Hydrogeological Assessment for the proposed dam and slurry irrigation at the Dartford Farming Trust in Underberg, KwaZulu-Natal

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Attention To:

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HUNTS GREEN

HYDROGEOLOGICAL ASSESSMENT FOR THE PROPOSED DAM AND SLURRY IRRIGATION AT THE DARTFORD FARMING TRUST IN UNDERBERG

KWAZULU-NATAL, SOUTH AFRICA

JANUARY 2024

Required Client Review and Approval

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Quality	No				
Health & Safety	No				
Environment & Sustainability	Yes	S'boniso Nduli	Director	P00	For client information
Design and Engineering	No				
Other teams if required	No				

STRICTLY CONFIDENTIAL

EXECUTIVE SUMMARY

Hunts Green Consulting (Pty) Ltd was appointed by Emanzini WULA Consultants to conduct a hydrogeological 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 existing sludge dams for irrigation purposes.

The study area is located within the T51C quaternary catchment within the Pongola Mtavuma Water Management Area (WMA 4) and is drained by the Mzimkhulu River downstream, which discharges into the Indian Ocean in a south easterly direction.

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.

Underberg is located within the Mzimkhulu Region in the KwaZulu-Natal Coastal Foreland and Transkeian Coastal Foreland and Middleveld Groundwater Regions. The hydrogeologically relevant lithologies in the Mzimkulu Region comprise of the siltstone/shale, feldspathic sandstones and tillites of the Karoo Supergroup; the micaceous sandstones of the Natal Group; and the granite/gneiss of the Natal Metamorphic Province (NMP). These hydrogeological units are clearly defined within the Mzimkulu River catchment and occur in distinct bands or areas.

This Groundwater Region is characterised by a combination of intergranular and fractured arenaceous rocks. The aquifer types occurring in this region are mapped as minor/low to medium potential. The aquifer types occurring in this region are mapped as low to medium potential and the geology consists of mostly arenaceous rocks.

Regional groundwater levels varies between 6.5 mbgl to 42.5 mbgl with an average groundwater level of 24.5 mbgl. The shallow groundwater level is understood to corespond to the shallow weathered aquifers with the deeper groundwater elevation correcponding to the deeper fractured aquifers. Groundwater flow in the shallow weathered aquifer mimics the topographic relief.

Primary groundwater supplies using boreholes fitted with hand pumps, wind pumps or submersibles are obtainable in most of the lithological units. The exceptions are the Dwyka formation (tillites) or massive granites. In these areas groundwater supply could be obtained within an adjacent fault valley where the potential for high yielding boreholes is much enhanced.

The sandstone of the Natal Group represents the most productive groundwater-bearing lithology, followed by mudstone/shale lithologies, the granite/gneiss lithologies and the tillite sediments of the Dwyka Tillite Formation. Boreholes favourably located in the Natal Group Sandstone (NGS) provide good yields.

Groundwater usage in the catchment is not usually recorded and there are no yield estimates available for the boreholes connected to the water supply. It is estimated that there are relatively high volumes of groundwater being abstracted for domestic water use as there are a number of standalone schemes, which are dependent on the groundwater systems. The yield of groundwater is at its highest near Rietvlei, Creighton, and from the southwest to the northwest of Underberg.

Groundwater quality analysis for all sampled hydrocensus boreholes showed pH values between 7.2 and 7.6 with an average pH of 7.42. All boreholes complied with the all the recommended targeted water quality guideline range.

The groundwater quality in every borehole that was sampled demonstrates good water quality. WS-01 (Borehole 1) was found to have exceeded the SA Water Quality Guidelines: Irrigation for Cl concentration while all other parameters were in compliance with the guidelines.

Based on surface water sampling points WS-04 (Stream), all the parameters that were examined are in accordance with the relevant guidelines. Slurry dam (WS-03) exceeded the SA Water Quality Guidelines for irrigation for Cl and Na concentrations. Furthermore, the slurry dam exceeded the SA Water Quality Guidelines for livestock watering for TDS.

The slightly elevated Cl and Na concentration is said to have increased slightly due to old regional circulating groundwater, which is both natural and attributed to agricultural activities.

Over the years agricultural activities in and around Underberg has caused deterioration to the groundwater quality. The water quality of the aquifers indicates that groundwater contamination has already taken place and this is mainly due to agricultural activities and natural processes of the underlying geology.

The conceptual model was developed as follows:

- Contaminant Sources:
  - Slurry water (utilised for irrigation)
  - Dam Construction (i.e. increased turbidity, oil spills, leakages)
- Contaminant pathways:
  - Aquifers - these are rock units or open faults and fractures within rock units that are sufficiently permeable (effectively porous) to allow water flow;
- Receptors:
  - These include the groundwater users, streams and natural ecosystems that depend on the groundwater.

The use of water from slurry dams for irrigation has the potential to cause groundwater contamination. The quality of groundwater may be impacted by elevated parameters. In addition, ecosystems that depend on groundwater, such as nearby rivers, streams, and wetlands, may be affected.

However, based on the current results, the proposed irrigiation using slurry water and construction of a dam it is deemed to have a negligible impact on the environment if managed properly or in a even better manner. To ensure compliance with the National Water Act (36 of 1998) for disposal of waste by irrigation, no irrigation should take place within 100 m of a watercourse.

The stormwater management in the farm is adequate and there are no concerns with polluting 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. No significant impacts to the environment or downstream users are initicapated in the event of spillages or from the existing stormwater management practices within the the Dartford Farm.

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LIST OF ACRONYMS & ABBREVIATIONS

AIP	Alien Invasive Plants
CARA	Conservation of Agricultural Resources Act (CARA 43 of 93)
DEM	Digital Elevation Model
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
DTM	Digital Terrain Model
EWR	Ecological Water Requirements
NWA	National Water Act
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
MIPI	Midgley and Pitman
Mm^3	Million cumic meters
RM3	Rational method Alternative 3
SDF	Standard Design Flood
SRA	Streamflow Reduction Activities
WARMS	Water use Authorization & Registration Management System
WMA	Water Management Area
WRC	Water Resources Commission
WUL	Water Use License

1 Introduction

Hunts Green Consulting (Pty) Ltd was appointed by Emanzini WULA Consultants to conduct a hydrogeological 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 existing sludge dams for irrigation purposes.

The dam, irrigation fields, sludge dams and 500m regulated area are located on 4 farm portions, within the Underberg area, Dr Nkosazana Dlamini-Zuma Local Municipality, Kwazulu-Natal (Figure 1-1) namely:

- Portion 0 of the Farm Lot FP 173 No. 8581,
- Portion 0 of the Farm Lot 1B No. 7604,
- Portion 0 of the Farm 7603 and
- Portion 0 of the Farm 9162,

The study area is located within the T51C quaternary catchment within the Pongola Mtavuma Water Management Area (WMA 4) and is drained by the Mzimkhulu River downstream, which discharges into the Indian Ocean in a south easterly direction. The local setting of the Dartford farm project area is indicated in Figure 1-1.

It is the intention of the applicant to construct a storage dam with a capacity of 1 500 000m3 to be used for the irrigation of existing cultivation fields including perennial grass pastures and vegetables. Furthermore, the applicant currently utilises two sludge (Slurry) dams for irrigation purposes and these form part of the WUL application.

This groundwater assessment report forms part of the environmental regulatory process to assess the baseline groundwater conditions, potential impacts and mitigation plans pertaining to the proposed dam that will be utilised for irrigation purposes as well as the continued use of existing sludge dams for irrigation purposes.

1.1 Objectives

An essential to attain the required Water Use License authorisation for the Dartford Farm project is undertaking a detailed groundwater impact assessment study.

The objective of the study includes the assessment of the potential impacts and mitigation plans for the proposed dam that will be utilised for irrigation purposes as well as the continued use of existing sludge dams for irrigation purposes.

The specific objectives of the study include:

- Detailing the baseline groundwater characteristics. This represents the baseline groundwater quality, and flow characteristics within the proposed project area;
- Identifying potential impacts that can arise as part of the proposed activity; and
- Recommend on the potential mitigation measures to be implemented.

This specialist groundwater impact assessment study was undertaken in line with the Department of Water and Sanitation (DWS) Best Practice Guideline for Impact Prediction and is guided by following legislative requirements: National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA); Regulation 636 under the National Environmental Management: Waste Act; National Water Act (Act 36 of 1998) (NWA); and NWA amendment of Regulation 704 (GN R 704) of 1999.

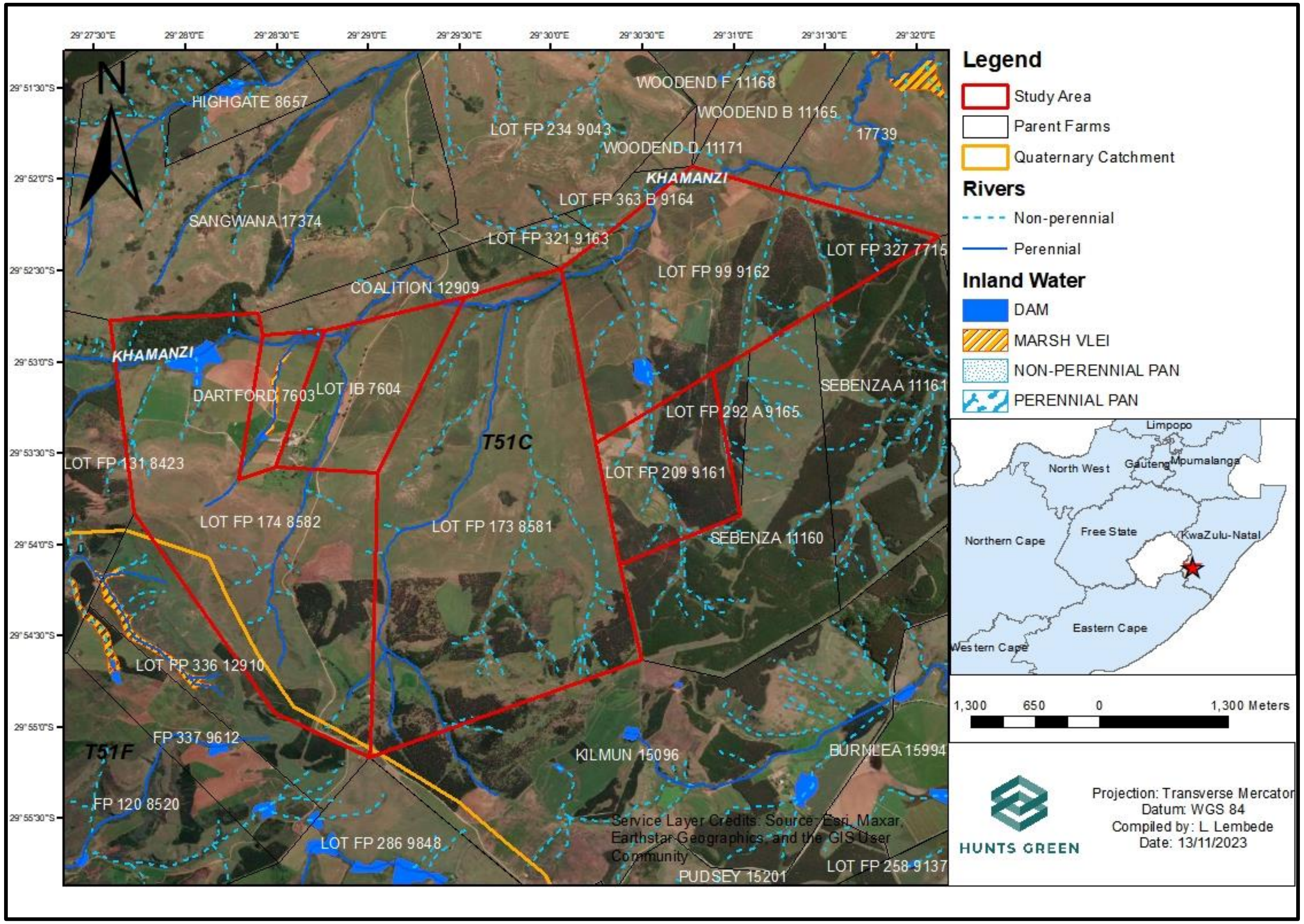

Figure 1-1: Local Setting of the Project Area

2 Investigative Methodology

The methodology adopted to describe or in determining the status quo of the Dartford Farm's hydrogeological system is summarised below.

2.1 Data used in this report

Quantitative and qualitative research approaches were utilised in the acquisition of all relevant hydrological and hydrogeological background data. This included the following:

- Desktop study
  - A review of the literature conducted within the greater Underberg area was made to provide an understanding of the baseline hydrological and hydrogeological background. The reviewed literature included geological, hydrogeological and surface water hydrology maps, reports and other database from various sources.
- Field work data
  - Field work was conducted in November 2023 as part of the hydrocensus survey (Figure 2-1, Table 2-2 and Table 2-3). Groundwater samples were collected to characterise baseline groundwater and quality. Further, groundwater level measurements were made in order to characterise groundwater flow system. Due to limited number of measurements made the potentiometric surface map could not be constructed.

2.2 Desktop Assessment

The Desktop Assessment is invaluable in gaining an understanding of key areas that need to be focused on in the groundwater impact assessment. The objectives of the deskptop assessment are to:

- Develop a better understanding of the conceptual hydrogeological characteristics and associated assumptions accurately describe the conditions on site.

All available data for the project area was requested. This included all geological, hydrogeological, groundwater and surface water data and reports, site plans and meteorological data for the project area.

2.3 Hydrocensus Survey

A hydrocensus was conducted within 1km radius on the 27th of November 2023 to provide an understanding of the baseline environment in the area. Sampling sites were selected based on the proposed project area and the existing surface geology maps within the Darford Farm (Figure 2-1). Groundwater samples were collected to obtain the baseline water quality parameters within the project area.

The following information was collected for each site:

- The status of the sampling site or borehole;
- Sampling site coordinates (X, Y and Z position) using a GPS;
- Field pH, EC and TDS values; and
- Primary use and/ or abstraction rates.

As a result to limited access and limited groundwater use within the project area, a total of two boreholes and two surface water (slurry dam and Stream) sampling site were sampled (Figure 2-1, Table 2-2 and Table 2-3).

Sub-sequent to the wellfield survey, an overview of the surrounding environment was made to assess and/ or to identify potential receptors that may be affected. The following conclusions were drawn:

a) The main source of drinking water supply in and around the proposed wellfield development area is groundwater through a number of privately owned boreholes which are mainly used for domestic, livestock, agricultural irrigation purposes; and

b) The surrounding area can be characterised as rural/farm-land with disseminated farms largely practising and/ or depending on agricultural farming for leaving.

The samples were sent to a SANAS accredited laboratory (UIS) for analysis. The analysis was performed for inorganic constituents as show in Table 2-1.

Table 2-1: Inorganic constituents analysed

pH	Sulphate (SO_4)
Electrical Conductivity (EC)	Ammonium (NH_4)

P-Alkalinity (PALK)	Potassium (K)
Total Alkalinity (TALK)	Nitrate (NO_3-N)
Iron (Fe)	Chromium (Cr)
Manganese (Mn)	Phosphate (PO_4-P)
Chloride (Cl)	Fluoride (F)
Magnesium (Mg)	Arsenic (As)
Sodium (Na)	Cadmium (Cd)
Aluminum (Al)	Lead (Pb)
Calcium (Ca)	Copper (Cu)
Zinc (Zn)	Cobalt (Co)
Nickel (Ni)	Total cations
Total anions	Ionic balance

Table 2-2: Hydrocensus Sampling Sites

Farm	Location	Latitude	Longitude	Sample ID	Date	Notes
Kevin Fraser	Existing Borehole 1	29°53'47.06"S	29°28'37.42"E	WS-01	27-11-2023	Water level at 3.22m, no historical information regarding volume pumped from the borehole, there were no solvents discharged in the vicinity of the borehole base on communication with the farmer.
Bana we	Existing Borehole 2 (Sampling Point 1)	29°52'18.60"S	29°29'48.93"E	WS-02	27-11-2023	Water level at 41.77m, no historical information regarding volume pumped from the borehole, there were no solvent discharged in the vicinity of the borehole base on communication with farmer.
Kevin Fraser	Slurry Sample	29°53'25.83"S	9°28'32.25"E	WS-03	27-11-2023	No seepage or leakages observed during the sampling.
Kevin Fraser	Stream (Sampling Point 2	29°53'0.30"S	29°28'49.60"E	WS-04	27-11-2023	Sampled from flowing stream. The water did not appear to be coming from seepage from the slurry.

Table 2-3: Hydrocensus Survey Photos

Existing Borehole 1	Existing Borehole 2 (Sampling Point 1)
	
Slurry dam	**Stream (Sampling Point 2**

27/11/2023 12:34	27/11/2023 13:30

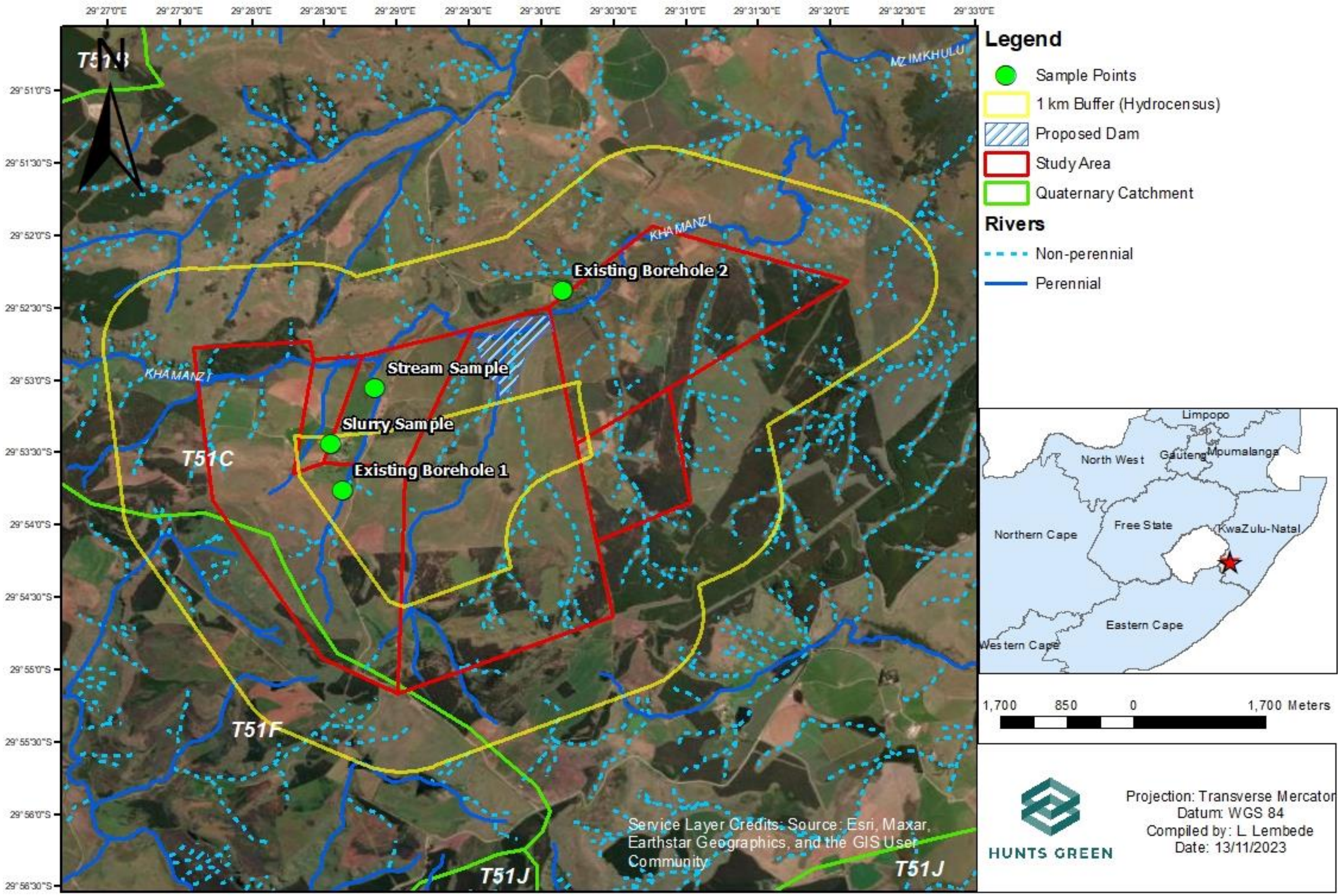

Figure 2-1: Hydrocensus Map

2.4 Impact Assessment Methodology

Impacts and risks were identified based on a description of the activities to be undertaken. Once impacts were identified, a numerical environmental significance rating process was undertaken which utilises the probability of an event occurring and the severity of the impact as factors to determine the significance of a particular environmental impact.

The severity of an impact was determined by taking the spatial extent, the duration and the severity of the impacts into consideration. The probability of an impact was then determined by the frequency at which the activity takes place or is likely to take place and by how often the type of impact in question has taken place in similar circumstances.

Following the identification and significance ratings of potential impacts, mitigation and management measures were incorporated into the groundwater management plan.

Details of the impact assessment methodology used to determine the significance of physical, bio-physical and socio-economic impacts are provided below.

The significance rating process follows the established impact/risk assessment formula:

Significance = CONSEQUENCE X PROBABILITY X NATURE

Where

Consequence = intensity + extent + duration

And

Probability = likelihood of an impact occurring

And

Nature = positive (+1) or negative (-1) impact

The matrix (Table 2-5) calculates the rating out of 147, whereby intensity, extent, duration and probability are each rated out of seven as indicated in Table 2-4. The weight assigned to the various parameters is then multiplied by +1 for positive and -1 for negative impacts.

Impacts are rated prior to mitigation and again after consideration of the mitigation has been applied; post-mitigation is referred to as the residual impact. The significance of an impact is determined and categorised into one of seven categories (The descriptions of the significance ratings are presented in Table 2-6).

It is important to note that the pre-mitigation rating takes into consideration the activity as proposed, (i.e., there may already be some mitigation included in the engineering design). If the specialist determines the potential impact is still too high, additional mitigation measures are proposed.

Table 2-4: Impact assessment parameter ratings

Rating	Intensity/ Replicability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	**Positive Impacts (Nature = +1)**			
7	Irreplaceable loss or damage to biological or physical resources or **highly** sensitive environments. Irreplaceable damage to **highly sensitive** cultural/social resources.	Noticeable, on-going natural and / or social benefits which have improved the overall conditions of the baseline.	International The effect will occur across international borders.	Permanent: The impact is irreversible, even with management, and will remain after the life of the project.	Definite: There are sound scientific reasons to expect that the impact will definitely occur. >80% probability.
6	Irreplaceable loss or damage to biological or physical resources or **moderate to highly** sensitive environments. Irreplaceable damage to cultural/social resources of **moderate to highly** sensitivity.	Great improvement to the overall conditions of a large percentage of the baseline.	National Will affect the entire country.	Beyond project life: The impact will remain for some time after the life of the project and is potentially irreversible even with management.	Almost certain / Highly probable: It is most likely that the impact will occur.>65 but <80% probability.

Rating	Intensity/ Replicability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	Positive Impacts (Nature = +1)			
5	Serious loss and/or damage to physical or biological resources or **highly** sensitive environments, limiting ecosystem function. Very serious widespread social impacts. Irreparable damage to highly valued items.	On-going and widespread benefits to local communities and natural features of the landscape.	Province/ Region Will affect the entire province or region.	Project Life (>15 years): The impact will cease after the operational life span of the project and can be reversed with sufficient management.	Likely: The impact may occur. <65% probability.
4	Serious loss and/or damage to physical or biological resources or **moderately** sensitive environments, limiting ecosystem function. On-going serious social issues. Significant damage to structures / items of cultural significance.	Average to intense natural and / or social benefits to some elements of the baseline.	Municipal Area Will affect the whole municipal area.	Long term: 6-15 years and impact can be reversed with management.	Probable: Has occurred here or elsewhere and could therefore occur. <50% probability.

Rating	Intensity/ Replicability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	**Positive Impacts (Nature = +1)**			
3	Moderate loss and/or damage to biological or physical resources of **low to moderately** sensitive environments and, limiting ecosystem function. On-going social issues. Damage to items of cultural significance.	Average, on-going positive benefits, not widespread but felt by some elements of the baseline.	Local Local including the site and its immediate surrounding area.	Medium term: 1-5 years and impact can be reversed with minimal management.	Unlikely: Has not happened yet but could happen once in the lifetime of the project, therefore there is a possibility that the impact will occur. <25% probability.

Rating	Intensity/ Replicability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	**Positive Impacts (Nature = +1)**			
2	**Minor loss and/or effects** to biological or physical resources or low sensitive environments, not affecting ecosystem functioning. Minor medium-term social impacts on local population. Mostly repairable. Cultural functions and processes not affected.	Low positive impacts experience by a small percentage of the baseline.	<u>Limited</u> Limited extending only as far as the development site area.	Short term: Less than 1 year and is reversible.	Rare / improbable: Conceivable, but only in extreme circumstances. The possibility of the impact materialising is very low as a result of design, historic experience or implementation of adequate mitigation measures. <10% probability.

Rating	Intensity/ Replicability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	**Positive Impacts (Nature = +1)**			
1	**Minimal to no loss** and/or effect to biological or physical resources, not affecting ecosystem functioning. Minimal social impacts, low-level repairable damage to commonplace structures.	Some low-level natural and / or social benefits felt by a very small percentage of the baseline.	Very limited/Isolated Limited to specific isolated parts of the site.	Immediate: Less than 1 month and is completely reversible without management.	Highly unlikely / None: Expected never to happen. <1% probability.

Table 2-5: Probability/consequence matrix

Significance																																					
-147	-140	-133	-126	-119	-112	-105	-98	-91	-84	-77	-70	-63	-56	-49	-42	-35	-28	-21	21	28	35	42	49	56	63	70	77	84	91	98	105	112	119	126	133	140	147
-126	-120	-114	-108	-102	-96	-90	-84	-78	-72	-66	-60	-54	-48	-42	-36	-30	-24	-18	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120	126
-105	-100	-95	-90	-85	-80	-75	-70	-65	-60	-55	-50	-45	-40	-35	-30	-25	-20	-15	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105
-84	-80	-76	-72	-68	-64	-60	-56	-52	-48	-44	-40	-36	-32	-28	-24	-20	-16	-12	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	84
-63	-60	-57	-54	-51	-48	-45	-42	-39	-36	-33	-30	-27	-24	-21	-18	-15	-12	-9	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63
-42	-40	-38	-36	-34	-32	-30	-28	-26	-24	-22	-20	-18	-16	-14	-12	-10	-8	-6	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42
-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Consequence																																					

Table 2-6: Significance rating description

Score	Description	Rating
109 to 147	A very beneficial impact that may be sufficient by itself to justify implementation of the project. The impact may result in permanent positive change	Major (positive) (+)
73 to 108	A beneficial impact which may help to justify the implementation of the project. These impacts would be considered by society as constituting a major and usually a long-term positive change to the (natural and / or social) environment	Moderate (positive) (+)
36 to 72	A positive impact. These impacts will usually result in positive medium to long-term effect on the natural and / or social environment	Minor (positive) (+)
3 to 35	A small positive impact. The impact will result in medium to short term effects on the natural and / or social environment	Negligible (positive) (+)
-3 to -35	An acceptable negative impact for which mitigation is desirable. The impact by itself is insufficient even in combination with other low impacts to prevent the development being approved. These impacts will result in negative medium to short term effects on the natural and / or social environment	Negligible (negative) (-)
-36 to -72	A minor negative impact requires mitigation. The impact is insufficient by itself to prevent the implementation of the project but which in conjunction with other impacts may prevent its implementation. These impacts will usually result in negative medium to long-term effect on the natural and / or social environment	Minor (negative) (-)
-73 to -108	A moderate negative impact may prevent the implementation of the project. These impacts would be considered as constituting a major and usually a long-term change to the (natural and / or social) environment and result in severe changes.	Moderate (negative) (-)
-109 to -147	A major negative impact may be sufficient by itself to prevent implementation of the project. The impact may result in permanent change. Very often these impacts are immitigable and usually result in very severe effects. The impacts are likely to be irreversible and/or irreplaceable.	Major (negative) (-)

2.5 Groundwater Assessment Report

A comprehensive hydrogeological report was prepared. This document will encompass the background data, the conceptual understanding of the hydrogeological system, conceptual contaminant source and receptors from the project area (i.e. Slurry dams) and conclusions.

Additionally, recommendations are made, which include further provide consideration of the monitoring network optimization, monitoring protocol, future studies, groundwater management, remediation strategies etc. The recommendations will discuss the the key management objectives to ensure compliance to the legislative requirements.

3 Baseline Description

The sub-sections below provide environmental background of the Dartford Farm including the greater Underberg area.

3.1 Catchment Climate and Hydrology

The study area is located within quaternary catchment T51C within the Pongola Mtavuma Water Management Area (WMA 4) and is drained by the Mzimkhulu River downstream, which discharges into the Indian Ocean in a south easterly direction (Figure 3-3). The characteristics of the T51C quaternary catchment are summarised in Table 3-1.

Table 3-1: Summary of Climate Characteristics of Quaternary Catchments

Catchment Name	Area (km^2)	Evaporation Zone	MAE (mm)	Rain Zone	MAP (mm)	MAR (mcm)
T51C	462	29A	1300	T5B	952	95.4

Figure 3-1 shows the historical distribution of rainfall, with the 90th percentile of monthly rainfall representing extreme wet conditions and the 10th percentile represents drought events. Rainfall will normally vary between the 30th and 70th percentiles, which indicate steady summer rainfall over a 6-month period and a shorter, relatively dry winter period.

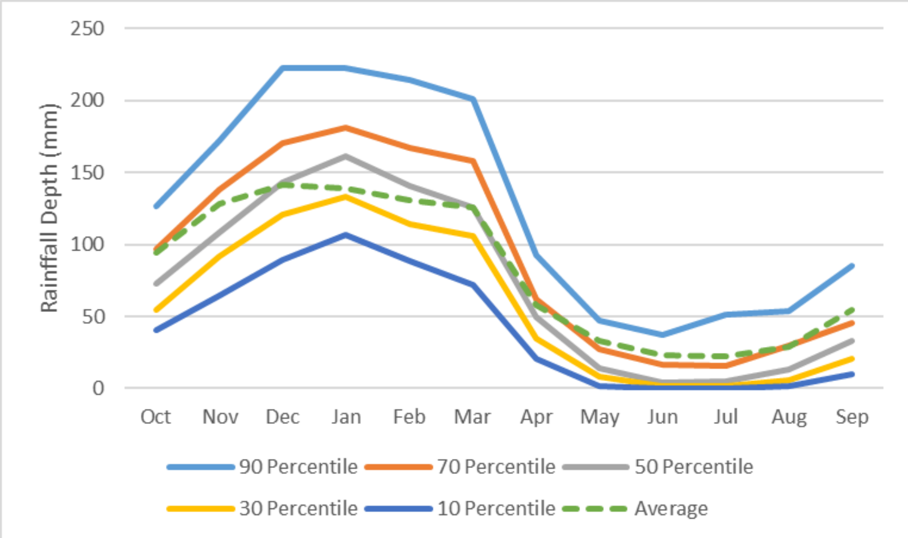

Figure 3-1: Monthly Rainfall Distribution for Quaternary Catchment T51C

The naturalized runoff for quaternary catchment T51C and for the delineated upstream runoff contributing catchment for the study area is approximately 120 Mm^3/annum and 10M m^3/annum, respectively (Bailey & Pitman, 2015). The quaternary catchment experiences wet months between November to April, followed by drier months between May to October (Figure 3-2). The driest month is July, with an average of 2.1 Mm^3, while the wettest month is February, with an average runoff of 22.9 Mm^3.

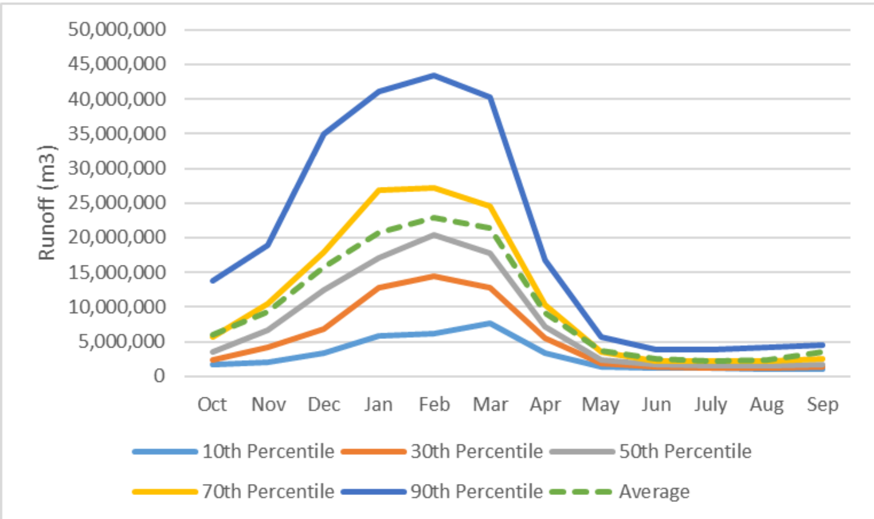

Figure 3-2: Naturalized Flow within Quaternary Catchment T51C

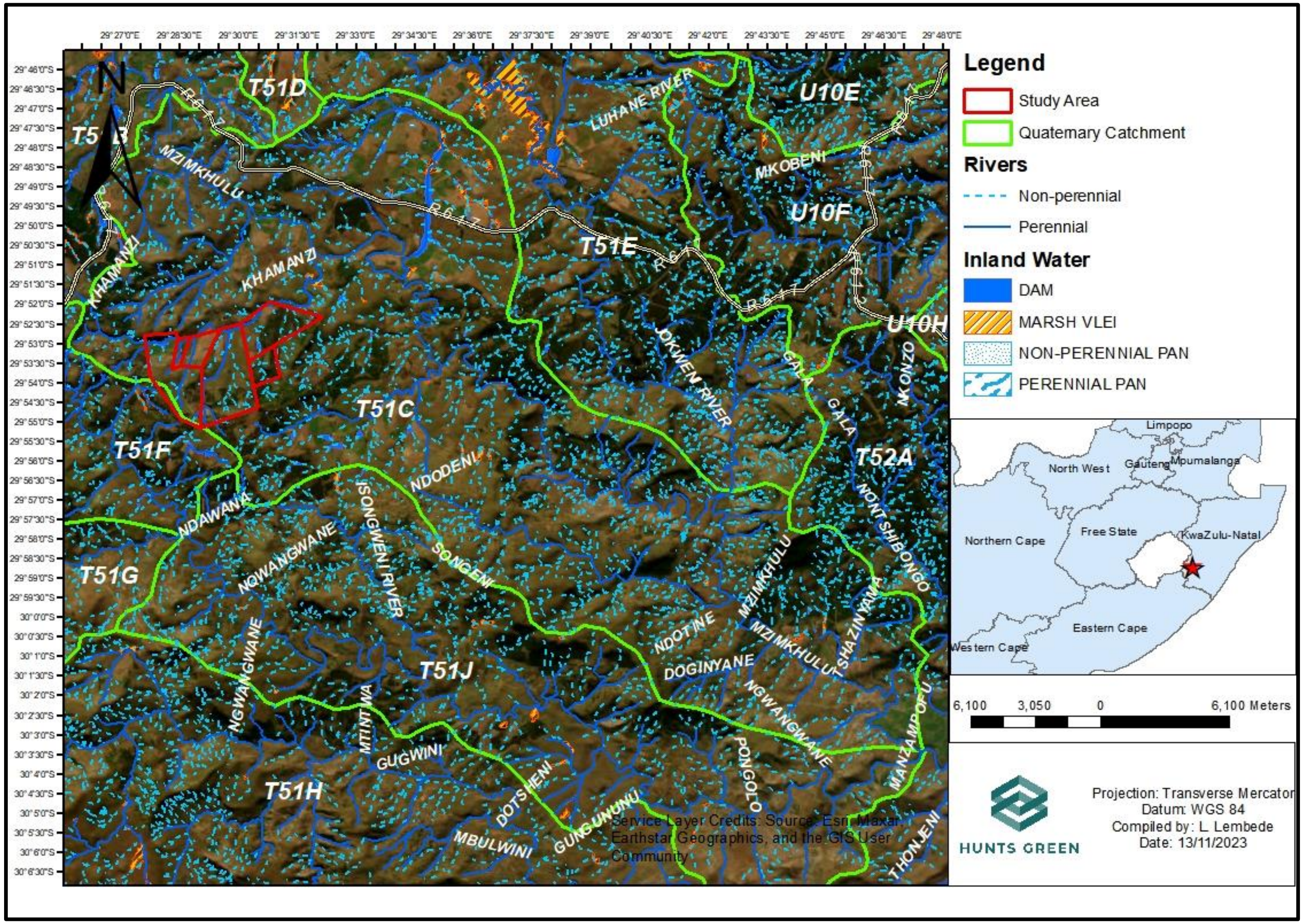
Legend
Study Area
Quatemary Catchment
Rivers
Non-perennial
Perennial
Inland Water
DAM
MARSH VLEI
NON-PERENNIAL PAN
PERENNIAL PAN
Limpopo
North West
Gauteng
Mpumalanga
Northern Cape
Free State
KwaZulu-Natal
Eastern Cape
Western Cape
6,100 3,050 0 6,100 Meters
HUNTS GREEN
Projection: Transverse Mercator
Datum: WGS 84
Compiled by: L. Lembede
Date: 13/11/2023
Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
T51D
U10E
U10F
U10H
T51E
T51C
T51F
T51G
T51J
T51H
T52A
MZIMKHULU
KHAMANZI
LUHANE RIVER
MKOBENI
JOKWENI RIVER
GALA
NDODENI
NDAWANA
NGWANGWANE
ISONGWENI RIVER
SONGENI
NDOTINE
DOGINYANE
GUGWINI
DOTSHENI
MBULWINI
GUNGUNUNU
PONGOLO
THONJENI
MANZAMPOFU
SHAZINYAMA
NONTSHIBONGO
MTINTWA
R617

Figure 3-3: Locality of Quaternary Catchment T51C

3.2 Topography and Drainage

The Section presents the findings of the yield assessment.

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 3-4). 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 3-5). 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 3-5).

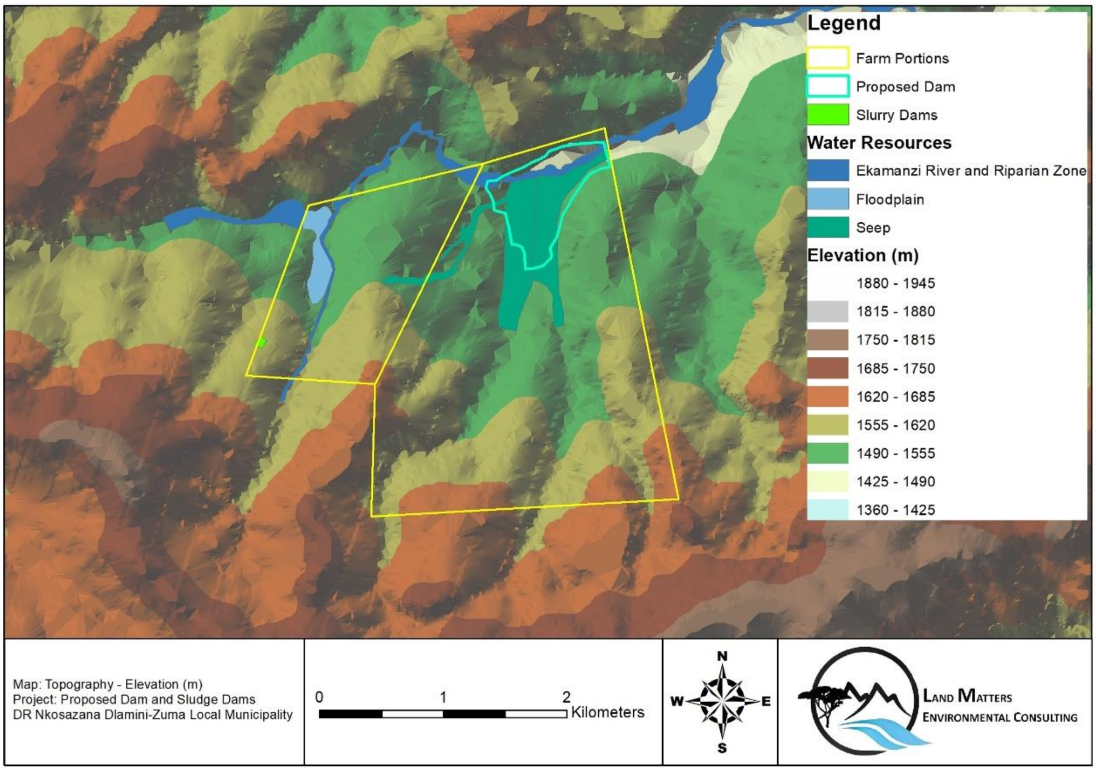

Figure 3-4: Topography (elevation of the study site)

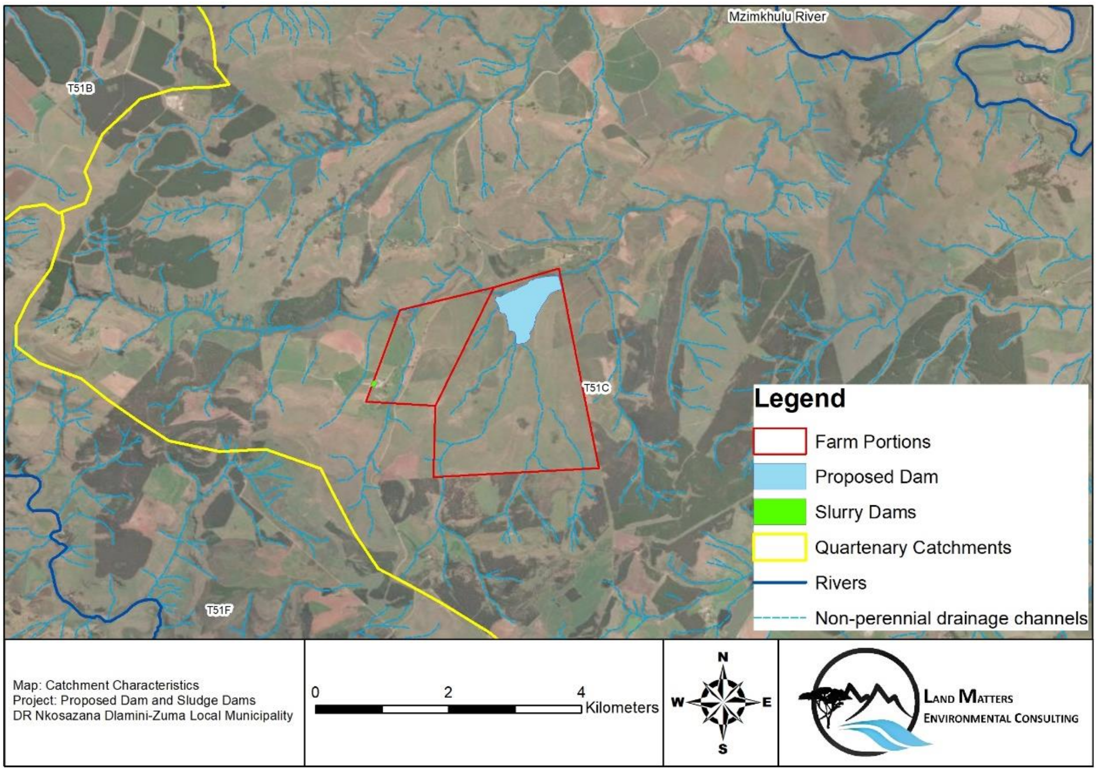

Figure 3-5: Catchment characterisitics of the study site

4 Hydrogeological Conceptual Environment

4.1 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).

4.2 Hydrogeology

Underberg is located within the Mzimkhulu Region. The Mzimkulu Region occurs in the KwaZulu-Natal Coastal Foreland and Transkeian Coastal Foreland and Middleveld Groundwater Regions (UW, 2020).

The hydrogeologically relevant lithologies in the Mzimkulu Region comprise of the siltstone/shale, feldspathic sandstones and tillites of the Karoo Supergroup; the micaceous sandstones of the Natal Group; and the granite/gneiss of the Natal Metamorphic Province (NMP). These hydrogeological units are clearly defined within the Mzimkulu River catchment and occur in distinct bands or areas.

The Natal group sandstones can be found in a relatively small area to the south of the Mzimkulu River in the Oribi Flats area as well as around the town of Paddock. Extending inland from the Oribi Flats area, the Mzimkulu River is bounded on both sides by extensive tillite deposits of the Dwyka Formation.

The Dwyka Formation covers the Ntabankulu and St Faiths area and extends southwards to Izingolweni. Further west all the way up to the Mzimkulu River source at the foothills of the

Drakensberg Mountains the hydrogeology is dominated by the Karoo Supergroup. Here shales are interspersed with igneous dolerite intrusions. The shales of the Pietermaritzburg Formation outcrop chiefly in the uplands around Ixopo and extend southwards through Harding.

4.2.1 Hydrogeology Characteristics

This Groundwater Region is characterised by a combination of intergranular and fractured arenaceous rocks. The aquifer types occurring in this region are mapped as minor/low to medium potential (UW, 2020). The aquifer types occurring in this region are mapped as low to medium potential and the geology consists of mostly arenaceous rocks.

The region is located within the semi-arid region os Southern Africa. Groundwater recharge occurs through rainfall recharges at the shallow aquifers in these areas and it is intercepted by the boreholes in the catchment. Recharge varies between 46 to 56 mm per annum. This zone is directly recharged by rainfall and as a result is only recharged during rainy season.

The area is located within the Mvoti to Umzimkulu Water Management Area. Regional groundwater levels varies between 6.5 mbgl to 42.5 mbgl with an average groundwater level of 24.5 mbgl. The shallow groundwater level is understood to corespond to the shallow weathered aquifers with the deeper groundwater elevation correcponding to the deeper fractured aquifers. Groundwater flow in the shallow weathered aquifer mimics the topographic relief.

4.2.2 Groundwater Potential

Primary groundwater supplies using boreholes fitted with hand pumps, wind pumps or submersibles are obtainable in most of the lithological units. The exceptions are the Dwyka formation (tillites) or massive granites. In these areas groundwater supply could be obtained within an adjacent fault valley where the potential for high yielding boreholes is much enhanced.

The sandstone of the Natal Group represents the most productive groundwater-bearing lithology, followed by mudstone/shale lithologies, the granite/gneiss lithologies and the tillite sediments of the Dwyka Tillite Formation. Boreholes favourably located in the Natal Group Sandstone (NGS) provide good yields.

Yields of 3ℓ/s (greater than 10 000 ℓ/hr) are not uncommon where large scale fracturing/faulting provide conduits for groundwater movement. Boreholes located in and around Underberg indicate yield characteristics in the range 0.1 to >3 ℓ/s. More precisely, the yields range between 0.5-3 ℓ/s with selected boreholes north-west where yields between 0.1->3 ℓ/s are characterised (Figure 4-1).

A groundwater assessment was undertaken as part of the DWS “Mzimkhulu River Catchment Water Resources Study” (2011). Conclusions and recommendations from this assessment were:

- The yields of groundwater are elevated near Rietvlei, Creighton, and from west-southwest to northwest of Underberg.
- Groundwater supply to these communities appears viable due to the presence of populations (both rural and urban) in these areas.
- The primary geological formations that yield high amounts are the Drakensbery basalts, Karoo dolerites, and closely-bedded argillaceous Karoo Supergroup rocks.
- Dolerite dikes and sill contacts, as well as observed lineaments, act as the main pathways for groundwater movement and storage, to a certain extent.
- Yields are typically higher in areas that are underlain by shallow soil profiles and soils with increased clay content.
- The only possible problematic determinants in the groundwater are magnesium (Mg), nitrate (NO3) and fluoride (F), and they peak in the southern areas of the Mzimkhulu River catchment.

4.3 Water Use

Underberg offers services to the farming and rural communities nearby. Potable water is provided to the towns of Underberg and Himeville by the Underberg WTP's raw water supply source, which is the Mzimkhulu River. The Underberg WTP supplies Underberg and Himeville and the Mzimkhulu WTP supplies the uMzimkhulu town and surrounding areas.

The upper part of the catchment is characterized by agricultural development, mostly under irrigation, that is nourished by numerous farm dams. The farming towns of Underberg, Himeville, Creighton, and Harding provide water supply infrastructure for the area.

The Underberg WTP, Mzimkhulu WTP and Ibisi WTP rely on run-of-river abstractions. There are three key flow gauges in the upper Mzimkhulu catchment (TH003, T5H004 and T5H005) located in the Pholela River in T51D, Mzimkhulu River in T51B and Nkonzo River in T51A, respectively. These stations are usually known for their long records and high-quality data. Low flows generally occur during the months of June, July, and August, which makes it difficult for communities to obtain water from natural sources such as streams and rivers. Despite this, the communities have sufficient water supply during summer months.

The Upper Mzimkhulu River and its tributaries provide water for commercial, industrial, and domestic uses, predominantly in rural communities and towns such as Underberg, Himeville, and Creighton, through point source abstraction. The middle section of the river near Umzimkhulu Town is prone to flooding, with some flow gauges having been washed away in the past.

Groundwater usage in the catchment is not usually recorded and there are no yield estimates available for the boreholes connected to the water supply. It is estimated that there are relatively high volumes of groundwater being abstracted for domestic water use as there are a number of standalone schemes, which are dependent on the groundwater systems.

The yield of groundwater is at its highest near Rietvlei, Creighton, and from the southwest to the northwest of Underberg. Groundwater supply to these communities appears viable due to the small populations (both rural and urban) in these areas.

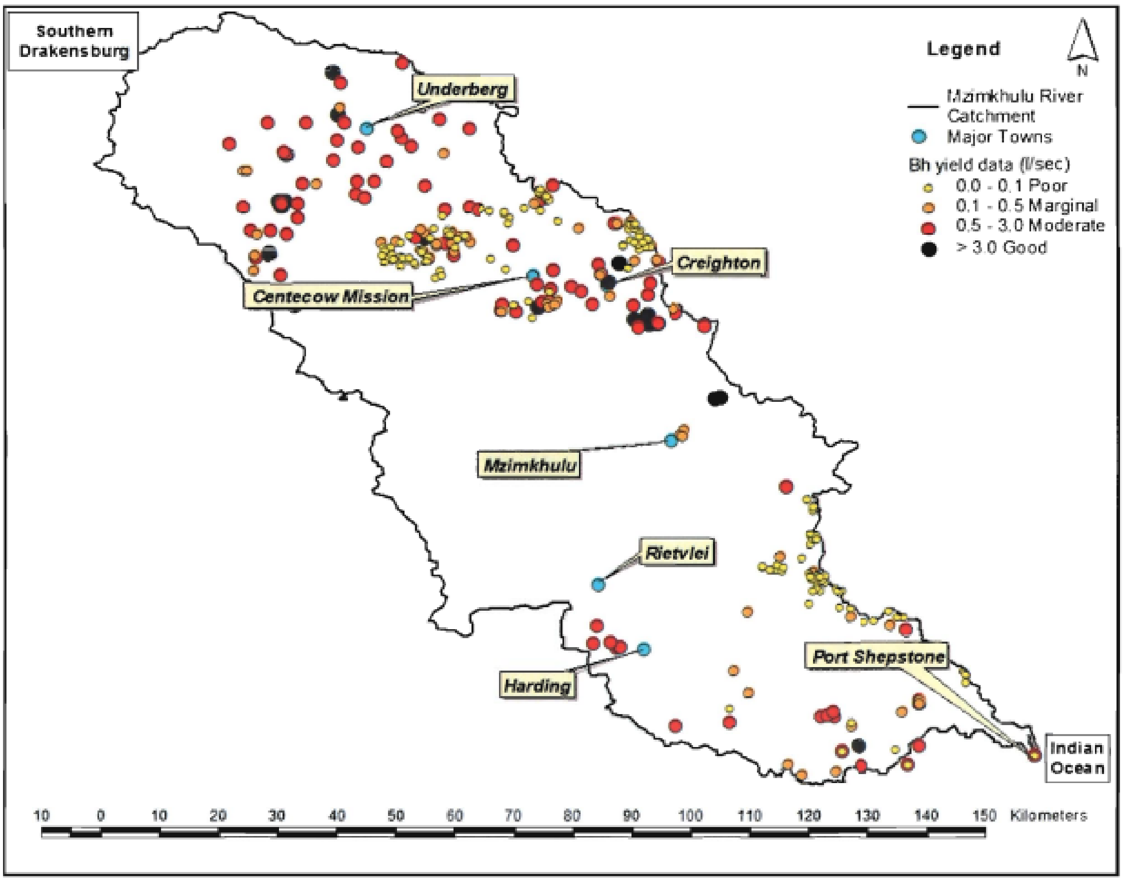

Figure 4-1: Regional Borehole Yied (DWS, 2011)

4.4 Water Quality

The water quality results from the samples collected during the hydrocensus are given below. Table 5-1, Table 2-2, Table 2-3 and Figure 2-1 provides the sampling point name, guideline limits used for comparisons, sampling date, coordinates and sampling site photos. The sampling site positions are indicated in Table 2-2, Table 2-3 and Figure 2-1. The following guideline limits were used for comparison with the results of water quality:

- The SAWQG, Volume 4, Agricultural Use: Irrigation; and
- The SAWQG, Volume 5, Agricultural Use: Livestock Watering.

5 The purpose of sampling was to determine basic water quality and gain a better understanding of any contamination (whether caused by slurry). The water samples that were taken were

sent to UIS Lab Laboratories for analysis of water quality. The lab results are presented in Appendices

Appendix A.

Borehole water quality data is very scarce, although from the information available the following general statements can be made based on the interpretation of the results in Table 5-1:

- Groundwater quality analysis for all sampled boreholes showed pH values between 7.2 and 7.6 with an average pH of 7.42. The pH between 7.2 and 7.6 indicates neutral groundwater. All boreholes complied with the all the recommended targeted water quality guideline range.
- The groundwater quality in every borehole that was sampled demonstrates good water quality. WS-01 (Borehole 1) was found to have exceeded the SA Water Quality Guidelines: Irrigation for Cl concentration while all other parameters were in compliance with the guidelines.
- The Cl concentration is said to have increased slightly due to old regional circulating groundwater, which is both natural and attributed to agricultural activities.
- Based on surface water sampling points WS-04 (Stream), it can be inferred that the stream is not impacted by the contaminated water or slurry. All the parameters that were examined are in accordance with the relevant guidelines.
- Slurry dam (WS-03) exceeded the SA Water Quality Guidelines for irrigation for Cl and Na concentrations. Furthermore, the slurry dam exceeded the SA Water Quality Guidelines for livestock watering for TDS. Elevated TDS is attributed to the slightly elevated dissolved metals such as Na and Cl.
- The slightly elevated Cl and Na concentration is said to have increased slightly due to old regional circulating groundwater, which is both natural and attributed to agricultural activities.

Table 5-1: Water quality from the site visit

Parameter	Units	SA Water Quality Guidelines: Recreational Water Use	SA Water Quality Guidelines: Irrigation	SA Water Quality Guidelines: Livestock Watering				
		Limit/s	Limit/s	Limit/s	Borehole1 (WS-01)	Existing Borehole 2 (WS-02)	Slurry Sample (WS-03)	Stream (WS-04)
pH – Value at 25°C	pH Units	≥ 6.5 to ≤ 8.5	≥ 6.5 to ≤ 8.4	-	7.48	7.2	7.62	7.41
Total Dissolved Solids (TDS) at 180°C	mg/l	-	≤ 260	≤ 1000	36.0	168	1614	32
Chloride as Cl	mg/l	-	≤ 100	≤ 1500	189.55	1.788	144.64	7.713
Sulphate as SO_4	mg/l	-	-	≤ 1000	<1	3.039	7.751	<1
Sulphate as SO_4 Fluoride as F	mg/l mg/l	- -	- ≤ 2	≤ 1000 ≤ 2	<1 0.137	3.039 0.1	7.751 0.181	<1 <0.1
Nitrate as N	mg/l	-	-	≤ 443	0.014	-	160.32	1.78
Nitrite as N	mg/l	-	-	-	0.004	<0.002	48.79	<0.002
Sodium as Na	mg/l	-	≤ 70	≤ 2000	11.98	15.85	94.80	6.20
Potassium as K	mg/l	-	-	-	1.87	1.3	391	1.59
Calcium as Ca	mg/l	-	-	≤ 1000	17.6	38.9	66.9	10.4
Magnesium as Mg	mg/l	-	-	≤ 500	4.38	7.08	79.40	5.81
Aluminium as Al	mg/l	-	≤ 5	≤ 5	<0.05	<0.05	<0.05	0.230
Boron as B	mg/l	-	≤ 0.5	≤ 5	<0.1	<0.1	<0.1	<0.1
Cadmium as Cd	mg/l	-	≤ 0.01	≤ 0.01	<0.001	<0.001	<0.001	<0.001
Total Chromium as Cr	mg/l	-	-	-	<0.001	<0.001	<0.001	<0.001
Copper as Cu	mg/l	-	≤ 0.2	≤ 0.5	<0.001	<0.001	<0.001	<0.001

Parameter	Units	SA Water Quality Guidelines: Recreational Water Use	SA Water Quality Guidelines: Irrigation	SA Water Quality Guidelines: Livestock Watering				
		Limit/s	Limit/s	Limit/s	Borehole1 (WS-01)	Existing Borehole 2 (WS-02)	Slurry Sample (WS-03)	Stream (WS-04)
Iron as Fe	mg/l	-	≤ 5	≤ 10	<0.005	<0.005	<0.005	0.230
Iron as Fe Lead as Pb	mg/l mg/l	- -	≤ 5 ≤ 0.2	≤ 10 ≤ 0.1	<0.005 <0.01	<0.005 <0.01	<0.005 <0.01	0.230 <0.01
Manganese as Mn	mg/l	-	≤ 0.02	≤ 10	0.020	<0.001	<0.001	<0.001
Manganese as Mn Nickel as Ni	mg/l mg/l	- -	≤ 0.02 ≤ 0.2	≤ 10 ≤ 1	0.020 <0.005	<0.001 <0.005	<0.001 <0.005	<0.001 <0.005
Zinc as Zn	mg/l	-	≤ 1	≤ 20	<0.005	<0.005	<0.005	<0.005
Total Alkalinity	mg CaCO3/l	-	-	-	88.8	144	1950	43.7
Ammonia (NH4) as N	mg/l	-	-	-	1.11	<0.05	213.38	<0.05
Orthophosphate (PO4) as P	mg/l	-	-	-	<0.005	0.008	48.79	0.007
Hexavalent Chromium as Cr6+	mg/l	-	≤ 0.1	≤ 1	<0.001	<0.001	<0.001	<0.001
Cobalt as Co	mg/l	-	≤ 0.05	≤ 1	<0.001	<0.001	<0.001	<0.001
Total Hardness	mg CaCO3/l	-	-	-	61.9	126	494	49.9

Light purple highlighted values/cells indicate concentrations exceeding/below the permissible limits for SAWQG: Irrigation, light blue highlighted values/cells indicate concentrations exceeding/below the permissible limits for SAWQG: Recreational Water Use, light orange highlighted values/cells indicate concentrations exceeding/below the permissible limits for SAWQG: Irrigation, light tan highlighted values/cells indicate concentrations exceeding/below the permissible limits for SAWQG: Livestock Watering. In cases where more than one of the above guideline limits applies, the guideline limit with the highest value is taken. Further, the light red highlighted values/cells indicate concentration exceeding the SAWQG for irrigation as well the livestock watering limits.

5.1 Source-Pathway-Receptor Model

The conceptual (Source-Pathway-Receptor) model was formulated as a description of the groundwater environment in terms of; the local aquifer system, the groundwater sources and potential receptors.

A description of the aquifer system is provided in terms of expected hydraulic parameters that govern the rate at which groundwater migrates locally. The groundwater sources are described in terms of the contributors to groundwater quantity and groundwater quality, i.e. groundwater recharge, local geology and potential contamination sources. The potential receptors are identified as the various dependants of the groundwater that may be impacted should there be an impact to the groundwater quantity and quality, i.e. surface water bodies and private boreholes users.

The conceptual model aims to describe the groundwater environment in terms of the contaminant source-pathway-receptor dynamics, such as (Figure 5-1 and Figure 5-2):

- Contaminant Sources:
  - Slurry water
  - Dam Construction (i.e. increased turbidity)
- Contaminant pathways:
  - Aquifers - these are rock units or open faults and fractures within rock units that are sufficiently permeable (effectively porous) to allow water flow;
- Receptors:
  - These include the groundwater users, streams and natural ecosystems that depend on the groundwater.

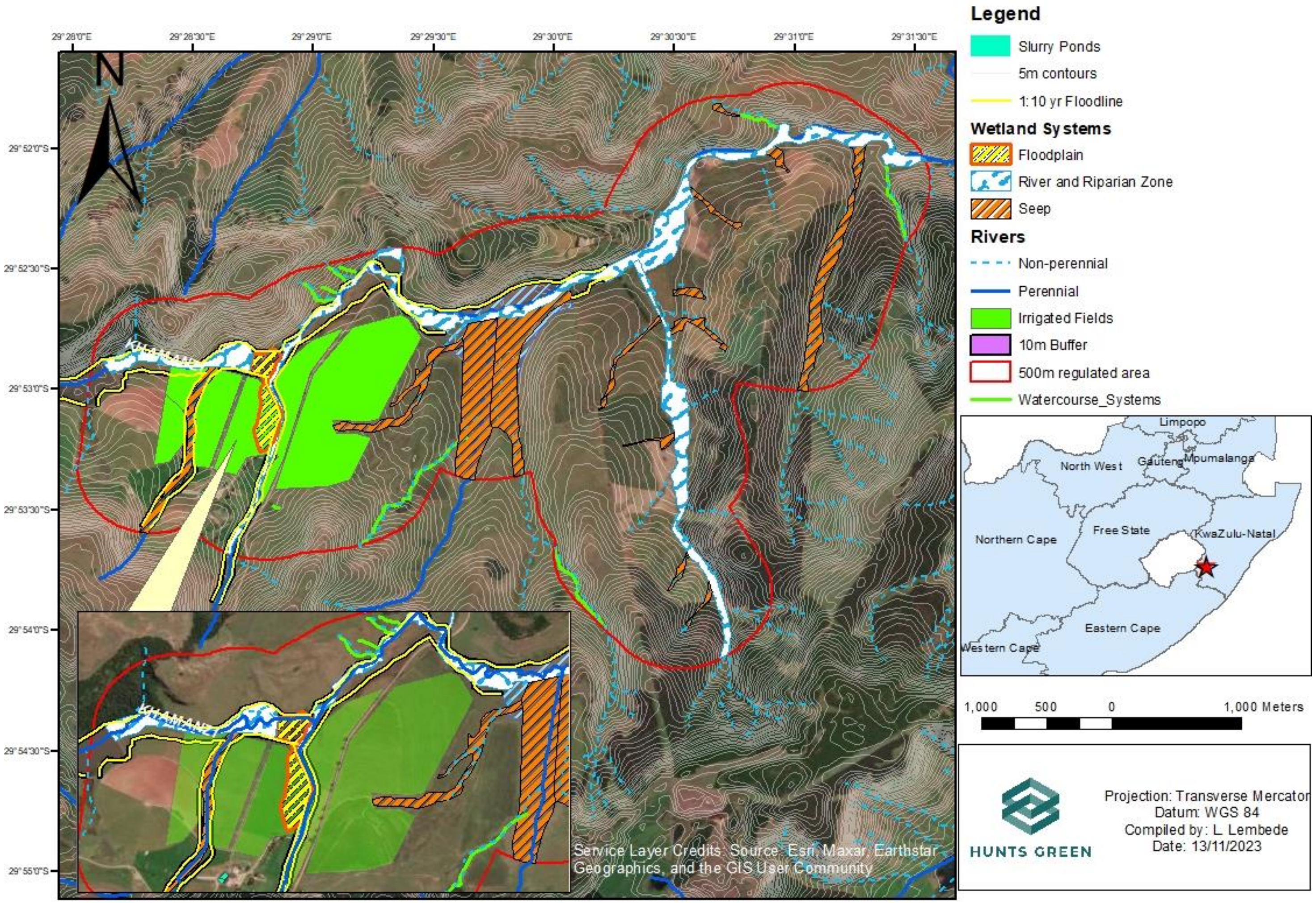

Figure 5-1: Potential sources, pathways and receptors

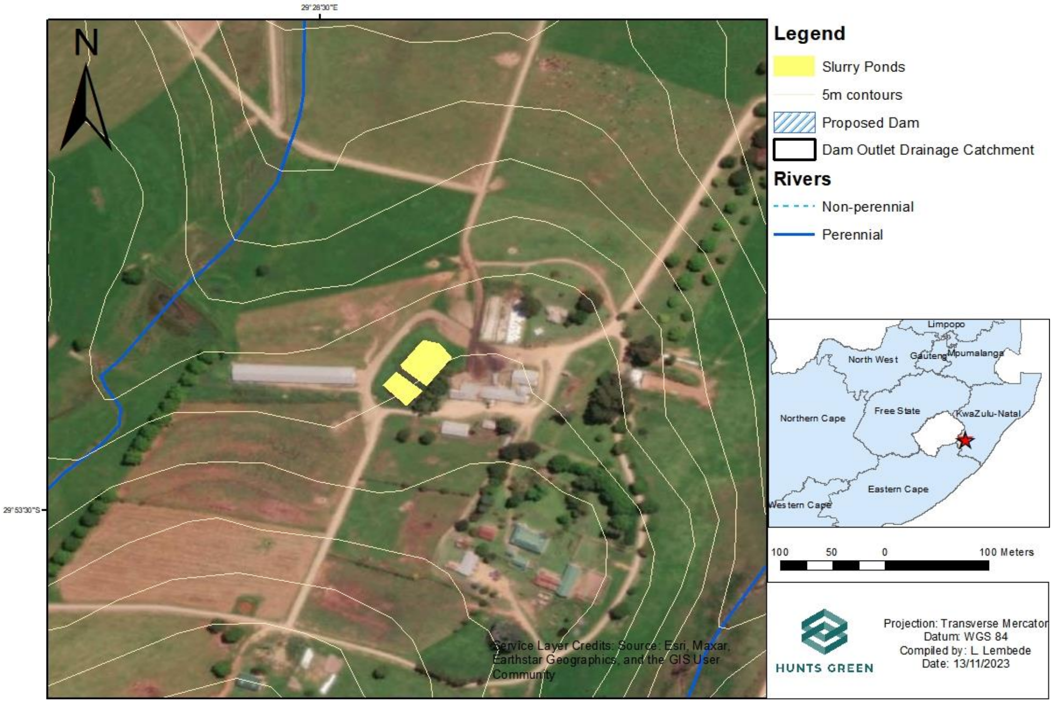

Figure 5-2: Location of the Slurry dams

6 Groundwater Impacts Assessment

The potential groundwater impacts were assessed considering the project lifetime: construction, operation phase. It is unlikely that the constructed infrastructure will be decommissioned in the foreseeable future and the decommissioning phase is therefore not assessed.

6.1 Construction Phase

Activities during the construction phase that may have potential impacts on the groundwater resources are described and the appropriate management/mitigation measures are provided below.

Table 6-1: Interactions and Impacts of Activity

Interaction	Impact
Site clearing for infrastructure establishment.	Increased surface runoffs and reduced rainfall recharge due to vegetation clearance. Runoff causing siltation of surface water resources, increasing turbidity leading to deteriorated water quality. Lowering of the watertable.
Excavation during the construction of the farm dam.	Any site clearing or construction activities that would involve excavation below the watertable depth may have a potential impact on the groundwater quantity and quality. Excavation exposing shallow weathered aquifer hence increasing risk to contamination by reducing the contaminant pathway fom surface to the water table. Contamination of runoff emanating from the construction areas.

6.1.1 Impact Description: Groundwater Resources and Quality

There will be no impact to the groundwater if excavation does not exceed the depth of the watertable, if it does exceed the depth of the watertable, the impact significance will depend on the depth of excavation below the watertable.

Recharge is understood to take place at a regional level. Furthermore, the excavation area that is part of the construction is small when compared to the recharge area.

Clearing or removal of vegetation exposes the surface and leaves the soils prone to erosion during rainfall events and as a result, runoff from these areas (which will be high in suspended solids and sediments) can lead to increased Total Suspended Solids and sedimentation in the nearby water course.

Dust generated during the construction activities and caused by increased vehicular movements can also be deposited into the water course, thereby contributing to the accumulation of suspended solids in the water course, leading to the siltation of the water course.

Dirty or contaminated runoff emanating from construction activities, such as the cement mixing areas, fuels storage areas, other liquid waste and general waste have the potential to contaminate the nearby water courses.

Human activity will generate waste which includes general wastes (paper, glass, plastic and cans) and biological sewage waste that may be either exposed or spilled during construction. The handling and disposal of such waste must be managed appropriately, as this poses a risk to the surface water resources.

Although there are elevated levels of certain parameters which exceeds the WUL limits, further impacts or deterioration of water quality on the natural water course may occur as a result of the proposed development and its associated activities.

6.1.2 Management/ Mitigation Measures

The following mitigation measures are recommended:

- Clearing of vegetation must be limited to the development footprint. All site clearing activities will take place above the water table;
- Ensure that all construction activities take place above the water table. The water table is approximately 6 m deep below ground level and there is sufficient space for the construction activities to take place without reaching the aquifer;
- Any soil stockpile during necessary excavation should be moderately compacted to prevent erosion of the soils into the nearby water resources;
- Dust suppression measures must be undertaken on the cleared areas during construction;
- If possible, construction activities should be prioritized during dry seasons to avoid potential erosion during high rainfall events.

- Concrete batching and mixing should not occur directly on the ground to avoid washing of this material into the stream;
- All storage areas (fuels, paints, chemicals, etc.) should be appropriately bunded and spill kits should be in place, and construction workers trained in the use of spill kits, to contain and immediately clean up any potential leakages or spills;
- Ensure that all oil changes, refuelling and lubrication of equipment's is done away from the waterbody and in a manner such that any spillage will not enter the waterbody;
- Mobile chemical ablutions for construction workers and general waste bins should be provided and regularly maintained.
- Environmental Control Officer (ECO) should be appointed to ensure implementation of the recommended mitigation/management measures during construction.

Table 6-2: Impact significance rating for the construction phase

Impact: Site Clearing/Excavation, Lowering Water Level, Reduced Recharge			
Dimension	**Rating**	**Motivation**	**Significance**
Duration	2	The impact may only occur during construction of infrastructure	32-Negligible (negative)
Intensity	3	This will have minor to medium-term intensity resulting in reduction of proximal recharge potential and lowering water level	
Spatial scale	3	The impacts will be localised	
Probability	4	Without appropriate mitigation, it is probable that this impact will occur	
Post-mitigation			
Duration	2	The impact will likely occur during the construction phase only	16-Negligible (negative)
Intensity	3	Should the impact occur, it will have minor medium-term impacts resulting in a reduction in water water level locally or reduced recharge.	
Spatial scale	3	The impacts will be localised	
Probability	2	With mitigation measures in place. It will be rare/improbable for this impact to occur.	

Impact: Water Contamination (spillage, leakage, oil spills)			
Dimension	**Rating**	**Motivation**	**Significance**

Duration	2	The impact will likely only occur during the construction phase	40- Minor (negative)
Intensity	4	This will moderately impact the water quality and the ecosystem functionality for downstream users	
Spatial scale	4	The impacts may extend in the greater surrounding area from where the impact occurred	
Probability	4	Without appropriate mitigation, it is probable that this impact will occur	
Post-mitigation			
Duration	2	The impact will likely only occur during the construction phase	20-Negligible (negative)
Intensity	4	This will moderately impact the water quality and the ecosystem functionality for downstream users	
Spatial scale	4	The impacts may extend in the greater surrounding area from where the impact occurred	
Probability	2	With the existing measures already in place. It will be rare/improbable for this impact to occur.	

6.2 Operational Phase

Activities during the operational phase that may have potential impacts on the groundwater resources are described and the appropriate management/mitigation measures are provided below.

Table 6-3: Interactions and Impacts of Activity

Interaction	Impact
Irrigation using contaminated water from the Slurry Dams	Contamination of groundwater resources.
Presence of increased impermeable surface area (paving, roads, roofs) leading to increased runoff velocity	Alteration of natural hydrology due to increased runoff.

6.2.1 Impact Description: Contamination of groundwater resources

The use of water from slurry dams for irrigation has the potential to cause groundwater contamination. The quality of groundwater may be impacted by elevated parameters. In addition, ecosystems that depend on groundwater, such as nearby rivers, streams, and wetlands, may be affected.

6.2.2 Management/ Mitigation Measures

The following mitigation measures are recommended:

- If the groundwater is contaminated, the plume may reach the local streams as baseflow however the likelihood of this is low due to the relatively deep water levels (6-42 m and 24 on average), this situation is expected to be losing stream groundwater-surface water interaction and base flow isn't expected locally.
- Seepage or leakages into the groundwater environment is not expected and impacts are regarded as negligible. Should an impact be detected through monitoring, affected receptors should be compensated.

Table 6-4: Impact significance rating for the construction phase

Impact: Water Contamination			
Dimension	**Rating**	**Motivation**	**Significance**
Duration	7	The impact will likely occur for as long as the project life	60- Minor (negative)
Intensity	4	This will moderately impact the water quality and the ecosystem functionality for downstream users	
Spatial scale	4	The impacts may extend in the greater surrounding area from where the impact occurred	
Probability	4	Without appropriate mitigation, it is probable that this impact will occur	
Post-mitigation			
Duration	7	The impact will likely only occur during the construction phase	30-Negligible (negative)
Intensity	4	This will moderately impact the water quality and the ecosystem functionality for downstream users	
Spatial scale	4	The impacts may extend in the greater surrounding area from where the impact occurred	
Probability	2	With mitigation measures place. It will be rare/improbable for this impact to occur.	

6.2.3 Stormwater Management Plan of Slurry Dams

Slurry dams facilitate separation of the solid and liquid fraction of slurry through settling, which normally significantly improves water quality with each dam stage – if the dams are constructed correctly and are functioning as they should (Viljoen, 2019).

The slurry originates from the dairy farm and consists of a mixture of wash water, dung and urine. The slurry is conveyed from the dairy area to the slurry dams by a trench and a pipe that is mostly underground (see Figure 6-1). The inputs from the dairy area into the slurry ponds is estimated as 20-25 m3 per day.

The slurry ponds are made up of clay filled earth dams, with an estimated storage capacity of approximately 3700 to 4000 m3. The wastewater from the slurry ponds is used to irrigate pastures through the center pivot and/or tractor drawn slurry spreader. Historically, there have been very rare incidences of spillages from the sluddy ponds where extreme thuderstorms have filled the dams quicker than can be pumped.

The stormwater management in the farm is adequate and potential pollution of nearby watercourses will be negligible. 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 (see Figure 6-3). Additionally, the adjacent soils are deep, well-drained hutton soils, where most of the nutrient-rich overland flows from the slurry dams would infiltrate into the soils. No significant impacts to the environment or downstream users are initicapated in the event of spillages or from the existing stormwater management practices within the the Dartford Farm.

It is recommended that the trench and pipe used to convey the slurry are always kept clear and free of litter and substances that may cause blockages and potentially reduce the effectiveness of the conveyance of slurry.It was noted that the trench is grassed, it is also recommended that the grass cover is always maintained to prevent erosion and sedimentation build up in the slurry dams. Additionally, depending on the needs of the farmer, the shed area in the dairy farm may be fitted with gutters and downpipes (see highlighted area in Figure 6-1) for rainwater harvesting in a storage tank to increase water availability for on site use. It is further recommended that if there is an expansion of the herd size in future, which would increase inputs into the slurry dams and spillages occur more frequently, the storage capacity should be evaluated to ensure that the impacts of excess nutrient rich water remains minimal, with no significant impacts to the environment and downstream water users. To ensure compliance with the National Water Act (36 of 1998) for disposal of waste by irrigation, no irrigation should take place within 100 m of a watercourse.

Figure 6-1: Trenches Conveying Sludge from Dairy Area to the Slurry Dams

Figure 6-2: Sludge Dams with Solids and Liquids

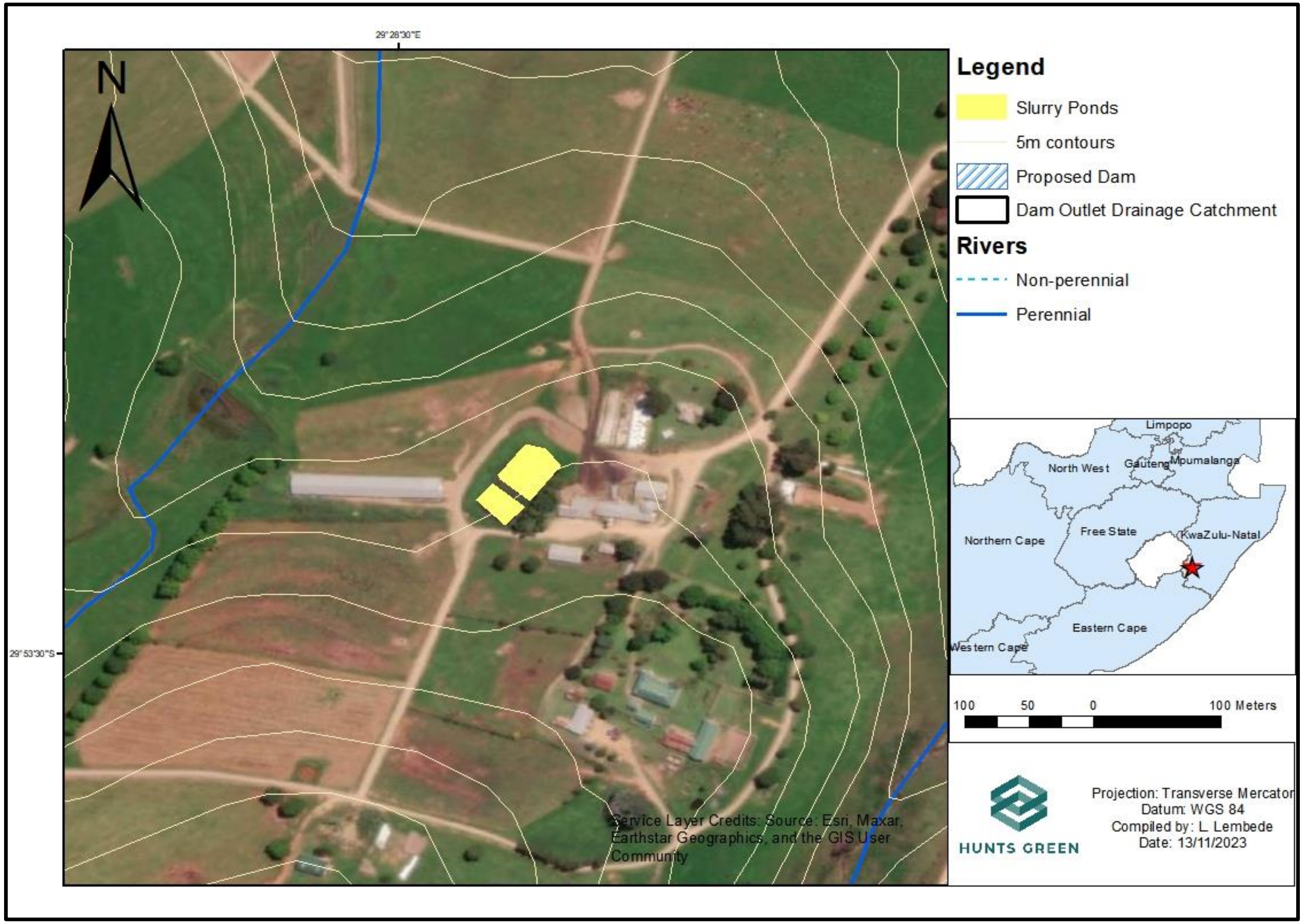

Figure 6-3: Layout Plan of the Slurry Ponds

6.3 Cummulative Impacts

Observing the project area and its surroundings (within 3-5 km radius of the project area) the area consists of mainly undeveloped rural areas, as well as agricultural activities.

The potential cumulative impacts include:

- Possible depletion of natural water resources, or contamination of groundwater and surface water should the development not be managed properly (such as if wastewater management and monitoring programme is not implemented); and
- Increased waste generation (including wastewater generation) which could result on groundwater and surface water contamination.

7 Groundwater Management and Monitoring Plan

Groundwater monitoring should be undertaken to establish the baseline water quality and level trends as well as impact of the proposed activities on the local aquifers, through the following:

- Water quality trends through sampling; and
- Water usage through groundwater level.

It is recommended that continous monitoring on the hydrocensus sampling (Figure 2-1) sites should be utilised for long-term monitoring to established logn term trends as indicated abovew.

7.1.1 Groundwater Level

Groundwater levels must be recorded on a quarterly basis to detect any changes or trends in groundwater elevation and flow direction.

7.1.2 Groundwater Quality

Groundwater is a slow-moving medium and drastic changes in the groundwater composition are not normally encountered within days. Considering the proximity of private boreholes and streams to the proposed development, monitoring (water quality and water level) should be conducted quarterly to reflect influences of wet and dry seasons. The sampling frequency could be further adjusted following the trend analysis and absence of any impact from the project area.

Samples should be collected by using best practice guidelines and should be analysed by a SANAS accredited laboratory.

7.1.3 Water Sampling and Presevation

When sampling the following procedures are proposed:

- One (1) litre plastic bottles with a cap are required for the sampling exercises;
- Glass bottles are required if organic constituents are to be tested;
- Collected samples must be stored in cooler box or fridge while on site; and
- Sample bottles should be marked clearly with the borehole name, date of sampling, sampling depth and the sampler's name and submitted to a SANAS accredited laboratory.

7.1.4 Parameters to be monitored

- TDS, EC, pH, Alkalinity;
- Major ions i.e. Ca, Mg, Na, K, SO_4, NO_3, F, Cl; and
- Minor and trace metals.

7.2 Sensitive of the Site

Over the years agricultural activities in and around Underberg has caused deterioration to the groundwater quality. The water quality of the aquifers indicates that groundwater contamination has already taken place and this is mainly due to agricultural activities and natural processes of the underlying geology.

Based on the current results, the proposed irrigiation using slurry water and construction of a dam it is deemed to have a negligible impact on the environment if managed properly or in a even better manner.

8 Conclusions and Recommendations

Hunts Green Consulting (Pty) Ltd was appointed by Emanzini WULA Consultants to conduct a hydrogeological 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 existing sludge dams for irrigation purposes.

The study area is located within the T51C quaternary catchment within the Pongola Mtavuma Water Management Area (WMA 4) and is drained by the Mzimkhulu River downstream, which discharges into the Indian Ocean in a south easterly direction.

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.

Underberg is located within the Mzimkhulu Region in the KwaZulu-Natal Coastal Foreland and Transkeian Coastal Foreland and Middleveld Groundwater Regions. The hydrogeologically relevant lithologies in the Mzimkulu Region comprise of the siltstone/shale, feldspathic sandstones and tillites of the Karoo Supergroup; the micaceous sandstones of the Natal Group; and the granite/gneiss of the Natal Metamorphic Province (NMP). These hydrogeological units are clearly defined within the Mzimkulu River catchment and occur in distinct bands or areas.

This Groundwater Region is characterised by a combination of intergranular and fractured arenaceous rocks. The aquifer types occurring in this region are mapped as minor/low to medium potential. The aquifer types occurring in this region are mapped as low to medium potential and the geology consists of mostly arenaceous rocks.

Regional groundwater levels varies between 6.5 mbgl to 42.5 mbgl with an average groundwater level of 24.5 mbgl. The shallow groundwater level is understood to corespond to the shallow weathered aquifers with the deeper groundwater elevation correcponding to the deeper fractured aquifers. Groundwater flow in the shallow weathered aquifer mimics the topographic relief.

Primary groundwater supplies using boreholes fitted with hand pumps, wind pumps or submersibles are obtainable in most of the lithological units. The exceptions are the Dwyka formation (tillites) or massive granites. In these areas groundwater supply could be obtained within an adjacent fault valley where the potential for high yielding boreholes is much enhanced.

The sandstone of the Natal Group represents the most productive groundwater-bearing lithology, followed by mudstone/shale lithologies, the granite/gneiss lithologies and the tillite sediments of the Dwyka Tillite Formation. Boreholes favourably located in the Natal Group Sandstone (NGS) provide good yields.

Groundwater usage in the catchment is not usually recorded and there are no yield estimates available for the boreholes connected to the water supply. It is estimated that there are relatively high volumes of groundwater being abstracted for domestic water use as there are a number of standalone schemes, which are dependent on the groundwater systems. The yield of groundwater is at its highest near Rietvlei, Creighton, and from the southwest to the northwest of Underberg.

Groundwater quality analysis for all sampled boreholes showed pH values between 7.2 and 7.6 with an average pH of 7.42. All boreholes complied with the all the recommended targeted water quality guideline range.

The groundwater quality in every borehole that was sampled demonstrates good water quality. WS-01 (Borehole 1) was found to have exceeded the SA Water Quality Guidelines: Irrigation for Cl concentration while all other parameters were in compliance with the guidelines.

Based on surface water sampling points WS-04 (Stream), all the parameters that were examined are in accordance with the relevant guidelines. Slurry dam (WS-03) exceeded the SA Water Quality Guidelines for irrigation for Cl and Na concentrations. Furthermore, the slurry dam exceeded the SA Water Quality Guidelines for livestock watering for TDS.

The slightly elevated Cl and Na concentration is said to have increased slightly due to old regional circulating groundwater/water, which is both natural and attributed to agricultural activities.

Over the years agricultural activities in and around Underberg has caused deterioration to the groundwater quality. The water quality of the aquifers indicates that groundwater contamination has already taken place and this is mainly due to agricultural activities and natural processes of the underlying geology.

The use of water from slurry dams for irrigation has the potential to cause groundwater contamination. The quality of groundwater may be impacted by elevated parameters. In addition, ecosystems that depend on groundwater, such as nearby rivers, streams, and wetlands, may be affected.

Based on the current results, the proposed irrigiation using slurry water and construction of a dam it is deemed to have a negligible impact on the environment if managed properly or in a even better manner. To ensure compliance with the National Water Act (36 of 1998) for disposal of waste by irrigation, no irrigation should take place within 100 m of a watercourse.

The stormwater management in the farm is adequate and there are no concerns with polluting 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. No significant impacts to the environment or downstream users are initicapated in the event of spillages or from the existing stormwater management practices within the the Dartford Farm.

9 Details of Specialist

This Specialist Report has been compiled by the following specialists:

Table 9-1: Details of the Specialist(s) who prepared this Report

Responsibility	Report Writing
Full Name of Specialist	Simamkele Baqa
Highest Qualification	MSc Hydrogeology
Years of experience in specialist field	9-10

9.1 Declaration of the Specialist

I, **Simamkele Baqa**, 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.

Signature of the specialist

Simamkele Baqa

Full Name and Surname of the specialist

Hunts Green Consulting

Name of company

January 2024

Date

10 References

Bailey, A., & Pitman, W. (2015). *Water Resources of South Africa 2012 Study (WR2012).* Pretoria: Water Research Commission.

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11 Appendices

Appendix A

FCA Report | Doc ID :
1 | Rev. No :
16/11/2022 | Issue Date :

Approved By : Quality Manager

UIS Analytical Services (Pty) Ltd · Reg. No. 2000/027788/07 · VAT No. 4920202969
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12 AMENDED FINAL CERTIFICATE OF ANALYSIS

Hunts Green Consluting (Pty) Ltd
170 kenneth Road Greenhills
Randfontein
1759

Date Required 2023-12-11
Client Provided Information:
PAID
Q-ENV-23/02418
Samples Received: 4

Contact: Simamkele Baqa

Tel. No.:

Email: sima.baqa@huntsgreen.com/lungi.lembede@huntsgree

Report Revision 1 (Replace Revision no0)

Testing Laboratory T0184

Test Start Date: 30/11/2023
Test Complete Date: 23/01/2024

Notes

The results relate specifically to the items tested as received.

The report shall not be reproduced except in full, without the written approval of the laboratory. [1] Analysis is SANAS Accredited.

[2] Analysis is not SANAS Accredited.

[3] Outsourced not performed by this laboratory.

[4] Deviations: N/A unless specifically stated below.

Revision Detail:

Rev 1 replaces Rev 0: Client requested pH analysis.

TECHNICAL SIGNATORY: Ricardo Kayser

			Sample ID: 927438	Sample ID: 927439	Sample ID: 927440
			WS-01/27/11/2023	WS-02/27/11/2023	WS-03/27/11/2023
			Type: Water	Type: Water	Type: Water
Analyte	Unit	Test Method	value	value	value
[2] Total Phosphate as P	mg P/l	[3] UIS-OS-T032	<0.2	<0.2	48.8
[1] Ammonia as N	mg/l	[1] UIS-EA-T034a	1.113	<0.05	213.378
[1] Chloride Cl	mg/l	[1] UIS-EA-T034	189.554	1.788	144.635
[1] Fluoride F	mg/l	[1] UIS-EA-T034	0.137	0.1	0.181
[1] Nitrate NO3	mg/l	[1] UIS-EA-T034	<0.442	1.59	-
[1] Nitrate NO3 as N	mg/l	[1] UIS-EA-T034	<0.1	0.359	<0.1
[1] Nitrite NO2	mg/l	[1] UIS-EA-T034	0.014	-	160.324
[1] Nitrite NO2 as N	mg/l	[1] UIS-EA-T034	0.004	<0.002	48.790

[1] Ortho-Phosphate as P	mg/l	[1] UIS-EA-T034	<0.005	0.008	48.790
[1] Phosphate PO4	mg/l	[1] UIS-EA-T034	<0.015	0.025	150
[1] Phosphate PO4 as P	mg/l	[1] UIS-EA-T034	<0.005	0.008	48.790
[1] Sulphate SO4	mg/l	[1] UIS-EA-T034	<1	3.039	7.751
[2] Ca Hardness	mg/l CaCO3	[2] UIS-CP-T004	43.8	97.0	167
[2] Mg Hardness	mg/l CaCO3	[2] UIS-CP-T004	18.0	29.2	327
[2] Total Hardness	mg/l CaCO3	[2] UIS-CP-T004	61.9	126	494
[2] TDS by Summation	mg/l	[2] UIS-CP-T003	91.4	164	1830
[1] Ca	mg/l	[1] UIS-EA-T007	17.6	38.9	66.9
[1] K	mg/l	[1] UIS-EA-T007	1.87	1.3	391
[1] Mg	mg/l	[1] UIS-EA-T007	4.38	7.08	79.40
[1] Na	mg/l	[1] UIS-EA-T007	11.98	15.85	94.80
[2] Ag	mg/l	[1] UIS-EA-T007	<0.05	<0.05	<0.05
[2] Al	mg/l	[1] UIS-EA-T007	<0.05	<0.05	<0.05
[2] As	mg/l	[1] UIS-EA-T007	<0.01	<0.01	0.100
[2] B	mg/l	[1] UIS-EA-T007	<0.1	<0.1	<0.1
[2] Ba	mg/l	[1] UIS-EA-T007	<0.001	0.110	<0.001
[2] Be	mg/l	[1] UIS-EA-T007	<0.001	<0.001	<0.001
[2] Bi	mg/l	[1] UIS-EA-T007	<0.05	<0.05	<0.05
[2] Cd	mg/l	[1] UIS-EA-T007	<0.001	<0.001	<0.001
[2] Co	mg/l	[1] UIS-EA-T007	<0.001	<0.001	<0.001
[2] Cr	mg/l	[1] UIS-EA-T007	<0.001	<0.001	<0.001
[2] Cu	mg/l	[1] UIS-EA-T007	<0.001	<0.001	<0.001
[2] Fe	mg/l	[1] UIS-EA-T007	<0.005	<0.005	<0.005
[2] Li	mg/l	[1] UIS-EA-T007	<0.05	<0.05	<0.05
[2] Mn	mg/l	[1] UIS-EA-T007	0.020	<0.001	<0.001
[2] Mo	mg/l	[1] UIS-EA-T007	<0.001	<0.001	<0.001
[2] Ni	mg/l	[1] UIS-EA-T007	<0.005	<0.005	<0.005
[2] P	mg/l	[1] UIS-EA-T007	<0.05	<0.05	19.0
[2] Pb	mg/l	[1] UIS-EA-T007	<0.01	<0.01	<0.01
[2] S	mg/l	[1] UIS-EA-T007	0.360	1.72	3.90
[2] Sb	mg/l	[1] UIS-EA-T007	<0.01	<0.01	<0.01
[2] Se	mg/l	[1] UIS-EA-T007	0.020	0.010	0.300

[2] Si	mg/l	[1] UIS-EA-T007	2.34	14.4	30.1
[2] Sn	mg/l	[1] UIS-EA-T007	<0.1	<0.1	<0.1

			Sample ID: 927441
			WS-04/27/11/2023
			Type: Water
Analyte	Unit	Test Method	value
[2] Total Phosphate as P	mg P/l	[3] UIS-OS-T032	<0.2
[1] Ammonia as N	mg/l	[1] UIS-EA-T034a	<0.05
[1] Chloride Cl	mg/l	[1] UIS-EA-T034	7.713
[1] Fluoride F	mg/l	[1] UIS-EA-T034	<0.1
[1] Nitrate NO3	mg/l	[1] UIS-EA-T034	7.88
[1] Nitrate NO3 as N	mg/l	[1] UIS-EA-T034	1.78
[1] Nitrite NO2	mg/l	[1] UIS-EA-T034	<0.007
[1] Nitrite NO2 as N	mg/l	[1] UIS-EA-T034	<0.002
[1] Ortho-Phosphate as P	mg/l	[1] UIS-EA-T034	0.007
[1] Phosphate PO4	mg/l	[1] UIS-EA-T034	0.022
[1] Phosphate PO4 as P	mg/l	[1] UIS-EA-T034	0.007
[1] Sulphate SO4	mg/l	[1] UIS-EA-T034	<1
[2] Ca Hardness	mg/l CaCO3	[2] UIS-CP-T004	26.0
[2] Mg Hardness	mg/l CaCO3	[2] UIS-CP-T004	23.9
[2] Total Hardness	mg/l CaCO3	[2] UIS-CP-T004	49.9
[2] TDS by Summation	mg/l	[2] UIS-CP-T003	62.3
[1] Ca	mg/l	[1] UIS-EA-T007	10.4
[1] K	mg/l	[1] UIS-EA-T007	1.59
[1] Mg	mg/l	[1] UIS-EA-T007	5.81
[1] Na	mg/l	[1] UIS-EA-T007	6.20
[2] Ag	mg/l	[1] UIS-EA-T007	<0.05
[2] Al	mg/l	[1] UIS-EA-T007	0.230
[2] As	mg/l	[1] UIS-EA-T007	<0.01

[2] B	mg/l	[1] UIS-EA-T007	<0.1
[2] Ba	mg/l	[1] UIS-EA-T007	0.030
[2] Be	mg/l	[1] UIS-EA-T007	<0.001
[2] Bi	mg/l	[1] UIS-EA-T007	<0.05
[2] Cd	mg/l	[1] UIS-EA-T007	<0.001
[2] Co	mg/l	[1] UIS-EA-T007	<0.001
[2] Cr	mg/l	[1] UIS-EA-T007	<0.001
[2] Cu	mg/l	[1] UIS-EA-T007	<0.001
[2] Fe	mg/l	[1] UIS-EA-T007	0.230
[2] Li	mg/l	[1] UIS-EA-T007	<0.05
[2] Mn	mg/l	[1] UIS-EA-T007	<0.001
[2] Mo	mg/l	[1] UIS-EA-T007	<0.001
[2] Ni	mg/l	[1] UIS-EA-T007	<0.005
[2] P	mg/l	[1] UIS-EA-T007	<0.05
[2] Pb	mg/l	[1] UIS-EA-T007	<0.01
[2] S	mg/l	[1] UIS-EA-T007	0.240
[2] Sb	mg/l	[1] UIS-EA-T007	<0.01
[2] Se	mg/l	[1] UIS-EA-T007	<0.01
[2] Si	mg/l	[1] UIS-EA-T007	12.1
[2] Sn	mg/l	[1] UIS-EA-T007	<0.1

5

			Sample ID: 927438	Sample ID: 927439	Sample ID: 927440
			WS-01/27/11/2023	WS-02/27/11/2023	WS-03/27/11/2023
			Type: Water	Type: Water	Type: Water
Analyte	Unit	Test Method	value	value	value
[2] Sr	mg/l	[1] UIS-EA-T007	0.100	0.520	0.100

[2] Ti	mg/l	[1] UIS-EA-T007	<0.1	<0.1	<0.1
[2] Tl	mg/l	[1] UIS-EA-T007	<0.05	<0.05	<0.05
[2] V	mg/l	[1] UIS-EA-T007	<0.001	<0.001	<0.001
[2] Zn	mg/l	[1] UIS-EA-T007	<0.005	<0.005	<0.005
[1] Ion Error Balance	%	[2] UIS-CP-T005	-58.2	12.3	-30.4
[1] Sum of Anions	me/l	[2] UIS-CP-T005	6.9	2.6	45.0
[1] Sum of Cations	me/l	[2] UIS-CP-T005	1.8	3.3	24.0
[1] P Alkalinity	mg/l CaCO3	[1] UIS-EA-T001	<0.6	<0.6	<0.6
[1] Total (M) Alkalinity	mg/l CaCO3	[1] UIS-EA-T001	88.8	144	1950
[1] pH		[1] UIS-EA-T001	7.48	7.2	7.62
[2] pH Temperature	Deg C	[1] UIS-EA-T001	25.0	25.0	25.0
[1] Total Dissolved Solids at	mg/l	[1] UIS-EA-T005	36.0	168	1614

			Sample ID: 927441
			WS-04/27/11/2023
			Type: Water
Analyte	Unit	Test Method	value
[2] Sr	mg/l	[1] UIS-EA-T007	0.080
[2] Ti	mg/l	[1] UIS-EA-T007	<0.1
[2] Tl	mg/l	[1] UIS-EA-T007	<0.05
[2] V	mg/l	[1] UIS-EA-T007	<0.001
[2] Zn	mg/l	[1] UIS-EA-T007	<0.005
[1] Ion Error Balance	%	[2] UIS-CP-T005	10.0
[1] Sum of Anions	me/l	[2] UIS-CP-T005	1.1
[1] Sum of Cations	me/l	[2] UIS-CP-T005	1.3
[1] P Alkalinity	mg/l CaCO3	[1] UIS-EA-T001	<0.6
[1] Total (M) Alkalinity	mg/l CaCO3	[1] UIS-EA-T001	43.7
[1] pH		[1] UIS-EA-T001	7.41
[2] pH Temperature	Deg C	[1] UIS-EA-T001	25.0
[1] Total Dissolved Solids at	mg/l	[1] UIS-EA-T005	32.0