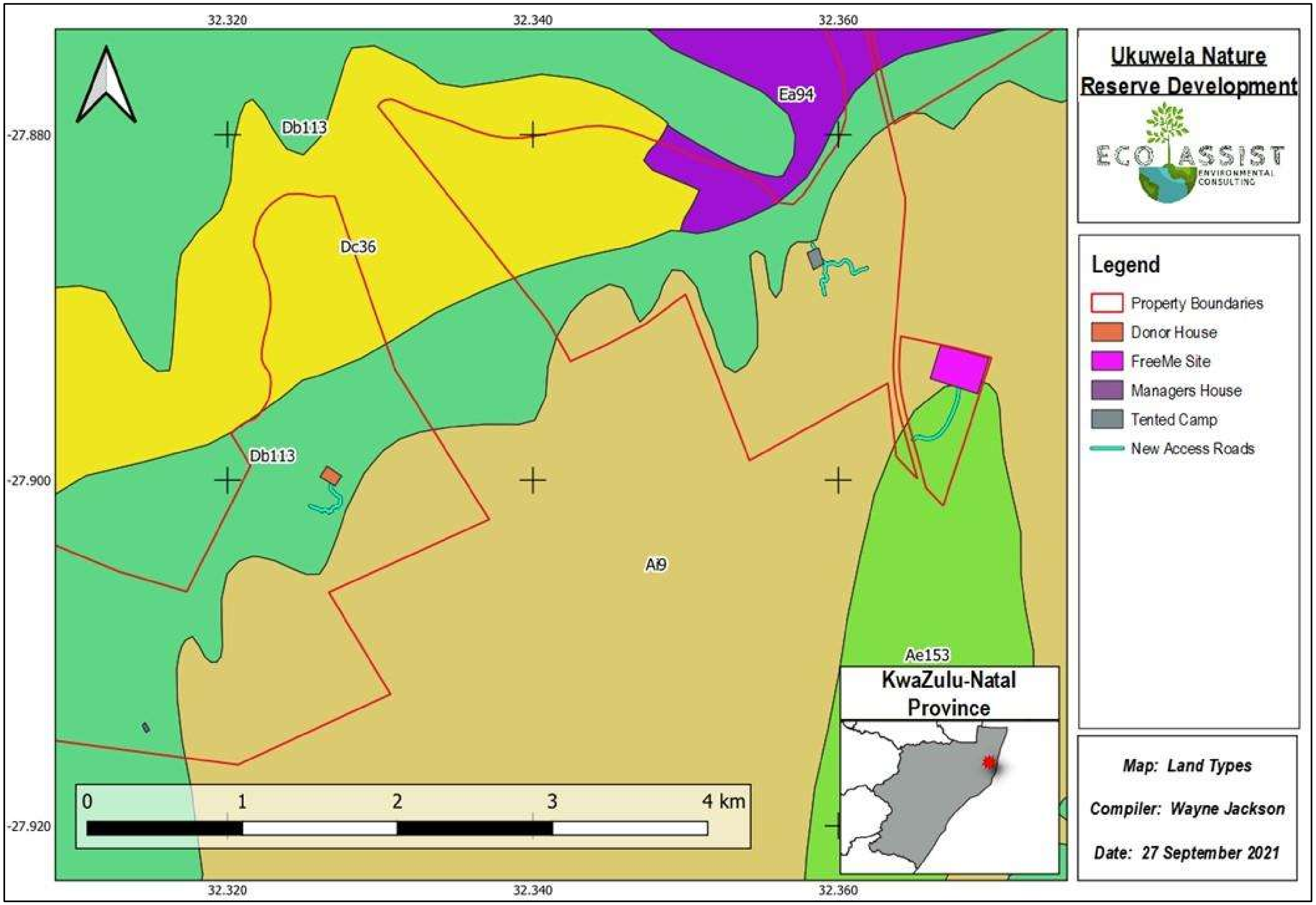

Figure 7-9: Land Types within the project area.

7.4 Wetland Summarised Findings

The wetland assessment was conducted by Jake Alletson from Alletson Ecologicals, 2021 and the following is a summary of the findings to inform the Hydropedological assessment.

Managers House (Figure 7-10);

- The wetlands within 500m of the house are shown in Figure 7-10 and have been verified by the Wetland Specialist. These wetlands are probably all associated with the past agricultural activities in the area. Some may be old borrow pits from which road material may have been extracted while others may be vestigial stock watering points. Wetland 1 is a tall sedge/grass system and is probably a Seep although the hydrology is unclear. Dominant species include Wild Rice Grass (*Leersia hexandra*), Buffalo Grass (*Stenotaphrum secundatum*), Sedges (*Cyperus sexangularis*) and other Cyperus species.
- The slope of the hill below the house is away from any wetland but is toward the headwaters of a minor watercourse. However, the house is some 280m away from the watercourse and so is well outside of the Regulated Area of the channel and will not affect it.

Donor House (Figure 7-11);

- The only wetland area which appears to be included within the 500m radius around either the donor's house or the new road is a small portion of the NFEPA wetland which includes the channel of the Mzinene River. However, the mapping exaggerates the width of the wetland and the radius does not reach to the river channel which has no floodplain at that point.
- On the basis of the distance of the donor's house and the associated new section of access road from any wetland or watercourse it is concluded that there will be no impact on the natural systems.

Reserve Office and FreeMe Complex (Figure 7-12);

- Drainage from the site is toward both the east and to the west where a small dam is located some 600m away and so will not be affected. The only wetland found within the 500m radius of the site appears to be a small seep in a pineapple field to the north-east. This site was not visited but was only observed on Google Earth. There are further wetlands in that area but all seem to have been transformed to some extent by agriculture. The proposed development is most unlikely to affect any of them.

Tented Camp (Figure 7-13);

- There are two small seasonal watercourses near the camp site and their regulated areas will include the camp. The Mzinene River and a portion of a flooded backwater are located some 300m from the camp centre with the terrain in that area being characterised by low gradients.
- During the construction phase there should be very little impact on the two small watercourses provided that the mitigatory measures put forward are implemented. Most important of these is the establishment of a buffer of 30m in width between any structures and the channels. The ablution facilities must be placed so that the septic tanks can be placed further away from the channels and supernatant water should be led to soakaway pits at least 50m from the channels.
- Due to the flat terrain and an intervening space of approximately 300m it is not thought that the tented camp poses any threat to the Mzinene River and its associated wetlands.

It is probable that the deep roots of trees will take up any nutrients which may possibly enter the ground water and so remove them from the system.

The construction phase will have a very low potential for any impacts on the watercourses or wetlands and they will be short term impacts largely restricted to that phase. All impacts can be reduced even further by careful management of the construction sites and process. In the operational phase the impacts arising from the operation and maintenance of the facilities will obviously persist through a longer time. Impacts from routine road and site maintenance are very limited and can easily be reduced through monitoring of the areas and then addressing any problems as they arise.

Seepage from the tented camp septic camps is a longer-term issue but it too can be reduced through proper design and construction. According to the wetland specialist from Alletson Ecologicals, "*The Mzinene River which flows along the reserve boundary will in effect become an extension of the larger park area and so contribute to the wellbeing of that area. In addition, since the northern bank of the river is also in a private conservation area, the protection of the south bank will give the lower reaches of the river enhanced conservation value*".

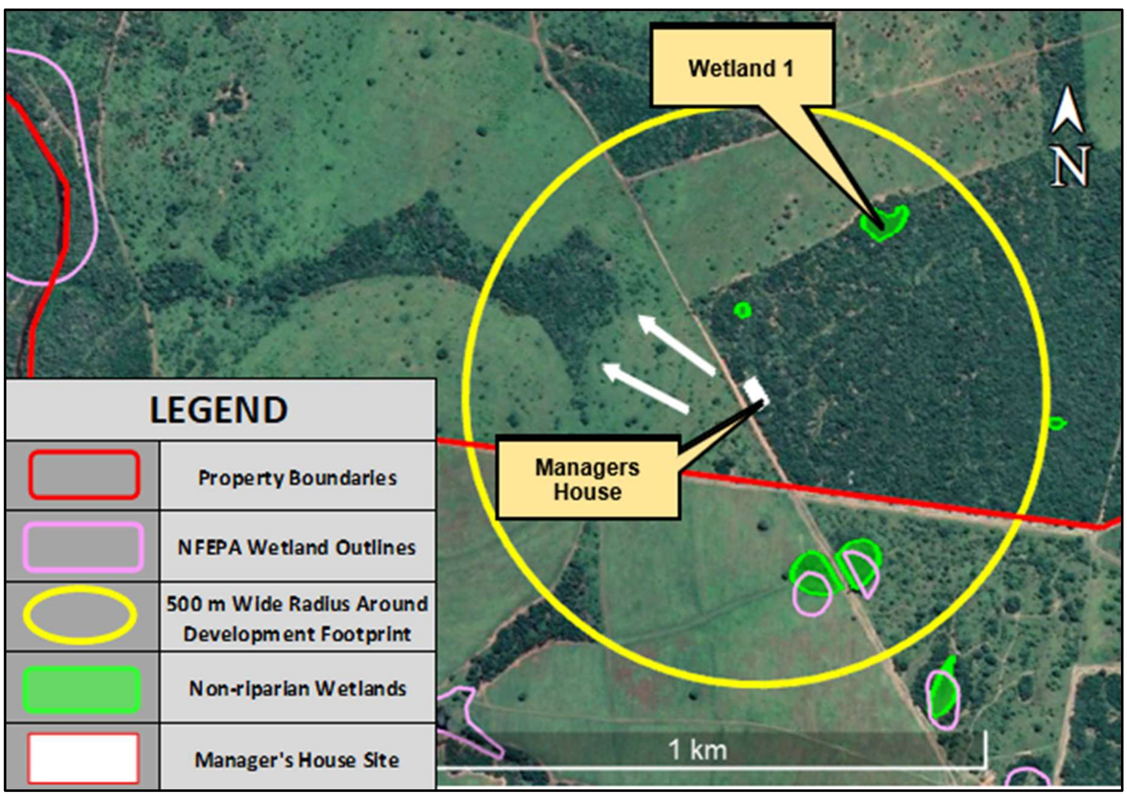

Figure 7-10: Wetlands within 500m of the manager's house site. The arrows indicate hill slope (SiVEST SA (Pty) Ltd, 2021).

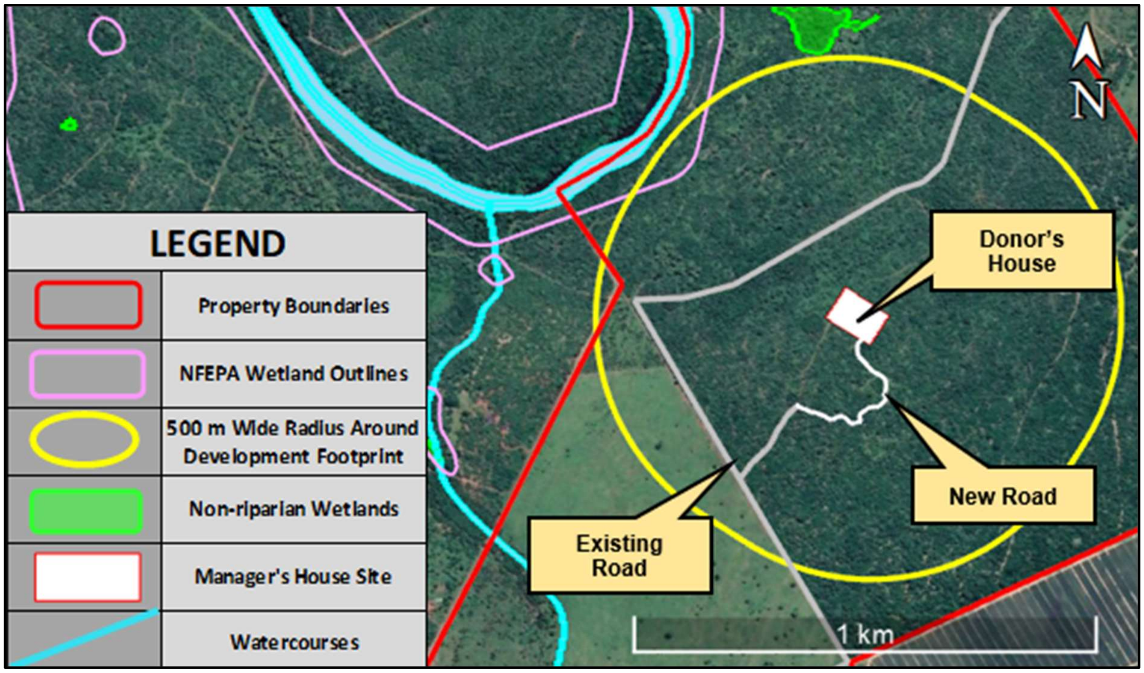

Figure 7-11: Wetlands in the vicinity of the proposed donor's house,. (Alletson Ecologicals, 2021)

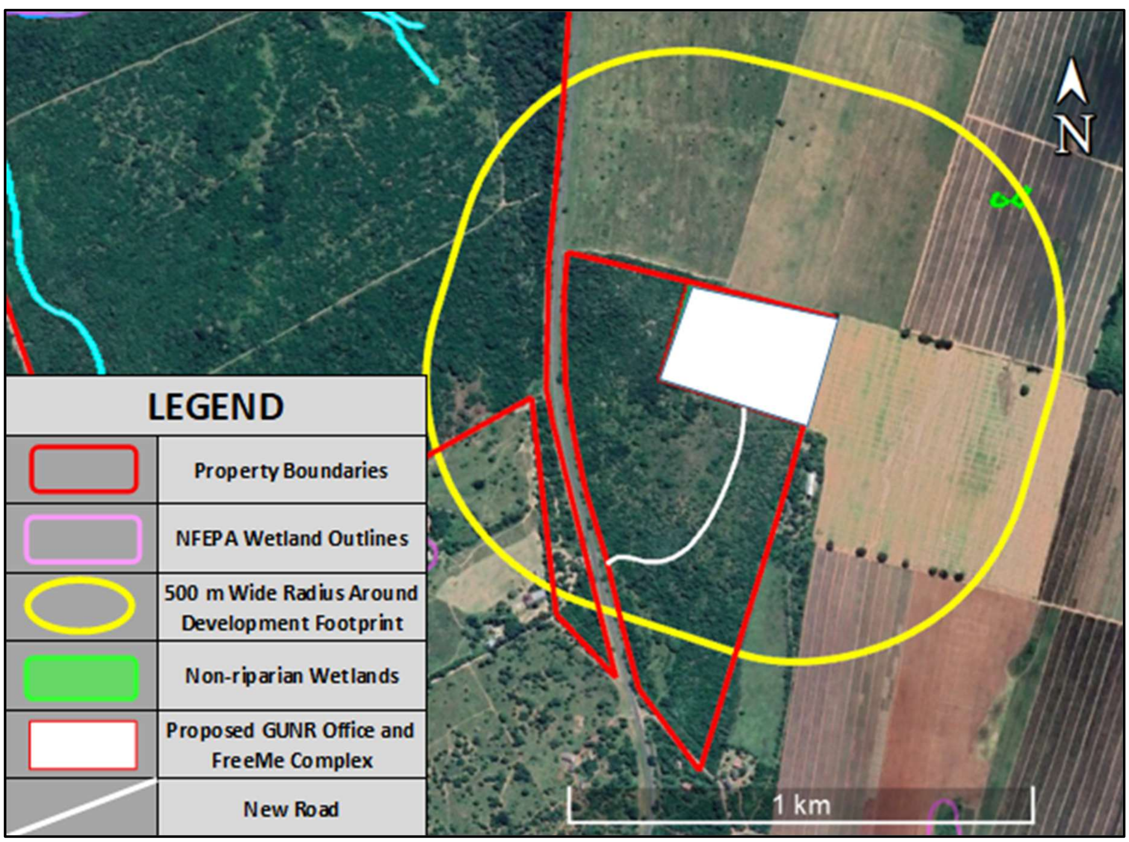

Figure 7-12: Wetlands in the vicinity of the proposed GUNR Office and the FreeMe Complex (Alletson Ecologicals, 2021)

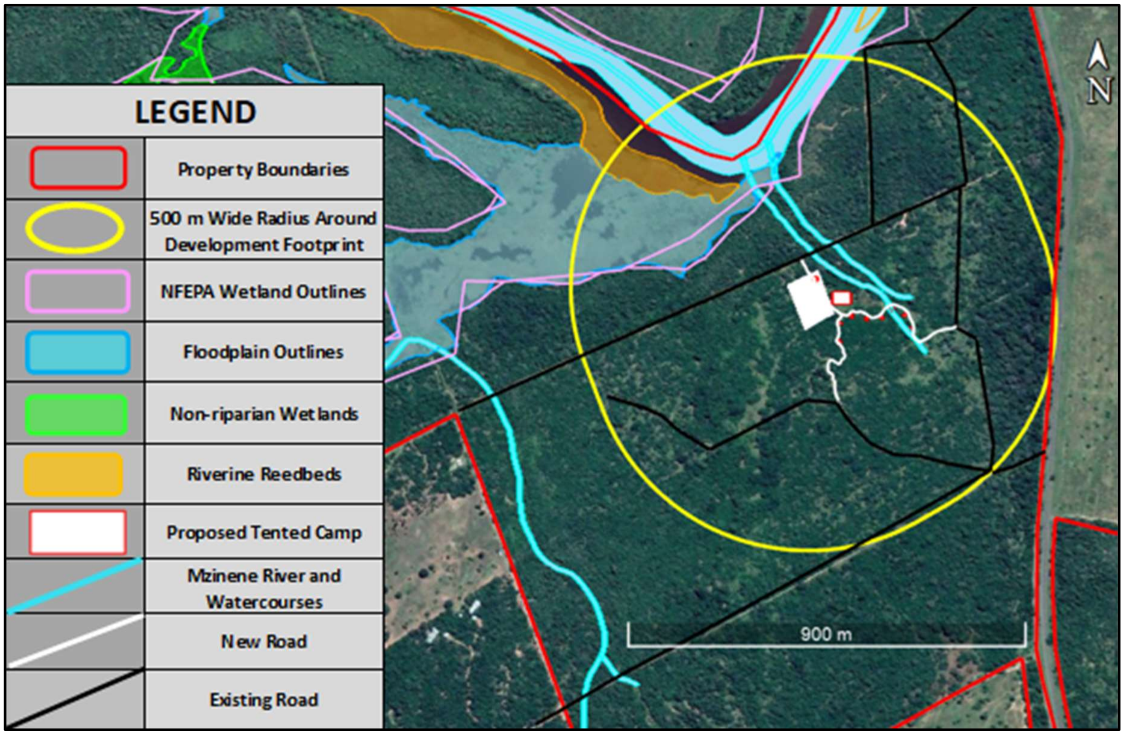

Figure 7-13: Wetlands in the vicinity of the proposed Tented Camp . (Alletson Ecologicals, 2021).

8 SITE ASSESSMENT RESULTS

A semi-detailed soil survey was conducted for the project areas in August 2021 using a hand-held auger and a GPS to log all information in the field. The soils were classified to the family level as per the “Soil Classification: A Natural and Anthropogenic System for South Africa” (Soil Classification Working Group, 2018). The soil forms found are described in the subsequent sections and the extent is shown in Figure 8-4 and Figure 8-5.

8.1 Soil Assessment

The following soil forms were identified on-site (Eco-Assist Environmental, 2021);

- Oakleaf (Orthic topsoil over a Neocutanic B-horizon, with a Lithic C-horizon) (See Figure 8-3);
- Tukulu (Orthic topsoil over a Neocutanic B-horizon, with signs of wetness in the C-horizon);
- Clovelly (Orthic topsoil over a thick Yellow-Brown Apedal horizon, with a lithic C-horizon) (See Figure 8-1);
- Fernwood (Orthic topsoil over a thick Albic horizon) (See Figure 8-2); and
- Longlands (Orthic topsoil over an Albic horizon, with Soft plinthic C-horizon).

The Managers house site was dominated by the deep Tukulu soil form. The soil profile is slightly bleached with a sandy matrix (5% to 10% clay).

The Donor house was dominated by red well drained Oakleaf soils. The clay content of these soils ranged from 5% to 15%.

The Free Me site was dominated by the deep sandy Clovelly soil form. The clay content was low at between 0% and 5%.

The Tented camp site was dominated by the Fernwood and Longlands soil forms. These are bleached Albic horizon soils, which indicate lateral flows.

Figure 8-1: Shows the Clovelly soils in the project area (FreeMe site).

Figure 8-2: Shows the sandy and bleached properties of the Fernwood and Longlands soil forms in the tented camp area.

Figure 8-3: Shows the red Neocutanic horizon of the Oakleaf soils at the Donor House site.

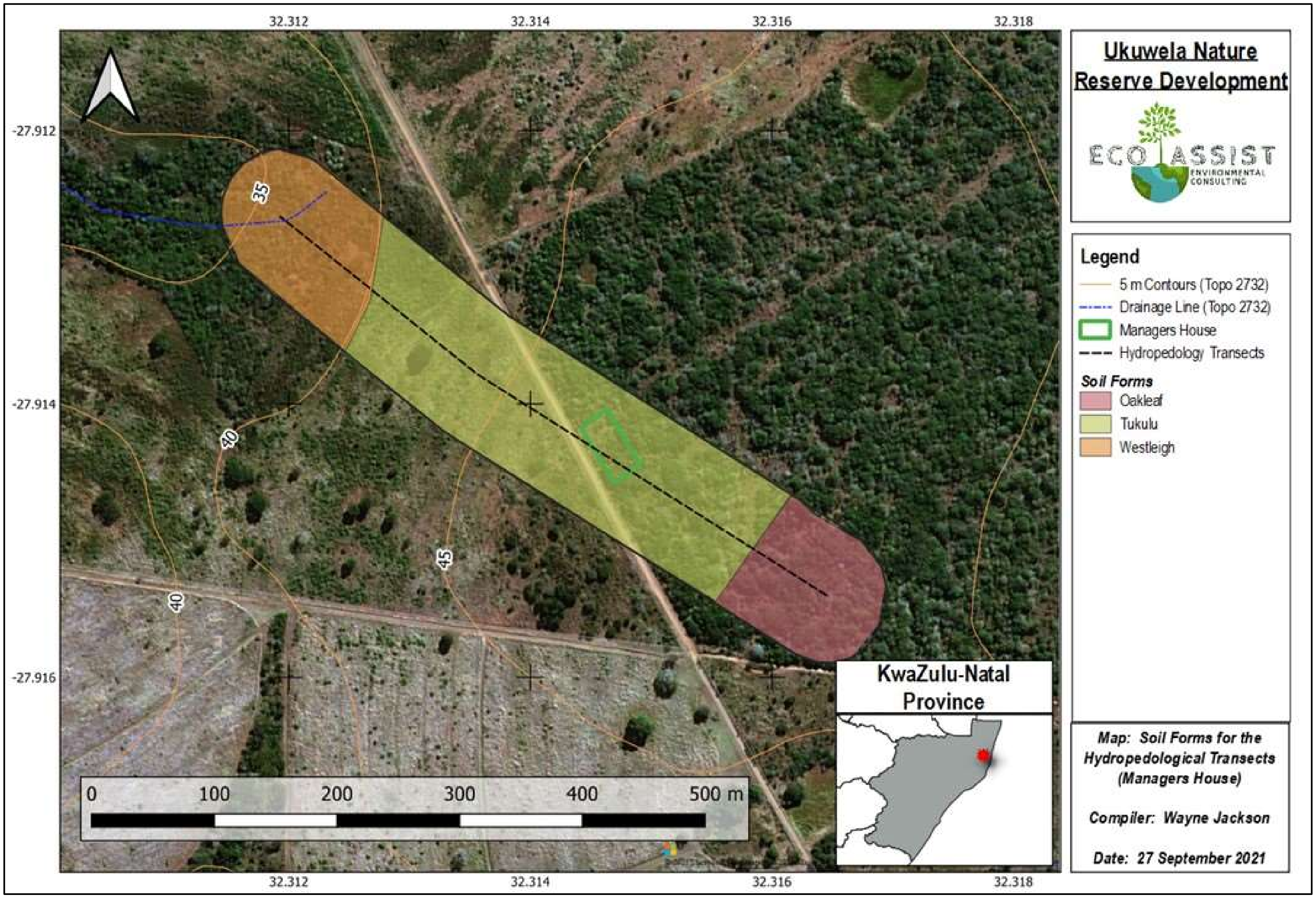

Figure 8-4: The soil delineation for the transect at the Managers House site.

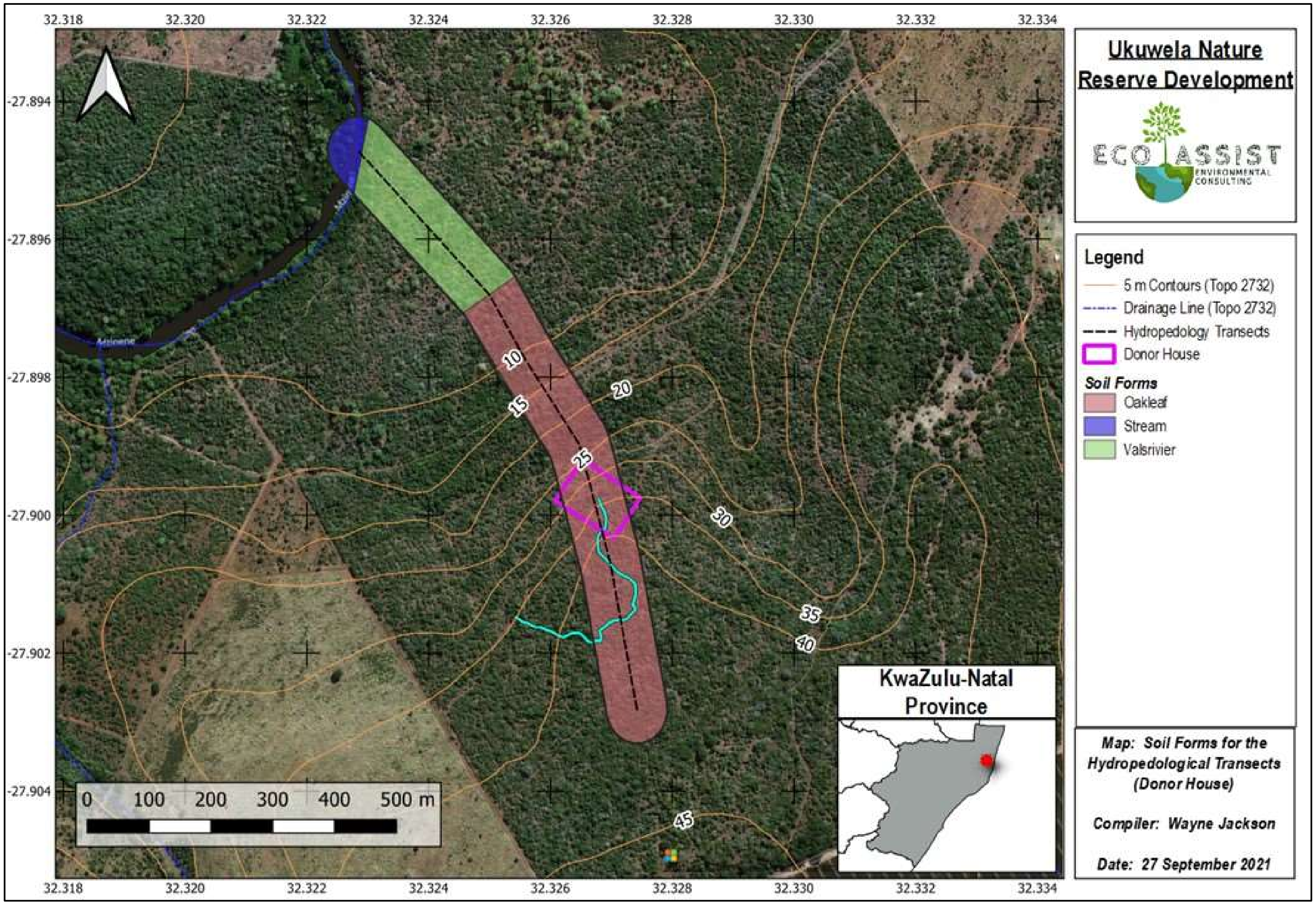

Figure 8-5: The soil delineation for the transect at the Donor House site.

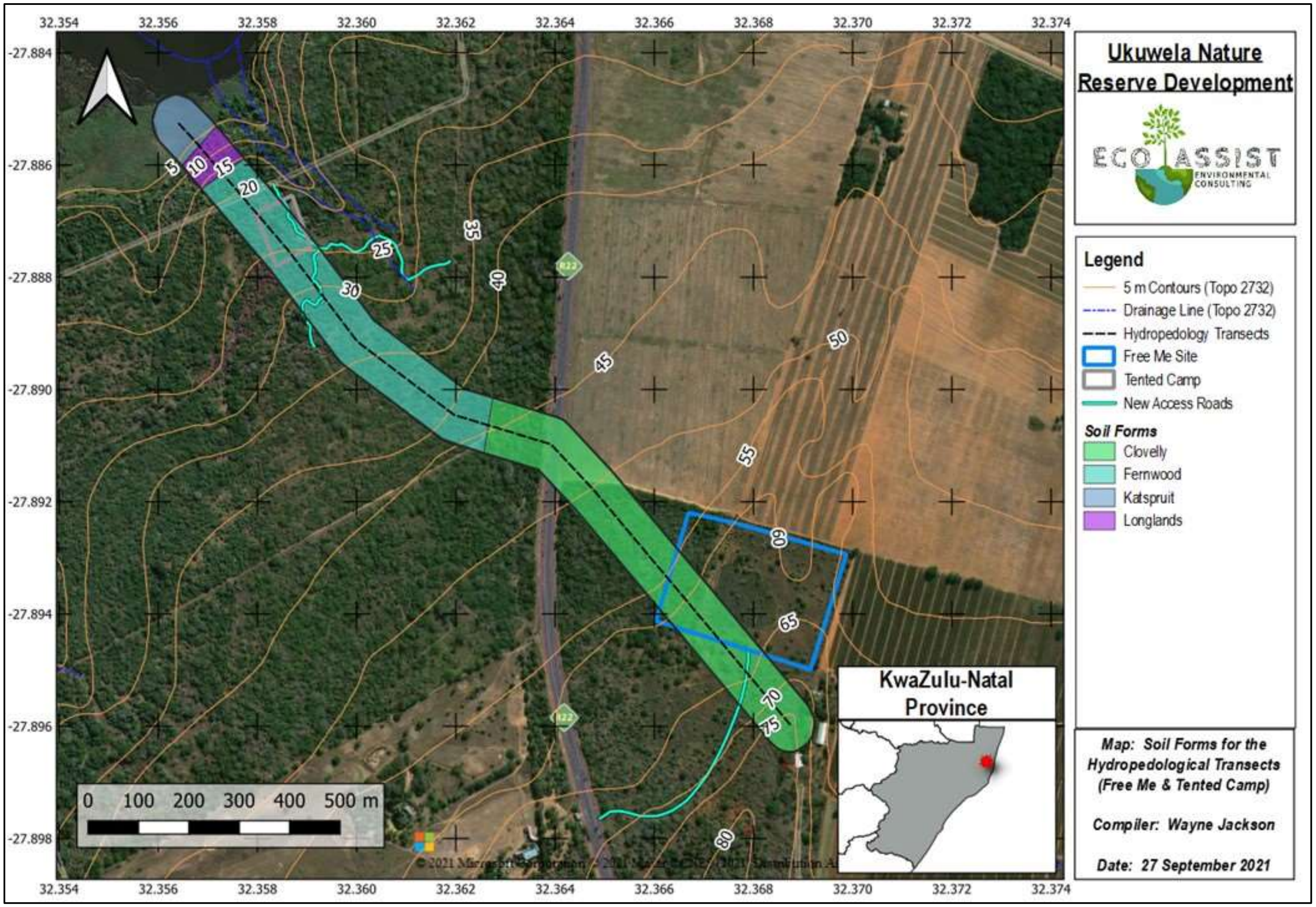

Figure 8-6: The soil delineation for the transect at the Tented camp and the Free Me sites.

8.2 Hillslope Hydrology

The hydropedology survey was conducted to obtain information regarding the soil morphology and hydropedological flow paths relevant to the hillslope by means of several transects. The hydropedological soil types classified during the site assessment are illustrated in Figure 8-7 to Figure 8-9 below.

The hillslope catena's from the top of the catchment right down to the valley bottoms have a general concave shape. The dominant hydrological soil driver for the project area is that of recharge soils in the crest to midslope landscape positions (The water movement is vertical into the soil profiles and recharges the groundwater zones). The soil driver then becomes that of the interflow (soil/bedrock) hydropedological units. This is due to the accumulation of water from upslope areas within the soil profile of the lower slopes. The Hydrological flow drivers either then join a river/stream network or express wetness at surface (responsive hydropedological unit).

Recharge soils are 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 a limited contribution to evapotranspiration or deep freely drained soils that can contribute significantly to evapotranspiration (Hydropedological grouping of South African soil forms, 2019).

These were identified as the Clovelly and Oakleaf soil forms.

Interflow (soil/bedrock) soils are soils that are freely drained soils which overlie relatively impermeable bedrock. Hydromorphic properties signify periodic saturation associated with a water table at the soil bedrock/interface. The duration and magnitude of lateral flow in interflow soils depend on the rate of evapotranspiration, position in the hillslope (lateral addition/release), slope angle and the anisotropy in permeability between the conducting and impeding layer (Hydropedological grouping of South African soil forms, 2019).

Where the midslope position does not drop of in gradient steeply the accumulation of soil depth is retained. However, the accumulation of sub-surface water becomes evident as the parent material limits rapid recharge into the groundwater zones. The soil morphology changes to sub horizons with signs of wetness (Tukulu, Fernwood, and Longlands soil forms). These soils are indicative of interflow hydropedological soils with the interflow occurring at the soil/bedrock interface.

Responsive (saturated) soils are soils with morphological indications of long periods of saturation. Given that the latter soils are close to saturation during the rainy season, additional precipitation will typically flow overland due to saturation excess (Hydropedological grouping of South African soil forms, 2019).

These were identified as the Katspruit and shallow Westleigh soil forms.

The soils are described in Table 8-1.

Table 8-1: Soil form descriptions and their associated hydropedological classification.

Soil Form	Description	Hydropedological Group
Katspruit	Orthic A-horizon over a G-horizon. The G-horizon is non-calcareous.	Responsive (Saturated)
Oakleaf	Orthic topsoil over a Neocutanic horizon which is then underlain by an	Recharge (Deep)

Soil Form	Description	Hydropedological Group
	unspecified layer without signs of wetness.	
Fernwood	Orthic topsoil over a E-horizon which is then underlain by an unspecified layer without signs of wetness.	Interflow (Soil/Bedrock)
Longlands	Orthic topsoil over a E-horizon which is then underlain by a soft plinthic horizon.	Interflow (Soil/Bedrock)
Westleigh	Orthic topsoil over a soft plinthic horizon.	Interflow (Soil/Bedrock)
Tukulu	Orthic topsoil over a Neocutanic horizon which is then underlain by an unspecified layer with signs of wetness.	Interflow (Soil/Bedrock)

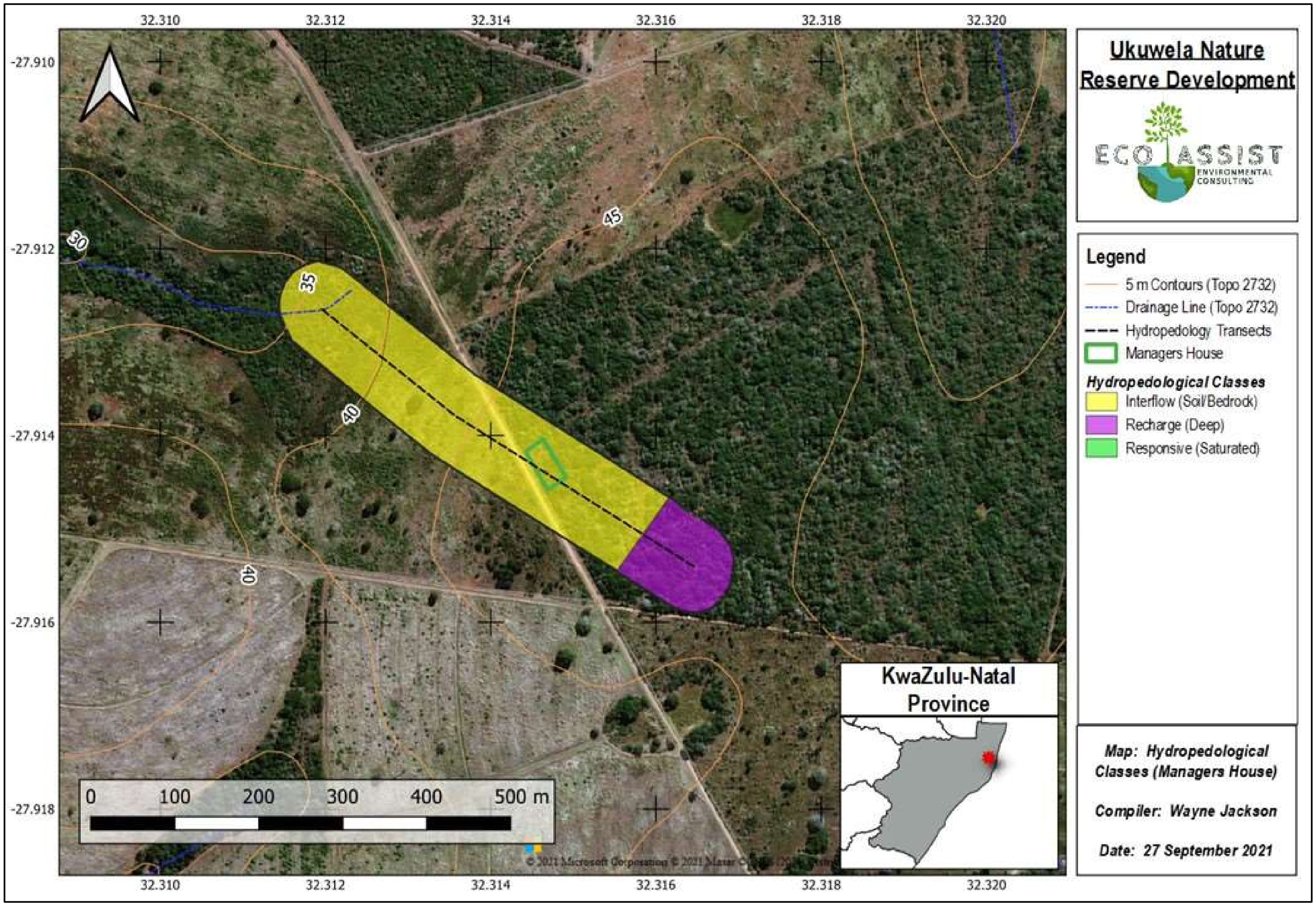

Figure 8-7: Hillslope hydropedological classification showing the hydrological soil units for the Managers House site.

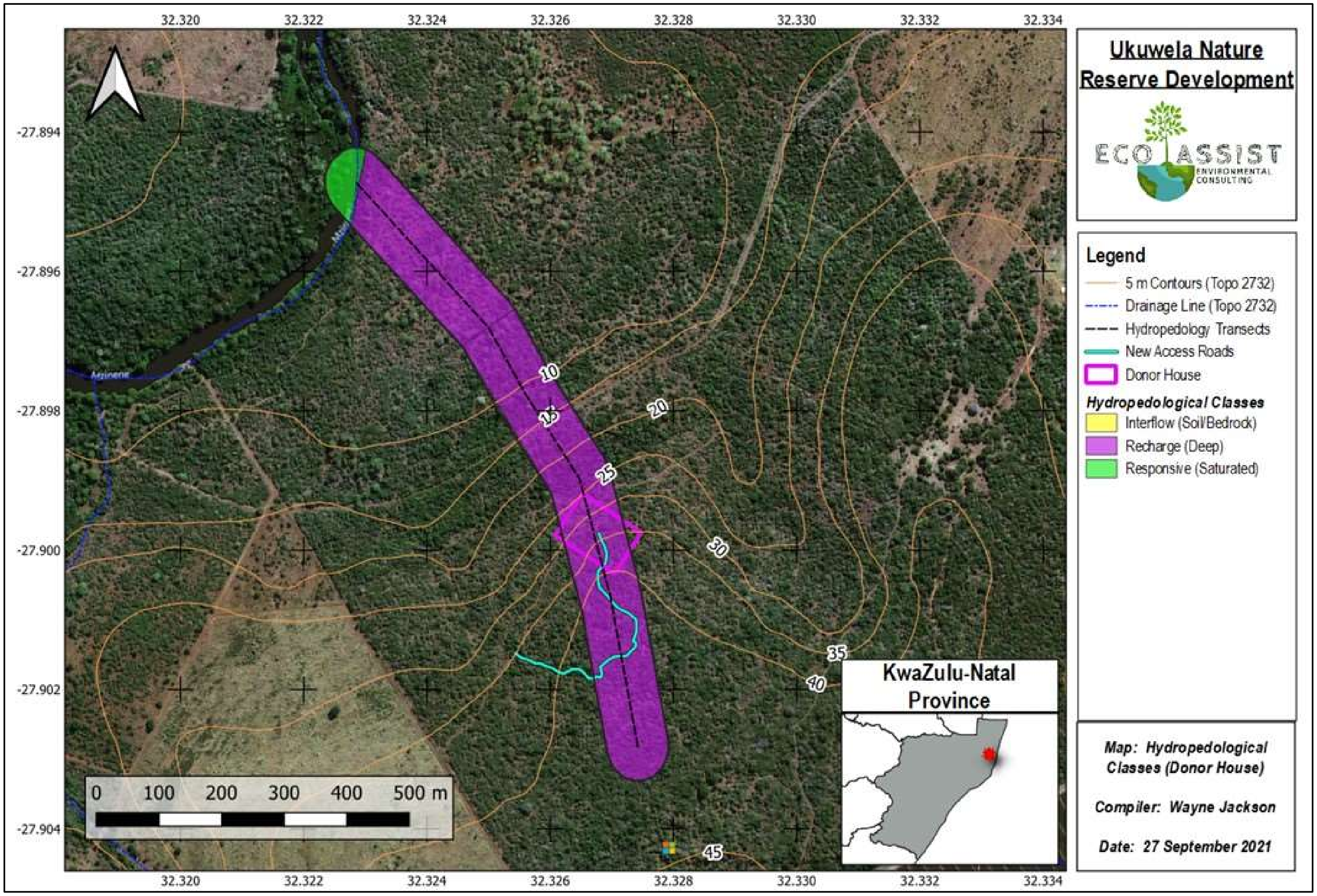

Figure 8-8: Hillslope hydropedological classification showing the hydrological soil units for the Donor House site.

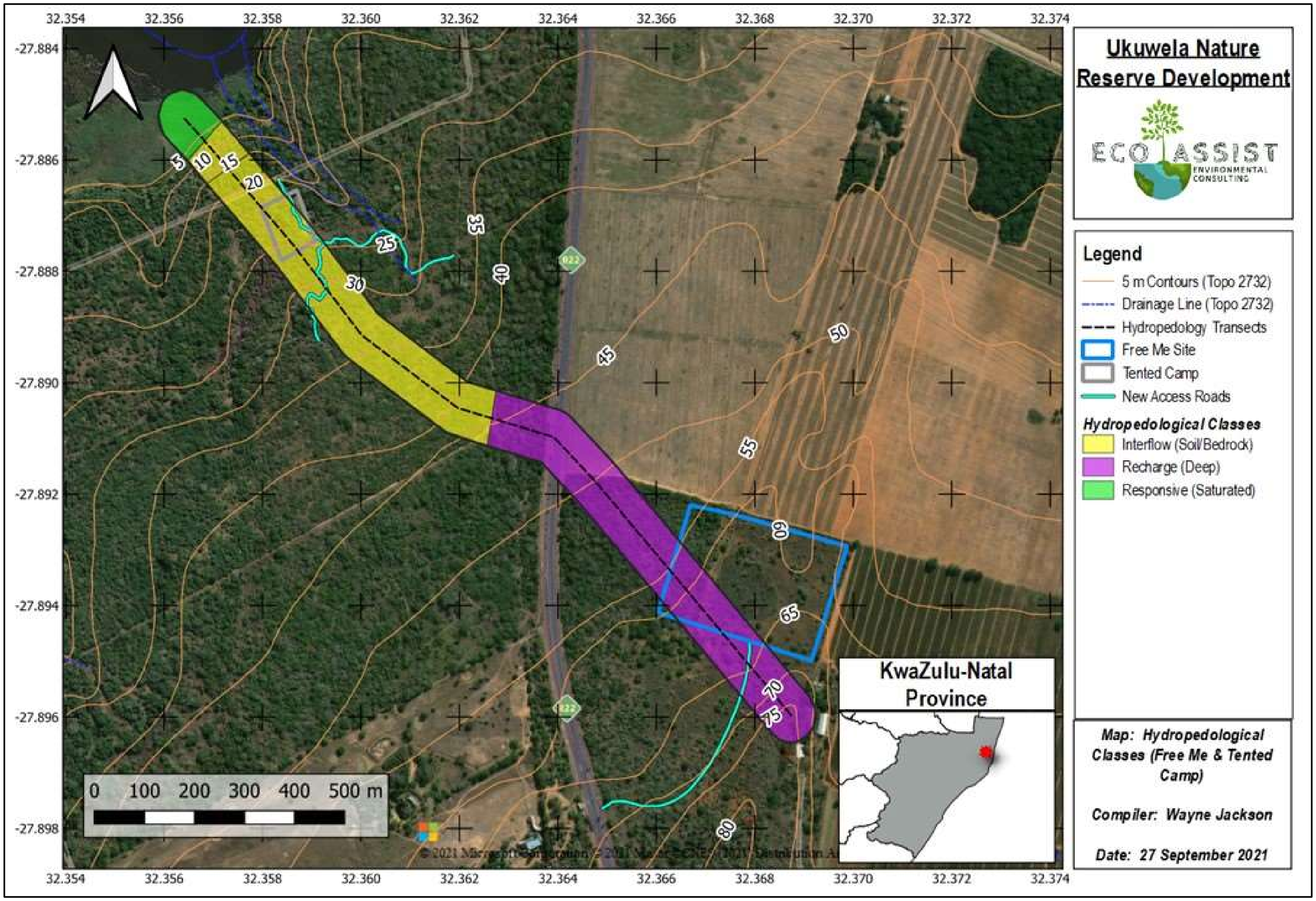

Figure 8-9: Hillslope hydropedological classification showing the hydrological soil units for the Tented Camp and the Free Me sites.

During the survey two (2) dominant hillslope hydropedological classes were identified. These are described in the section to follow.

Figure 8-10 shows the represented cross section for the Donor House site. The crest to footslope landscape positions were dominated by deep freely draining Oakleaf soil form in the upper slope and the Valsrivier soil form in the footslope, which indicated that the slopes are recharge hydropedological zones. Water primarily drains vertically into the soil profile where it either enters the groundwater or moves along the rock interface (could not be determined due to limitation of auger depth). The valley bottoms were found to respond at the river edge.

***Note:** The blue arrows indicate the dominant direction of flow. The size of the arrow indicates the dominance/intensity of flows.*

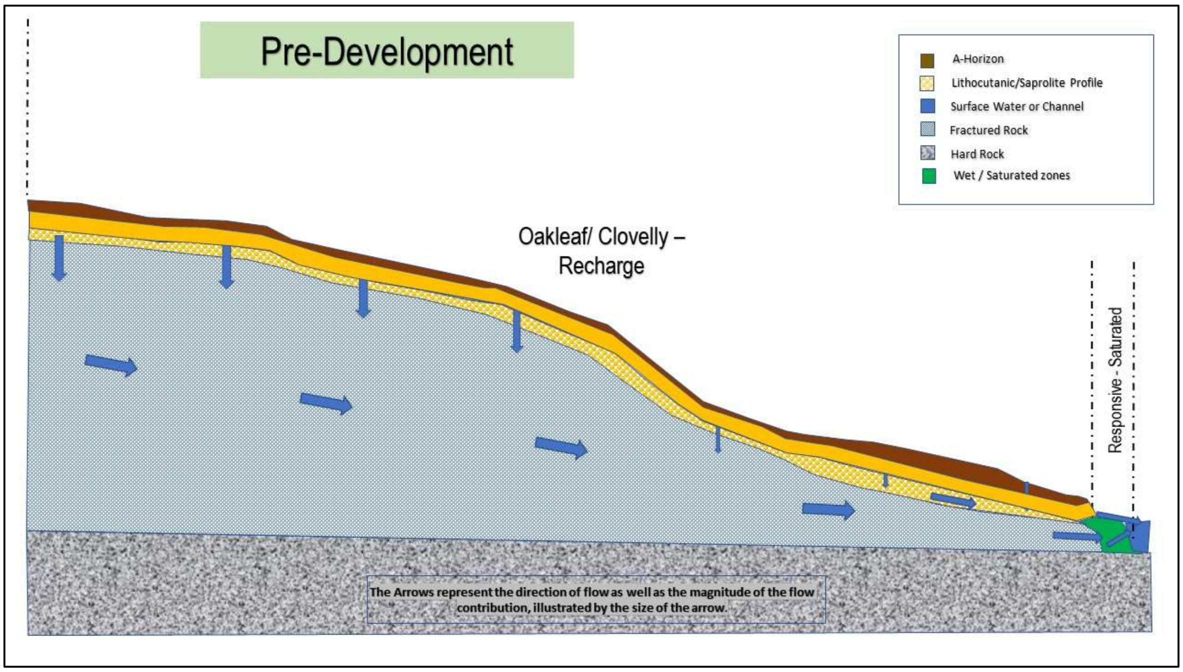

Figure 8-10: Hillslope hydrology for hydropedological soil catena of the Donor House site.

Figure 8-11 shows the represented cross section for the Managers House, Tented Camp, and the FreeMe sites. The crest to midslope landscape positions were dominated by deep freely draining Oakleaf/Clovelly soil forms which indicated that the slopes are recharge hydropedological zones. Water primarily drains vertically into the soil profile where it either enters the groundwater or moves along the rock interface (could not be determined due to limitation of auger depth). The foot slopes and valley bottoms were found to be slightly wetter with a gradual increase in moisture to surface from the Tukulu soil form to the Westleigh soil from, and then in some areas, a bleached Albic horizon was found prior to wetness indicating the Fernwood/Longlands soil forms. These soils indicate interflow between soil and bedrock hydropedological zones. The valley bottoms were found to be wet with Katspruit soils being dominant. These soils indicate saturated responsive hydropedological zones.

***Note:** The blue arrows indicate the dominant direction of flow. The size of the arrow indicates the dominance/intensity of flows.*

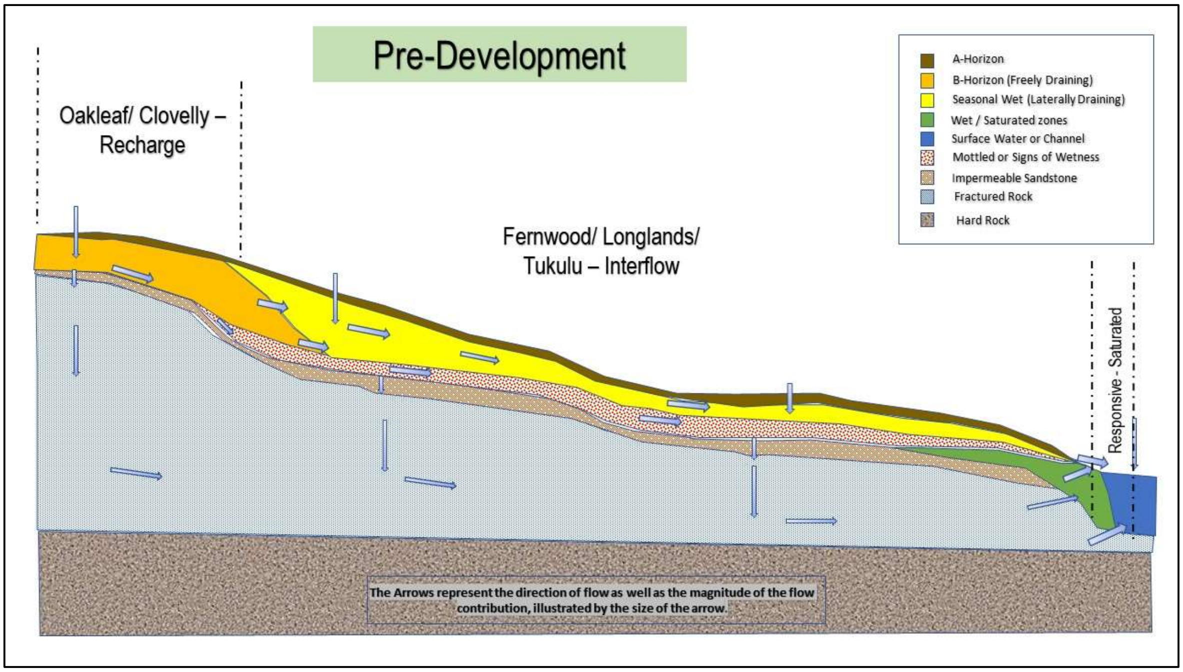

Figure 8-11: Hillslope hydrology for hydropedological soil catena of the Managers House, Tented Camp, and Free Me sites.

9 RISK/IMPACT ASSESSMENT

9.1 Hydropedological Impacts

This section determines the construction and operational phase impacts of the proposed development activities on the hydropedological flow drivers feeding the water resources.

9.1.1 Activities & Impacts Assessed

The development construction and operation take place on two (2) hydropedological soil units. These include deep recharge zones and Interflow zones. The impacts were assessed by activity as each activity will have a varied impact on the hydropedological flow drivers either in impact type or impact magnitude.

1. Residential development.

The relative number activities are shown in the post development hydropedological Figures provided in the below sections.

Figure 9-1 shows the represented cross section for the hydropedological soil catena for the Managers House site post-development. The transect has one location of the development situated in the recharge zone.

The Donor House site is proposed to be built on the recharge zones. This will reduce the amount of water that will enter the vadose zone as recharge. The runoff component will however increase with the increase in impervious surfaces. The increase runoff changes the landscape hydrodynamics and as a result could cause erosion in sections.

The risk associated with this portion of the development is rated as Low based on the low-density nature of the development.

***Note:** In Figure 9-1, the blue arrows indicate the dominant direction of flow. The size of the arrow indicates the dominance/intensity of flows. The green arrows indicate an increased flow whereas the red arrows indicate a reduction of flow in the given direction.*

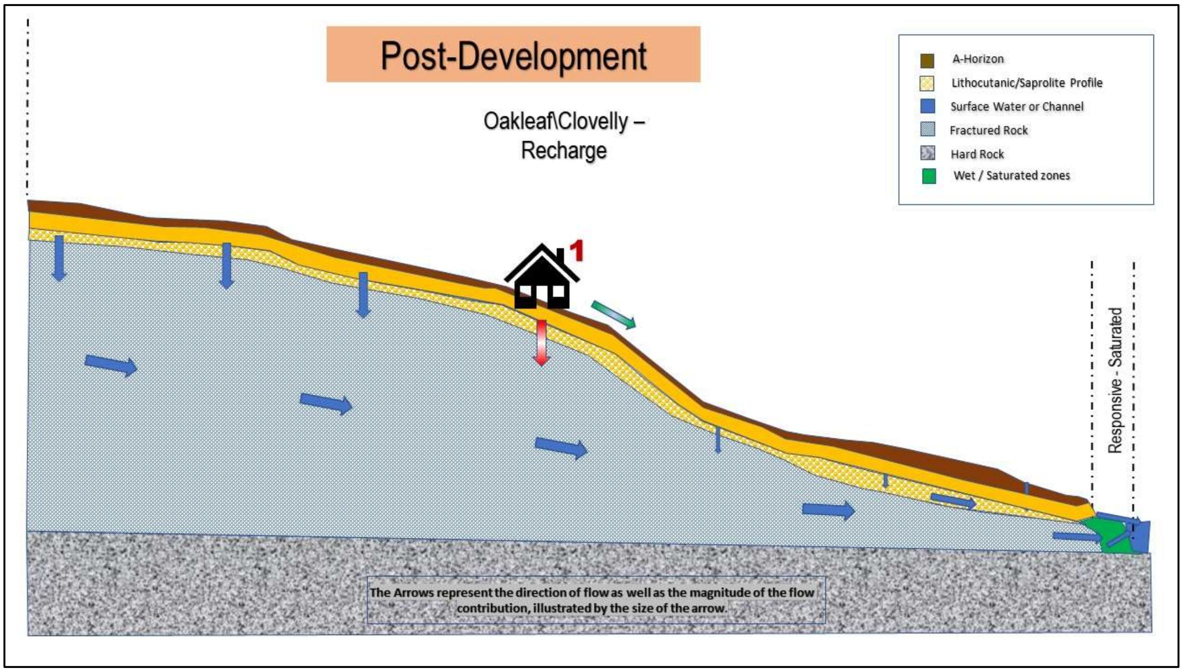

Figure 9-1: Hillslope hydrology for hydropedological soil catena for the Donor House site post-development.

Figure 9-2 shows the represented cross section for the Managers House, Tented Camps, and Free Me sites post-development. The transect has one location of the development situated in the recharge zone.

The Managers House and Free Me site will be built on the recharge zones. This will reduce the amount of water that will enter the vadose zone as recharge. The runoff component will however increase as a result of the increase in impervious surfaces. The increase runoff changes the landscape hydrodynamics and as a result could cause erosion.

The Tented Camp sites will be built on the interflow zones. This will reduce the amount of water that will enter the vadose zone as recharge. The runoff component will however increase with the increase in impervious surfaces. The increase runoff changes the landscape hydrodynamics and as a result could cause erosion. The sustained subsurface flow will be lost, and the saturated responsive zones or stream channels will become a stormwater fed system instead. This could deepen channels.

The risk associated with this portion of the development is rated as Low based on the low-density nature of the development.

***Note:** The blue arrows indicate the dominant direction of flow. The size of the arrow indicates the dominance/intensity of flows. The green arrows indicate an increased flow whereas the red arrows indicate a reduction of flow in the given direction.*

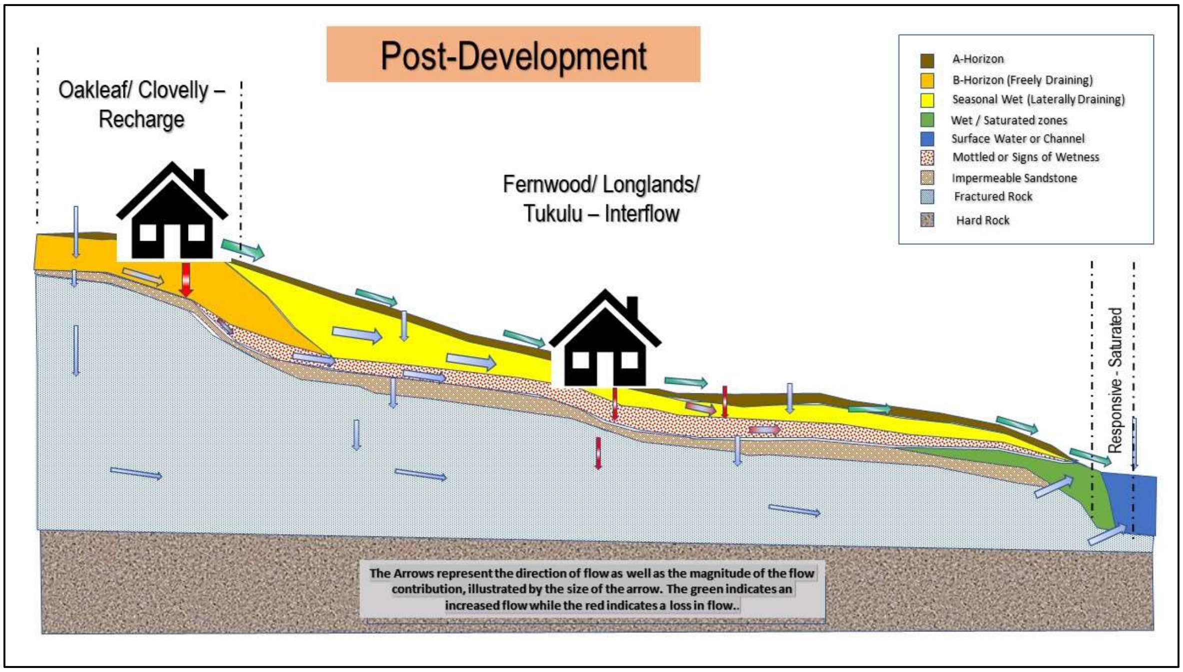

Figure 9-2: Hillslope hydrology for hydropedological soil catena for the Managers House, Tented Camps, and Free Me sites post-development.

9.1.1.1 Construction Phase

The construction phase activities investigated as part of this assessment includes:

- Clearing, stripping, and grubbing;
- Earthworks and reshaping;
- Temporary flow impoundment and diversion;
- Hazardous substances storage, handling, and disposal; and
- Rehabilitation and re-vegetation.

A brief description of the potential construction phase impacts assessed as part of this study are summarised in Table 9-1.

Table 9-1: Summary of construction phase impacts.

Impact Type	Impact Description
Direct flow driver modification impacts	C1: Infilling, excavation, and modification of the flow drivers during construction
Indirect hydrological and geomorphological process impacts	C2: Compaction of areas during construction altering infiltration
Contamination Impacts	C3: Pollution of the vadose zone from mishandling handling or spilling of hazardous substances.

9.1.1.2 Operational Phase

The operational phase activities investigated as part of this assessment includes:

- Formal stormwater management;
- Surface water impoundment, regulation, and abstraction;
- Maintenance of all development infrastructure.

A brief description of the potential operational phase impacts assessed as part of this study are summarised in Table 9-2.

Table 9-2: Summary of operational phase impacts.

Impact Type	Impact Description
Direct flow driver modification impacts	O1: Permeant alteration of flow drivers through increased impervious areas, stormwater management systems altering flow paths, and the blocking/altering of vadose zone through flows by large structures/roads.
Contamination Impacts	O2: Pollution of the vadose zone due to sewerage, spills, and stormwater inputs.

9.1.2 Impact Significance Assessment

The results of the impact significance assessment for the construction and operational phases impacts are described below.

9.1.2.1 Direct Flow Driver Modification Impacts

Construction Phase:

C1: Infilling, excavation, and modification of the flow drivers during construction.

- During construction, an area would have been cleared, reducing the infiltration rates, and increasing surface runoff. This alters the vadose zone flow volumes and flow dynamics.
- Canalisation and runoff diversions would have altered the hydrodynamics of the system by increasing surface runoff in some areas causing erosion.
- These impacts would be of low significance.

C2: Compaction of areas during construction altering infiltration.

- During construction, areas will become compacted due to the working of heavy machinery, reducing the infiltration rates, and increasing surface runoff. This alters the vadose zone flow volumes and flow dynamics.
- These impacts would be of low significance.

Operational Phase:

O1: Permanent alteration of flow drivers through increased impervious areas, stormwater management systems altering flow paths, and the blocking/altering of vadose zone through flows by large structures/roads.

- During operational phase of the area there would be large areas of impervious surfaces which would reduce infiltration and increase surface runoff. This alters the vadose zone flow volumes and flow dynamics.
- This impact is considered to be Low if allowance has been made for green engineering which introduces pervious materials into stormwater management designs allowing water to infiltrate into the landscape.

9.1.2.2 Contamination Impacts

Construction Phase:

C3: Pollution of the vadose zone from mishandling handling or spilling of hazardous substances.

- This impact is anticipated to be low due to the generally small amounts of spills and the soil's ability to absorb some contamination if the volume is small. However, in the event of spills they must be cleaned up immediately to avoid long term impacts.

Operational Phase:

O2: Pollution of the vadose zone due to sewerage, spills, and stormwater inputs.

- The contamination of the vadose zone could occur during a potential hazardous spill or a break in the sewerage systems. Although these are rare in occurrence the impacts could be long lasting.
- The impact is considered to be Low.

10 MITIGATION MEASURES

The mitigation hierarchy is regarded internationally as the best practice framework for environmental planning and managing environmental impacts. It is a set of prioritized, sequential steps that are applied to anticipate, avoid, and reduce the potential negative impacts of project activities on the natural environment. It involves a sequence of four key components: avoidance, minimization, remediation, and offset as illustrated in (Edwards, et al., 2018).

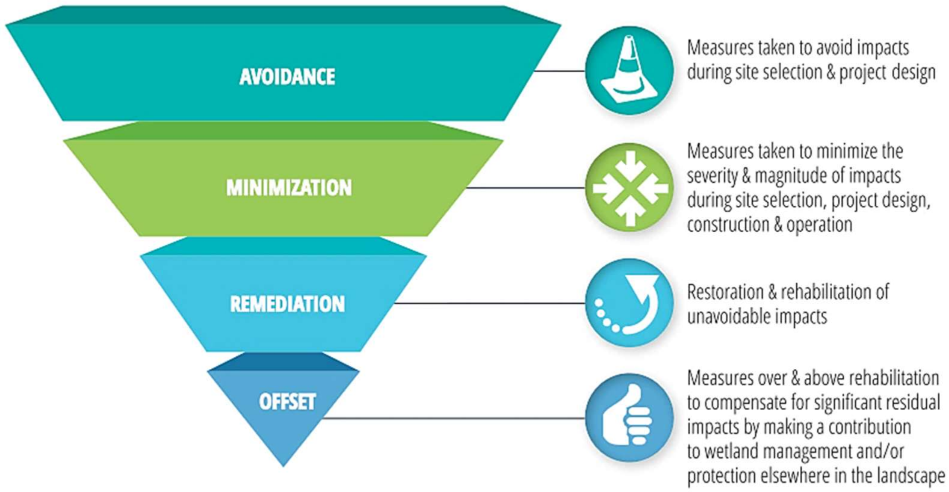

Figure 10-1: The mitigation hierarchy (Edwards, et al., 2018).

The focus of mitigation measures is to follow the mitigation hierarchy where possible. The activities that are not required within the water resource and its associated buffer zone will follow the avoidance principles and as a result impacts/risk are expected to be low for these activities. The aspects that occur within the water resource will follow the minimization and remediating principles to reduce the significance of potential impacts associated with the proposed activity. The prescribed mitigation measures for the proposed activity are provided in the respective sections below.

10.1 Site Planning

Every effort must be made to avoid potential impacts from the outset of a project (e.g., through careful spatial or temporal placement of elements of infrastructure) to prevent or limit impacts to water resources.

Various aspects will contribute to the risks described above, and as a result the mitigation measures for these aspects are listed below.

10.2 Site Clearing

During site clearing the vegetation and topsoil is removed, increasing the runoff and erosion potential of flowing water. to mitigate these impacts the following measures must be followed:

- Minimise the area of soil disturbance to reduce the impact of sedimentation into waterbodies.
- Clearing and grading must occur only where necessary to build and provide access to structures and infrastructure. Clearing must be done immediately before construction, rather than leaving soils exposed for months or years.
- Where possible, plants should be cut down to ground level instead of being removed completely to stabilise the soil during land-clearing operations.
- The proposed limits of land disturbance must be physically marked off to ensure that only the land area required for the development is cleared.

- When excavated areas are backfilled the surface must be level with the surrounding land surface, to minimise soil erosion from the areas when the excavation is complete.
- The most efficient approach to control erosion is to minimise the area of land disturbed as well as the duration for which it is exposed.
- Once surfaces have been exposed, they must immediately be protected from erosion, so limiting the source of the sediment.
- During the excavation of pits, roads, construction sites etc. the removed topsoil must be stored and appropriately protected so that it does not wash into waterbodies, causing sedimentation and nutrient loading. This is then used to backfill the area so that it can be effectively rehabilitated.
- Topsoil that is removed during excavation must NEVER be buried or rendered unusable in any way (such as mixing it with spoils or being compacted by machinery).
- During excavation soil must be excavated one layer at a time and stored in separate stockpiles so they can be returned in their natural order when the area is backfilled. This improves soil functions and improves the template for plant growth.

10.3 Access Control

- Water resources must be well fenced and sign-posted, to keep machinery, people, and livestock away from the water body as well as vegetated areas to reduce the soil disturbance, soil compaction and vegetation destruction, which thus reduces the amount of erosion and habitat loss.

10.4 Erosion & Sedimentation Control

- Temporary diversion must be used to direct runoff from impervious areas to the sediment traps.
    - Sediment traps detain sediments in stormwater runoff to protect receiving water bodies, and the surrounding area.
- Sediment traps must be used in areas of concentrated runoff.
    - Sediment traps are small impoundments that allow sediment to settle out of runoff. They are usually installed in a drainageway or other point of discharge from a disturbed area.
    - Sediment traps detain sediments in stormwater runoff to protect receiving water bodies, and the surrounding area.
    - The traps are formed by excavating an area or by placing an earthen embankment across a low area or drainage swale. An outlet or spillway is often constructed using large stones or aggregate to slow the release of runoff.

10.5 Soil Stabilisation

- Stabilization practices (e.g., revegetation) must occur as soon as possible after grading. In colder climates, a mulch cover is needed to stabilize the soil during the winter months when grass does not grow or grows poorly.
- The following measures can be used to stabilize soils for site preparation and construction: hydro mulch, straw (placed evenly on slope), crimping (rolling the placed straw with a sheep-foot roller), seeding, fertiliser, transplanting and net (jute netting pinned onto the slope).

10.6 Stockpile management

- Unprotected stockpiles are very prone to erosion and therefore must be protected. Small stockpiles can be covered with a tarp to prevent erosion. Large stockpiles must be stabilized by erosion blankets, seeding, and/or mulching.

10.7 Pollution Control

- If soil contamination occurs (i.e. due to a spill) the soil must be removed from the site and disposed of appropriately.
- Prevention of spills eliminates or minimizes the discharge of pollutants to water bodies.Handle hazardous and non-hazardous materials, such as concrete, solvents, asphalt, sealants, and fuels, as infrequently as possible and observe all national and local regulations when using, handling, or disposing of these materials.
- An effective response plan must be in place and personnel must be ready to mobilise in the event of a spillage to reduce the environmental effects of an oil or chemical spill.
- Spill control devices such as absorbent snakes and mats must be placed around chemical storage areas, and they can be used in an emergency to contain a spill.
- Implement preventative maintenance system to ensure that work vehicles are maintained in an acceptable condition. This would involve routinely checking vehicles for leaks before construction begins; and not allowing vehicles with significant leaks to operate or be repaired within the construction site. Ideally, vehicle maintenance and washing occurs in garages and wash facilities, not on active construction sites.
- Before an operation occurs near a waterbody, vehicles must be checked for leaks, to reduce soil and water contamination from vehicle fluids.
- Old engine oil must NOT be thrown on the ground or down a stormwater drain but rather collected in containers and recycled.
- Ensure that appropriate solid waste disposal facilities are provided, and adequate signage is provided for all solid, liquid, and hazardous waste types. These must contain waste products in a weatherproof manner and to prevent any airborne litter, access to scavengers or loss of food residues that may be washed into surface or ground waters. Collected waste needs to be disposed of at a registered landfill site/hazardous waste facility (where applicable).
- Re-fuelling areas for vehicles must be bunded and located away from water resources and sensitive environments to prevent any accidental spillage contaminating soil or seeping into groundwater aquifers. All servicing area run-off must be directed towards a fully contained collection sump for recovery and appropriate disposal.
- There must be no standing water at a stockpile site, to reduce erosion as well as the contamination of the water by nutrients/ toxics.

10.8 Development Construction & Maintenance

- Green Engineering structures should be considered to improve infiltration into soil profiles and minimise runoff volumes.
- Water on the road should be diverted away as quickly as possible, to minimise the amount of water running directly from the road into the water body. The drainage must lead the water to vegetated filter strips, which remove particles and contaminants from the water.

- Having more frequent drains on the approach to a water body ensures that the least amount of water is discharged directly into the water body and reduces sediment loading.
- A water bar diverts water flowing down a surface (e.g., road) to one side. This reduces the volume of water that flows down the surface and the subsequent erosion that occurs.

10.9 Runoff Control

- Green Engineering structures should be considered to improve infiltration into soil profiles and minimise runoff volumes.
- Runoff from disturbed areas (such as landing/depot areas, extraction routes, gravel pits, temporary and unpaved roads) must be directed to silt traps (silt fences, sandbags, etc) to remove sediment and reduce the sedimentation of the water bodies.
- **Check dams** are small, temporary dams constructed across a swale or channel. They can be constructed using gravel, rock, gabions, or straw bales. They are used to reduce the velocity of concentrated flow and, therefore, to reduce erosion in a swale or channel.

10.10 Sediment Controls

- Sediment basins and rock dams can be used to capture sediment from stormwater runoff before it leaves a site. Both structures allow a pool to form in an excavated or natural depression, where sediment can settle. The pool is dewatered through a single riser and drainage hole leading to a suitable outlet on the downstream side of the embankment or through the gravel of the rock dam. The water is released more slowly than it would be without the control structure.

10.11 Sanitation

- Portable toilets must be provided where work is being done and must be located a considerable distance away from water resources and riparian areas.

10.12 Site Management

- Alien and invasive vegetation have several detrimental effects on water quality, from nutrient enrichment to increased erosion and excessive water use, which is especially relevant in dry areas or in important catchments. Invasive species are highly likely to colonise disturbed areas, even after rehabilitation and follow-up clearing must be done until healthy vegetation returns to the site.
- Areas (away from surface water bodies and outside of the riparian zone) must be designated for the storage of materials and mixing of materials (such as concrete or chemicals). This reduces contamination of water resources from these materials/ activities.
- To ensure that it reaches most people signs must be written in the languages of the area (NOT just English). This ensures that non-English speakers can understand and will hopefully cooperate in reducing water pollution by the measures indicated on the sign.
- Within a construction site, vehicle access must be strictly controlled (i.e., there must be set parking, turning areas, set routes and no access to undisturbed areas.) This minimises soil disturbance and compaction and pollution from fluids leaking onto the ground as well as the disturbance of aquatic organisms.

11 RECOMMENDATIONS

The following recommendations have been made to minimise threats to sensitive receptors (sub-surface flow paths) and wetland functioning;

- Green engineering structures should be considered to improve infiltration into the vadose zones;
- It is recommended that an alien invasive management programme is implemented during the initial phase of construction and that monitoring be done throughout the construction phase. The alien invasive management programme must continue post construction for a period of 1 year; and
- Buffer zones are to be kept intact.

12 CONCLUSIONS

The Ukuwela development will have a Low impact on the flow drivers and wetlands within the project area post-mitigation. The impacts to the flow drivers include the increased runoff from the development upslope within the recharge zone and interflow zones. These stem from the increased impervious surfaces which promote runoff from the impervious surfaces.

It is the opinion of the Specialist that the proposed development may proceed, this is based on the above recommendations.

13 REFERENCES

Anderson, G. 2021. *Heritage Impact Assessment of the Proposed Developments at the Greater Ukuwela Game Reserve, Hluhluwe, KZN.* 2021.

Department of Agriculture, Forestry and Fisheries. 2017. *National land capability evaluation raster data layer.* Pretoria : s.n., 2017.

—. 2017. *National land capability evaluation raster data: Climate capability data layer.* Pretoria : s.n., 2017.

Eco-Assist Environmental. 2021. *Soils, Land Capability, and Land Use Specialist Assessment for the Proposed Construction of a Donor House and Associated Infrastructure at the Ukuwela Nature Resrve, Hlhluwe, KZN.* 2021.

Edwards, R, et al. 2018. *Wetland Management Guidelines: Building Capacity and Supporting Effective Management of Wetlands within South African Municipalities.* s.l. : Eco-Pulse Environmental Cunsulting, 2018.

Hydropedological grouping of South African soil forms. **Van Tol, J J and Le Roux, P A. 2019.** 2019, South African Journal of Plant and Soil.

Land Type Survey Staff. 1972 - 2006. *Land Types of South Africa: Digital Map (1:250 000 Scale) and Soil Inventory Databases.* Pretoria : ARC-Institute for Soil, Climate, and Water, 1972 - 2006.

Mucina, L and Rutherford, M C. 2006. *The Vegetation of South Africa, Lesotho, and Swaziland. Strelitzia 19.* Pretoria : National Biodiversity Institute, 2006. ISBN-13: 978-1-919976-21-1.

Alletson Ecologicals. 2021. *Consideration of aquatic environments in relation to proposed infrastructure developments within a nature reserve near Hluhluwe, KwaZulu-Natal.* 2021.

Soil Classification Working Group. 1991. *Soil Classification - A Taxonomic System for South Africa.* Pretoria : ARC-Institute for Soil, Climate, and Water, 1991.

—. 2018. *Soil Classification: A Natural and Anthropogenic System for South Africa.* Pretoria : ARC-Institute for Soil, Climate, and Water, 2018.

Van Tol, J J, Le Roux, P A and Lorentz, S. 2017. The science of hydropedology - Linking soil morphology with hydrological processes. *Water Wheel 16 (3).* 2017.