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2016/04/10/EMF

MBIZANA LOCAL MUNICIPALITY

Environmental Management Framework - Specialist Study

GEOLOGY

April 2016

Prepared for: IKAMVA Consulting

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Compiled by: J.A. Myburgh, J. Prinsloo, W Blay

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MBIZANA LOCAL MUNICIPALITY
Environmental Management Framework - Specialist Study
GEOLOGY

20 April 2016

Conducted for:

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LIST OF ABBREVIATIONS

Abbreviation	Description
DWS	Department of Water Affairs & Sanitation
EC	Electrical Conductivity
MAMSL	Meter Above Mean Sea Level
MBGL	Meter Below Ground Level
TDS	Total Dissolved Solids
WULA	Water Use Licensing and Authorisation
ANDM	Alfred Nzo District Municipality
EMF	Environmental Management Framework
DM	District Municipality
LM	Local Municipality
GRU	Groundwater Resource Unit

Table of contents

List of Figures

List of Tables

1 INTRODUCTION

1.1 Background

AGES Omega (Pty) Ltd, hereafter referred to as AGES, was appointed as independent service provider by IKAMVA Consulting on the 23d of March 2016 for the rendering of specialist geological consulting services in the compilation of a desktop study for inclusion in the Mbizana Local Municipality Environmental Management Framework. (EMF).

The appointment was made based on the proposal and cost estimate rendered by AGES on the 17th of March 2016. The proposal was rendered based on information supplied by IKAMVA at the time and subsequent discussions for clarification.

1.2 Preamble

Regulations pertaining to environmental management frameworks under sections 24(5) and 44 of the National Environmental Management Act of 1998, (Act No. 107 of 1998) was published on 18 June 2010.

Environmental management frameworks are aimed at:

(a) Promoting sustainability;

(b) Securing environmental protection, and

(c) Promoting cooperative environmental governance.

The purpose of the regulations is part is to provide the Minister or MEC with concurrence of the Minister to initiate the compilation of information and maps referred to in section 24(3) of the Act specifying the attributes of the environment in particular geographical areas;

(a) For such information to inform environmental management; and

(b) For such information and maps to be used as environmental management frameworks in the consideration, as contemplated in section 24(4)(b)(vi) of the Act, of applications for environmental authorisations in or affecting the geographical areas to which those frameworks apply.

The development of an environmental management framework must include an assessment of

(a) The need for an environmental management framework;

(b) The status quo of the geographical area that forms the subject of the environmental management framework;

(c) The desired state of the environmental; and

(d) The way forward to reach the desired state.

Geological specialist inputs into the Environmental Management Framework Status Quo Report are focussed in mapping baseline geological information and supplying related GIS information.

1.3 Location

The Mbizana Local Municipality of the Alfred Nzo District Municipality in the Eastern Cape Province, forms the study area for this study. The Mbizana Local Municipality has a total of 31 Wards and covers a surface area of approximately 2400 km2. The study area shares its north eastern boundary with part of the Provincial boundary between the Eastern Cape and Kwazulu Natal Provinces, and inland from the

Indian Ocean towards the Ntabankulu Local Municipality in the west. The Mbizana Local Municipality is bounded by the Mtamvuna River at its northern boundary and Mtentu River at the south. The study area has bearings (Hartbeeshoek94, Decimal Degrees): Figure 1.

- Mbizana Local Municipality central coordinates:
  Latitude: -30.94899° S Longitude: 29.84594° E

- Bizana Town coordinates:
  Latitude: -30.862161° S Longitude: 29.85270° E

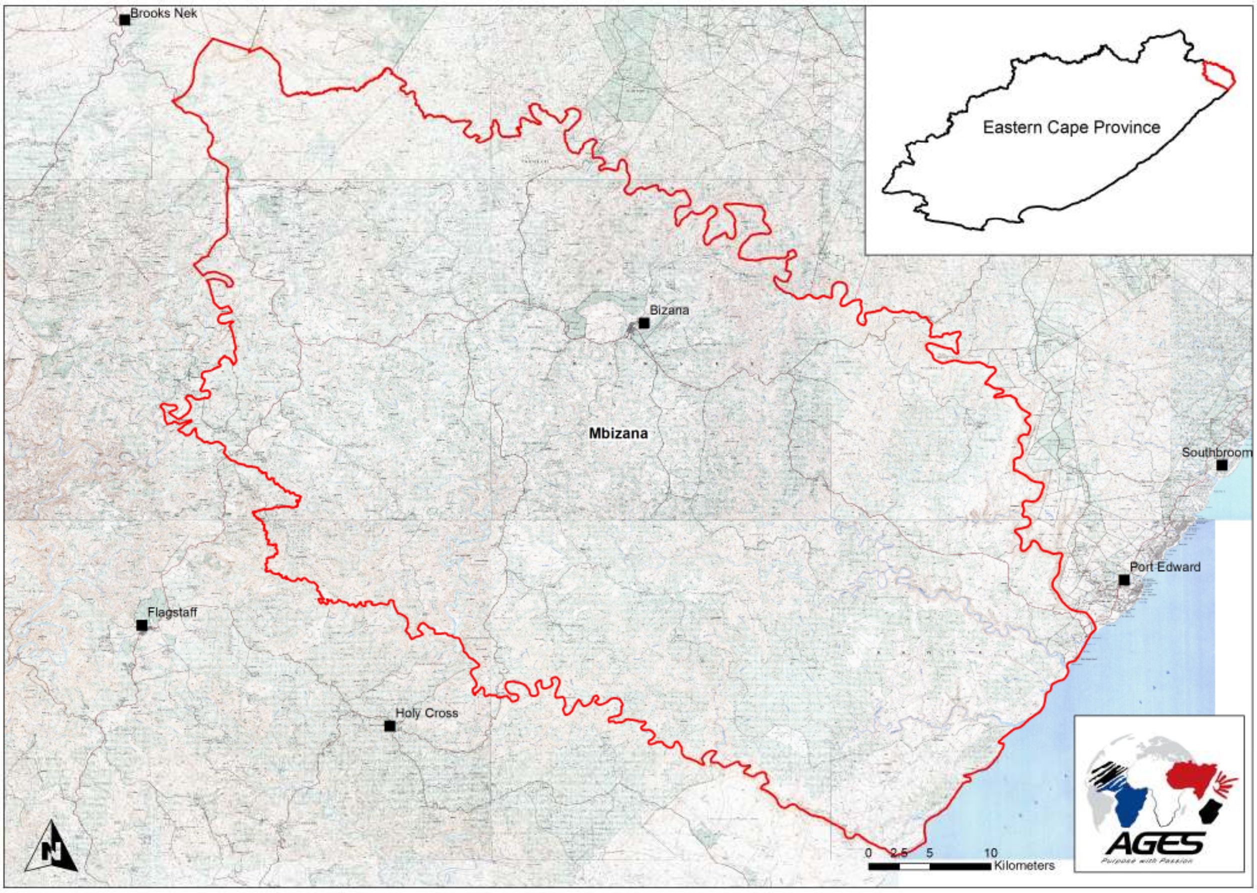

Figure 1: Locality of Study Area within the EC Province

2 SCOPE OF WORK

The scope of work was defined in terms of Reporting Requirements, as well as Deliverables as defined by the EMF Status Quo Report requirements.

Reporting Requirements:

- To provide a written description of the status quo of geology in the Mbizana Local Municipal area;
- To provide a spatial representation of geological features (solid geology and drift geology, slopes and geo-hazards) of the study area;
- To flag any geo-hazards – including the undertaking of a slope analysis;
- To identify study gaps and/or needs for future management of geological features; and
- To identify focus areas for future management.

Deliverables and Other Specifications:

- Written report to be in MS word format, detailing methodology, findings & interpretation of findings;
- GIS dataset in ESRI ARC GIS data format (WGS 84) and as specified by principal GIS consultant.
- Presented accurately to a minimum scale of 1:50 000;
- To include sensitivity ratings; and
- To include a table of metadata and brief description of the method of processing.

In subsequent verification discussions with IKAMVA, it was agreed that mineral occurences, soils, terrain morphology as well as the groundwater status of the area will be included in the study.

3 METHODOLOGY & INFORMATION SOURCES

The investigation is defined as a Desktop Study and the main focus was therefore to source and process data and information relating to the Geology of the Mbizana Local Municipality. It was agreed with the client that no on-site consultation or site verification would be required for the Geological Specialist Study. This was because of AGES's extensive experience and knowledge of the area based on historical projects.

The following phased approach was therefore followed by the project team:

- Sourcing of data and information from District and Local Municipality
- Sourcing of data and information from DWS and The Council of Geoscience
- Sourcing of spatial Geological Data from The Council of Geoscience.
- Sourcing of spatial Land-use, Morphology, Soils and Mineralogical information from the Soil and Irrigation Research Institute
- Review of internal AGES database for GIS data relating to Geology and Geohydrology of the LM
- Review of Eastern Cape Groundwater Master Plan
- Review of Alfred Nzo DM Groundwater Management Plan
- Review of previous Feasibility studies for the Mbizana LM.
- Processing of data and information for Desktop Study report purposes
- GIS map compilation and data archiving
- Report compilation with summary and recommendations for inclusion into the EMF Status Quo Report

A summary of metadata is given in chapter 9 with references to figures and tables that occur throughout this report.

4 GEOLOGY OF THE MBIZANA LOCAL MUNICIPALITY

4.1 Regional Geology

The geological history of the study area ensued after a period of magmatic activity around 1400 million years ago, after which the deposition of Natal Sandstones, the Karoo Supergroup as well as the Cretaceous and Quaternary Sediments followed.

The regional geology of the project has a general trend, where older, more metamorphosed rocks are found along the coastal region. The age and level of geological alteration over time decreases the further away from the coast the rocks are located, with exception to the Cretaceous and Quaternary Sediments.

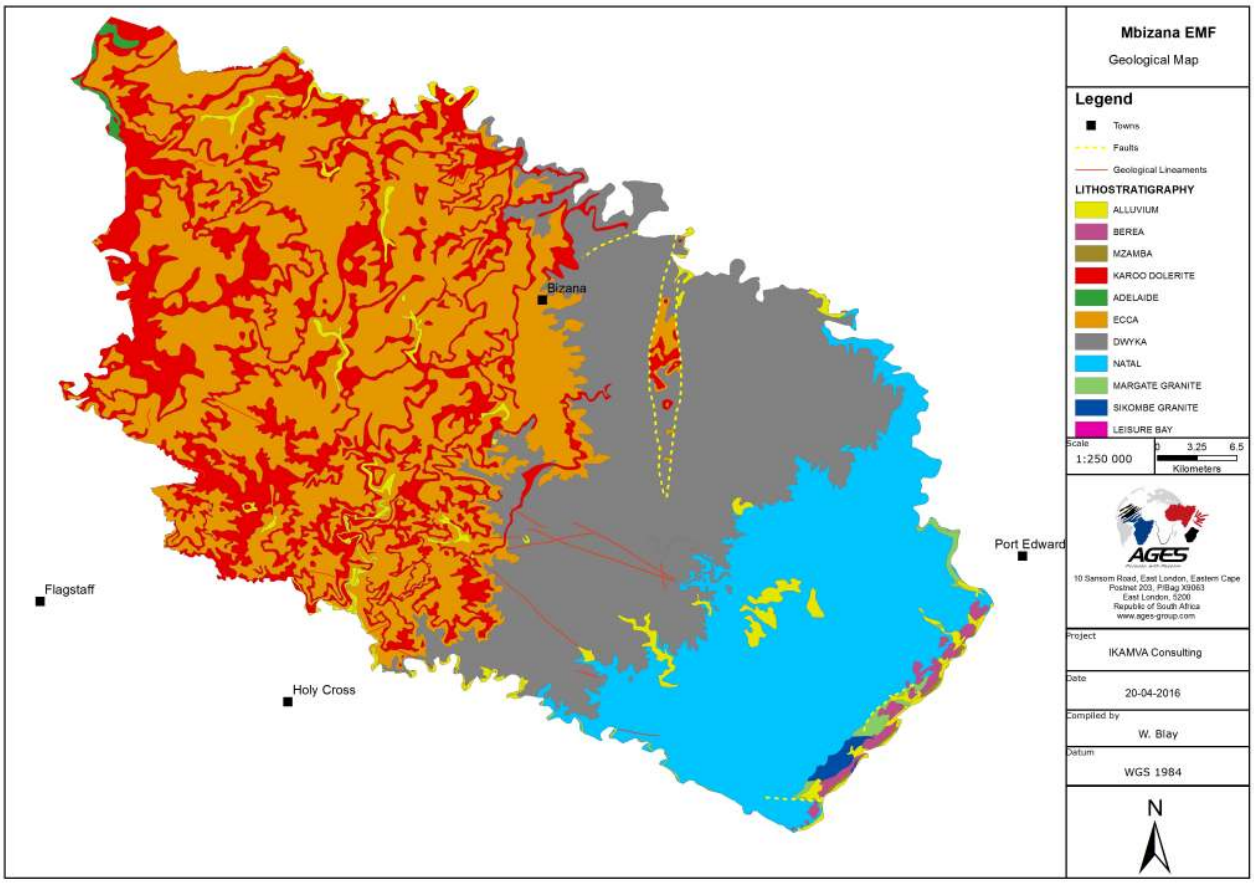

Figure 2: Regional Geology of the Mbizana LM

4.1.1 Natal Metamorphic and Structural Province

Approximately 1400 million years ago, subduction and collision along the southern margin of the Kaapvaal Craton produced the rocks of the Natal Metamorphic Province. The rocks were heated and deformed into a mountain range many thousands of kilometres long (Catuneanu 2002). Below is an explanation of the various formations of the Natal Metamorphic Province found witin the project area boundaries today. The extension of the Natal Metamorphic province is displayed in Figure 3

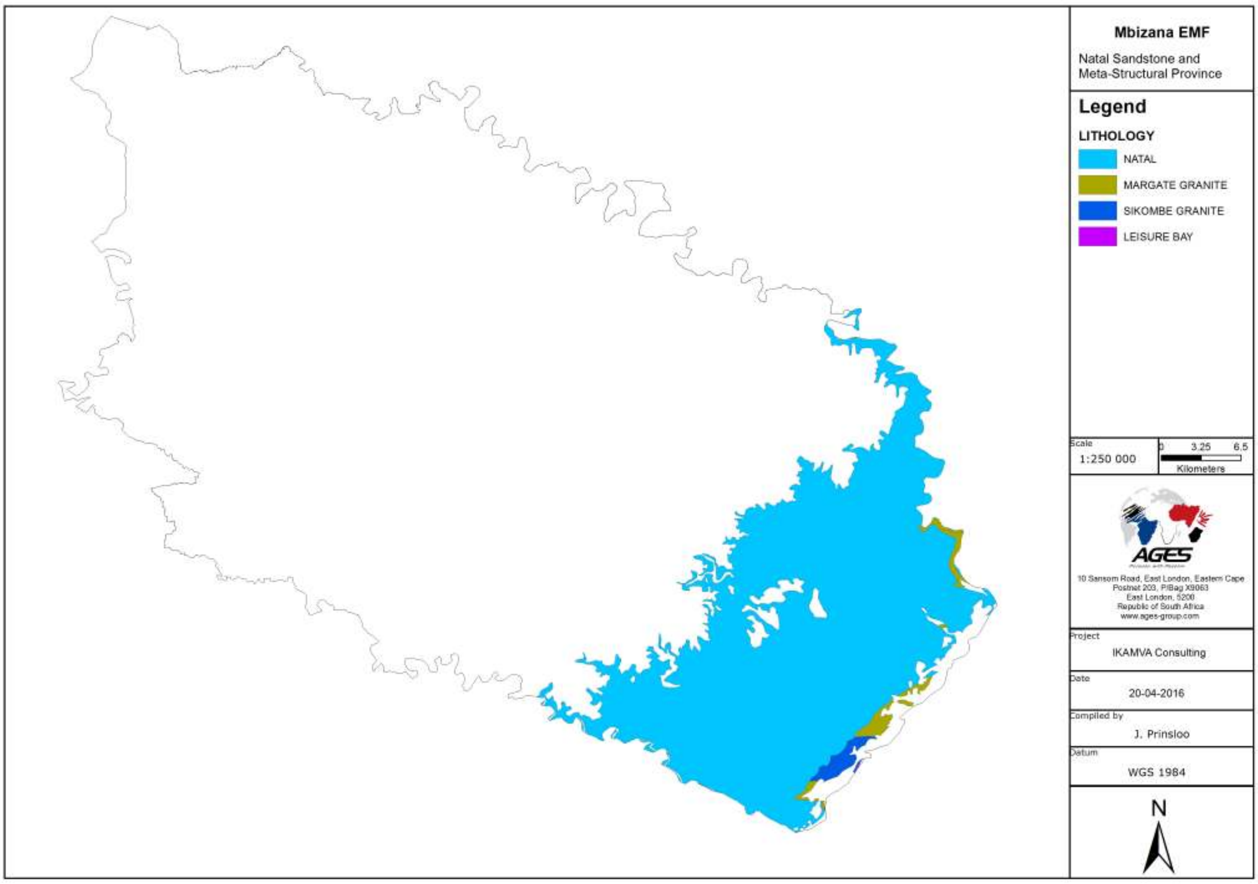

Figure 3: Extension of Natal Metamorphic Province

i. Leisure Bay Formation

The Leisure Bay Formation also known as the Leisure Bay Granulites, forms part of the larger Mapumulo Group and has been dated at approximately 1 400 Ma (Thomas, 1989). It is the oldest lithological unit within the project area and only encompasses a small surface area to the north east of Port Edward as is the scattered metamorphic nature of the formation.

The Leisure Bay Formation is highly metamorphosed and has been affected by contact as well as pressure metamorphosis and recrystallization. It is consistent of pelitic and semipelitic gneiss, calc-silicate gneiss and kinzigite (Grantham et al., 1991)

ii. Sikombe Granite Suite

Dated at approximately 1181 Ma the Sikombe Formation represents the southernmost intrusive granitic body of the Natal Metamorphic province. The outcrop of the formation has a surface area of approximately 5 km2 and is situated approximately 15km south of the EC/KZN border (Thomas et al., 2004).

The Sikombe Granites are consistent of coarse grained, grey, strongly foliated feldspar-megacrystic augen gneiss and granite. The gneissic nature of the suite is caused by the intrusion of the Margate Granite Suite to the north (Thomas et.al., 2004).

iii. Margate Granite Suite

The Margate Granite has been dated at approximately 1011 Ma (Eglinton et al., 1986) and is the upper representative of the Natal Meta-Structural province in the project area. Outcrops are present along the majority of the coastal area as well as in the lower reaches of the Mtamvuna River valley.

The formation is consistent of Garnet leucogranite, Charnokite and leucogranite. Abundant garnetiferous xenoliths are also found within the outcrops, as the Margate Suite intruded through the Leisure Bay Formation (Thomas et al., 1991).

4.1.2 Natal Sandstone

Following approximately 500 Ma of relative inactive geologic conditions and continental drift, the study area formed part of the shallow Agulhas sea, that stretched into the interior of the supercontinent Gondwanaland. It was in this shallow sea environment approximately at 490 Million years ago that the deposition of the Cape - Natal Sandstones occurred (Mcarthy and Rubridge, 2005).

The Natal Sandstones dominate the near coastal sub escarpment area of the project area and covers approximately 150 km2 within the project area boundary. The formation consists of Red-Brown, coarse to fine grained arkose to subarkose, light-grey quartz arenite, micaceous sandstone, grit, conglomerate, subordinate siltstone and mudstone. The sediment in northern KZN near the source of the sediment, coarser grained rocks dominate, with comparatively finer grained rocks present within the project area (Catuneanu 2002).The extension of the Natal sandstone is displayed on Figures 2 and 3.

4.1.3 Karoo Supergroup

The lithostratigraphic units of the Karoo Supergroup were concentrically deposited within and around the main Karoo Basin (Woodford and Chevalier, 2001). The sedimentation period stretched from approximately 310 Ma to 182 Ma and encompassed a period where vastly variable depositional environments dominated the study area. The depostional environments ranged from regressing glacial, to Submarine – deltaic and braided river depositional environments (Mcarthy and Rubridge, 2005). The Extension of the Karoo Supergroup rocks are displayed on Figure 4.

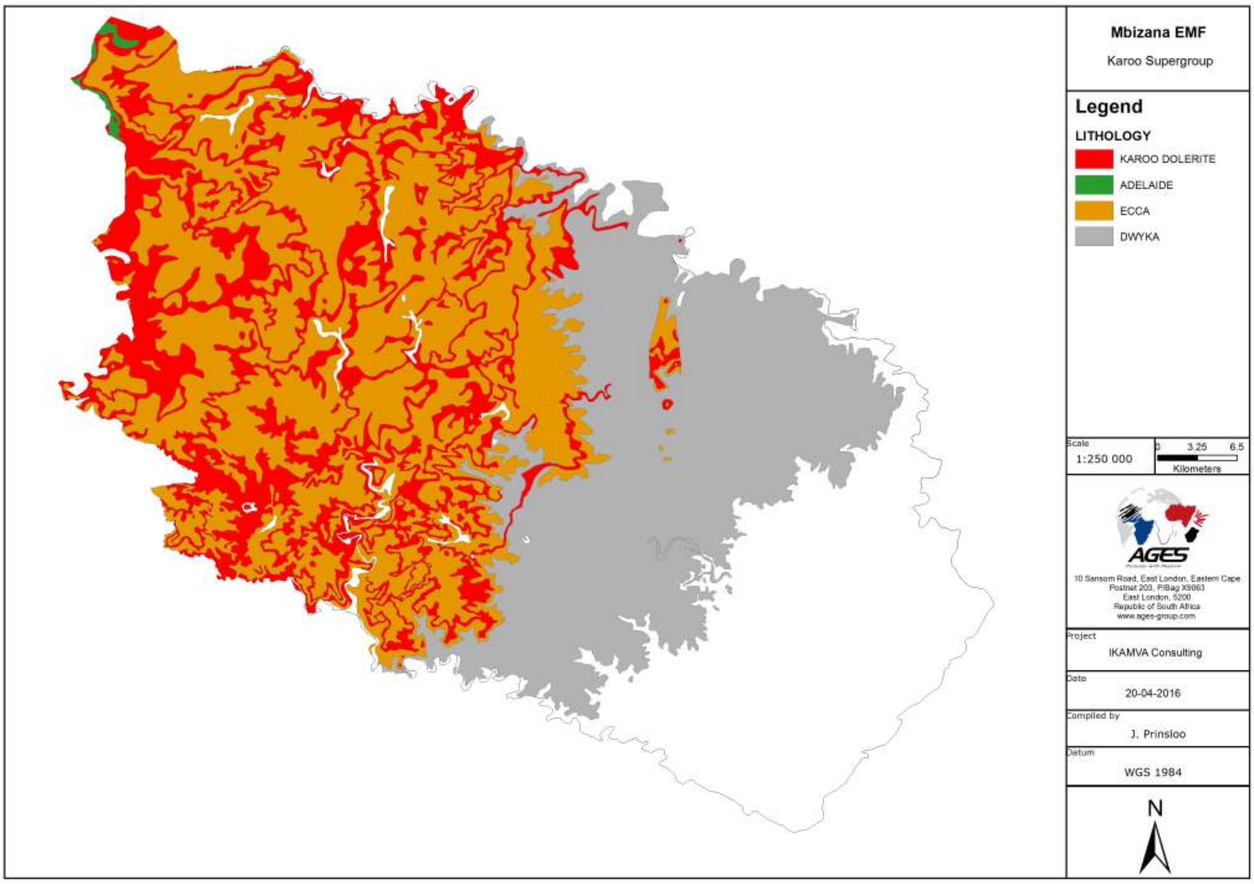

Figure 4: Extension of Karoo Supergroup

i. DwykaGroup

The rocks forming the Dwyka Group were deposited during a period when modern day South Africa was located over the South Pole approximately 310 million years ago and is present throughout the central region of the project area. During this period an ice sheet expeted to have been several kilometres thick covered southern Gondwana. The sediment that lithified to make up the Dwyka Group is glacial till, that was deposited during the north wards migration of the southern Gondwana.

The tillite consists of a fine sedimentary matrix and contains poorly sorted rounded and angular gravel, pebbles and dropstones, that was swept along with the glacial ice sheet (Mcarthy and Rubridge, 2005).

ii. Ecca Group

After the regression of the glaciers that shaped the Dwyka Group the study area was dominated by a deep sea environment. Submarine fans and turbidites were present in the deepest southern regions, with marine deltas and prodeltas in the northern regions where the sediments originate from (Woodford and Chevalier, 2001).

The Ecca Group is made up of 16 different sedimentary formations; however, in the extreme southern reaches of the group, of which the project area is part, the sediments are seen as undifferentiated. The undifferentiated Ecca Group in the study area is consistent mainly of dark grey shale, mudstone and sandstone and is present over the majority of the central and northern regions of the study area.

iii. Adelaide Subgroup

The lowest member of the larger Beaufort Group, the Adelaide Subgroup is present in the extreme northern reaches of the project area. The Beaufort Group of rocks were deposited approximately 251 million years ago, during a time when northward flowing braided and meandering rivers as well as shallow inland lakes dominated the depositional environment (Mcarthy and Rubridge, 2005).

The Adelaide Subgroup is consistent of the Middelton and Balfour Formations, however within the study area the Adelaide Subgroup is undifferentiated. The Adelaide Subgroup is consistent of grey, green and brownish-red mudstone, as well as yellow and grey fine-grained sandstone (Woodford and Chevalier, 2001).

4.1.4 Karoo Dolerites

Dramatic outpourings of lava spread across much of Gondwana about 182 million years ago heralding the start of Gondwana breakup. Magmatic Activities triggered by mantle plumes tend to be initiated by long-lived down welling lithospheric slabs causing instabilities at the lower mantle boundary layers.

The magma preferentially intruded the less resistant argillaceous rocks of the Ecca and Beaufort Groups, forming a vast interconnected network of dolerite dykes and sills, as well as conical sills, also known as ring structures. Because of this preference to intrude into the less resistant formations, only regional feeder dykes are sparsely present within the Dwyka and Natal Sandstone groups. The intrusions present within these formations exploited existing fracture and master joint systems. The extension of the Karoo dolerites are displayed on Figure 4.

4.1.5 Cretaceous and Quaternary Sediments

The most recent depositions within the project area, they are consistent mostly of unconsolidated materials and their extent is indicated on Figure 5.

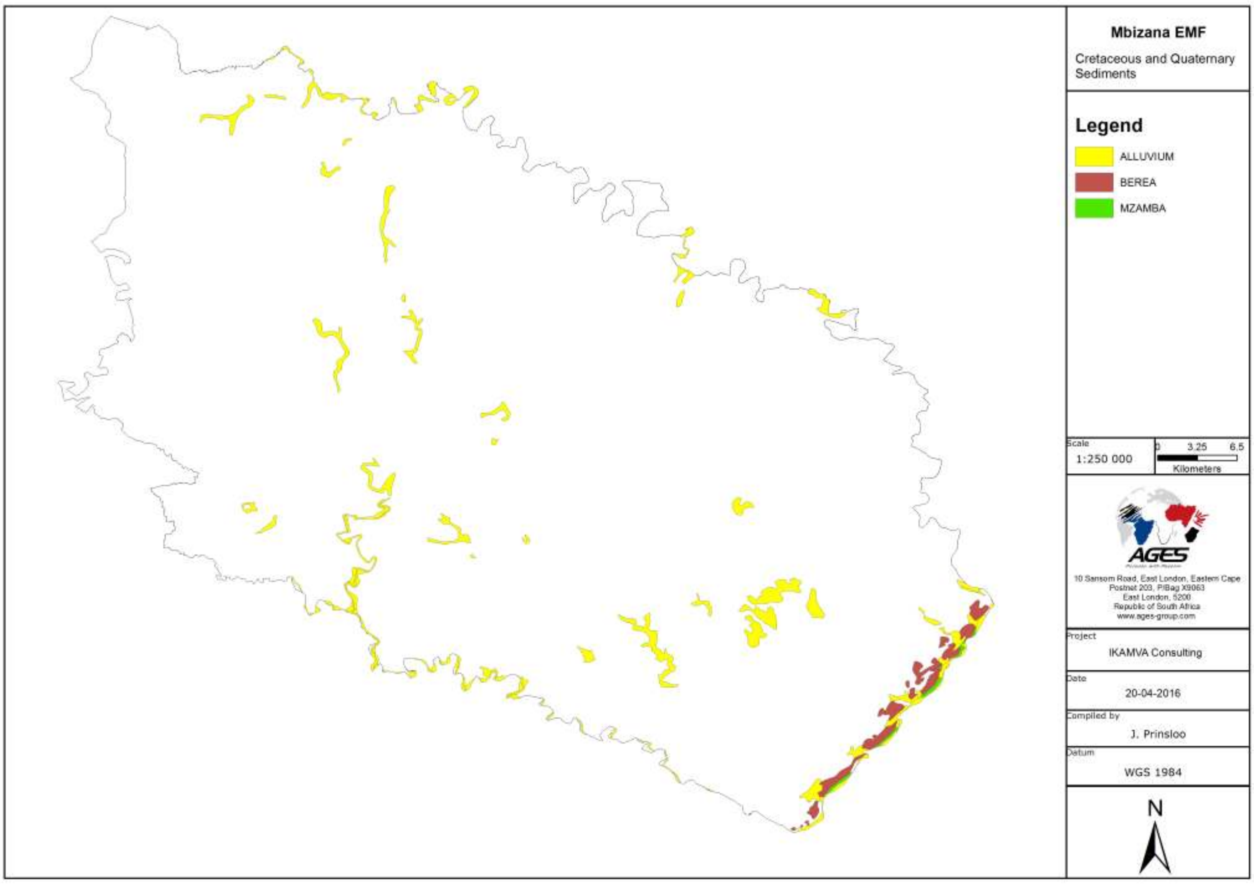

Figure 5: Extension of Cretaceous and Quaternary Sediments

i. Mzamba Formation

The Mzamba Formation is a storm influenced sedimentary succession that was deposited in an offshore marine environment. The formation is characterized by two sedimentary facies, the lower fine grained sandstone that was deposited in a relatively deep offshore environment. The second facies is the upper packstone (shell-bed) facies, which was deposited in a shallow offshore setting, which was lithified after it was buried by the overlying sediments.

The Mzamba formation is found in cliffs around the coastal margins of the study area. Shallow marine fossils are abundant throughout the formation. (Liu and Greyling, 1996)

ii. Berea Formation

The Berea Formation was deposited approximately 10 million years ago in a beach environment. The formation is consistent of red sand, subordinate white, yellow and brown sand as well as basal conglomerate. The pronounced red colour is brought on by the presence of iron oxide (Norman and Whitfield,)

iii. Alluvium

The most recent of all geological formations is the quaternary alluvium, which has been deposited by recent and current drainage systems and consists of poorly sorted alluvial sediments and is present in scattered formations throughout the project area.

4.2 Drift Geology

By definition, drift geology is any glacial material found anywhere on land or on sea (Press and Siever, 1986) and can therefore be used to describe the origin of the Dwyka Formation. However, the term drift geology is generally used to describe sedimentary depositions that are quaternary in age. The Dwyka Formation however is much older and based on this definition and general nomenclature; no recent geological features that have a drift origin are present within the project area.

4.3 Geo-Hazards

A geo-hazard is any geological state or structure or human activity that may hold a risk to the environmental or socio-economic state of a certain area (Nadim 2006). Ancient tectonic structures such as the fault zones found in the Dwyka and Natal Sandstone Formations and Natal Metamorphic Province along the coast hold a relatively low seismic risk (Wium, 2009). No earthquake exceeding 4.5 magnitude on the Richter scale has been registered in the past 100 years in the project area. Illegal human activity, such as unlicensed sand mining can be seen as a current environmental geo-hazard.

4.4 Mineral Deposits

Marked on Figure 6 are the positions of known heavy mineral sands, that contain titanium and zircon deposits along the coastal margin of the project area. Other geological features with possible economic value are the dolerite intrusions, that can be quarried for aggregates and gravel that can be used for construction purposes. Alluvial sand can also be used by the construction industry.

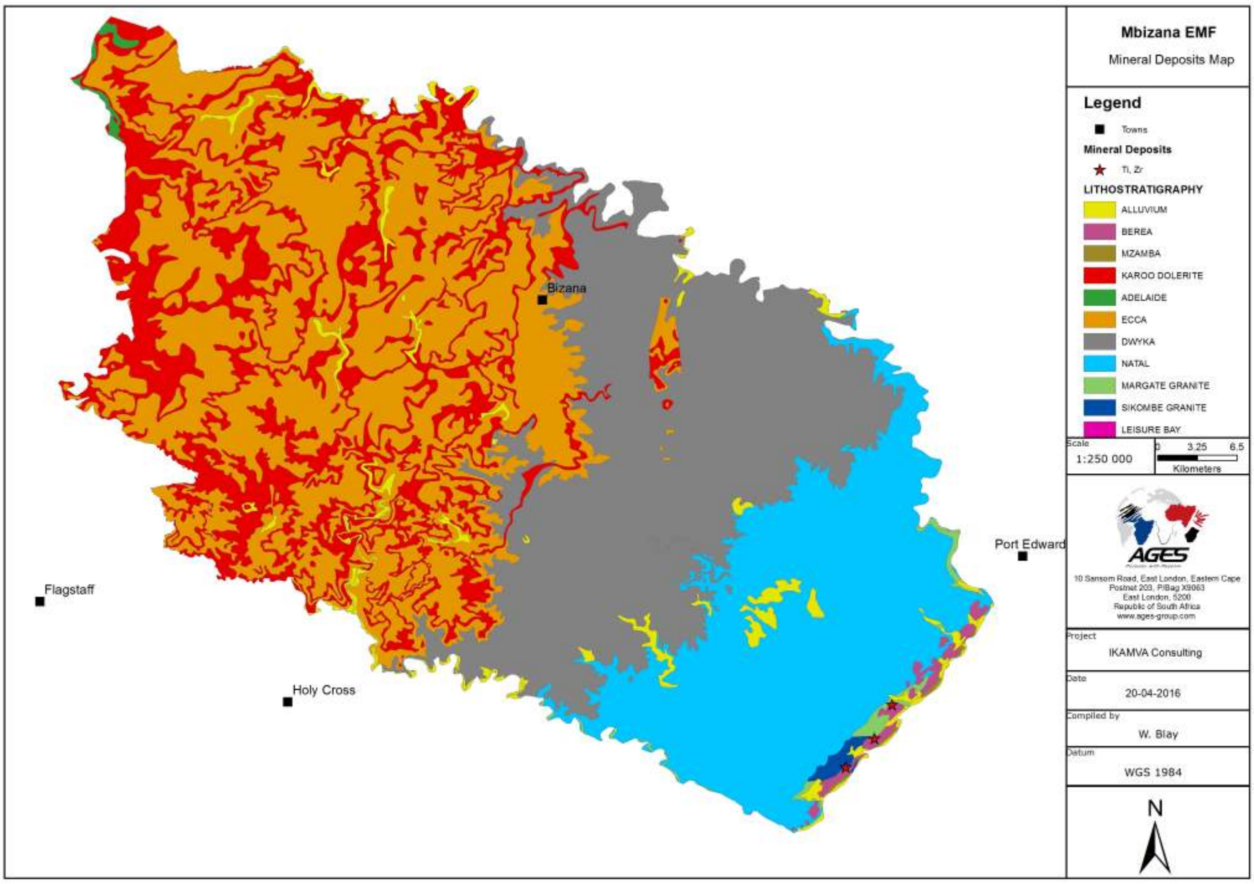

Figure 6: Mineral Deposits within the Mbizana LM

5 GEOMORPHOLOGY OF THE MBIZANA LOCAL MUNICIPALITY

5.1 Terrain Morphology

The study area is characterised by three main terrain morphology classes which changes in character from the higher lying inland areas towards the coast in the south east. The area from Mbizana Town towards the north western border of the study area is classified as Undulating Hills. The topography and terrain morphology of this area is mostly due to the occurrence of Karoo Supergroup Ecca Shales that have been intruded by dolerite in places.

The terrain changes as one moves towards the coast to Highly Dissected Low Undulating Mountains that form an escarpment which is mostly underlain by Dwyka Group Tillite of the Karoo Supergroup.

The area towards the coast is less mountainous and is classified as Table-lands that are mostly underlain by Natal Group Sandstone.

The distribution of these three terrain morphological units is indicated in Figure 7.

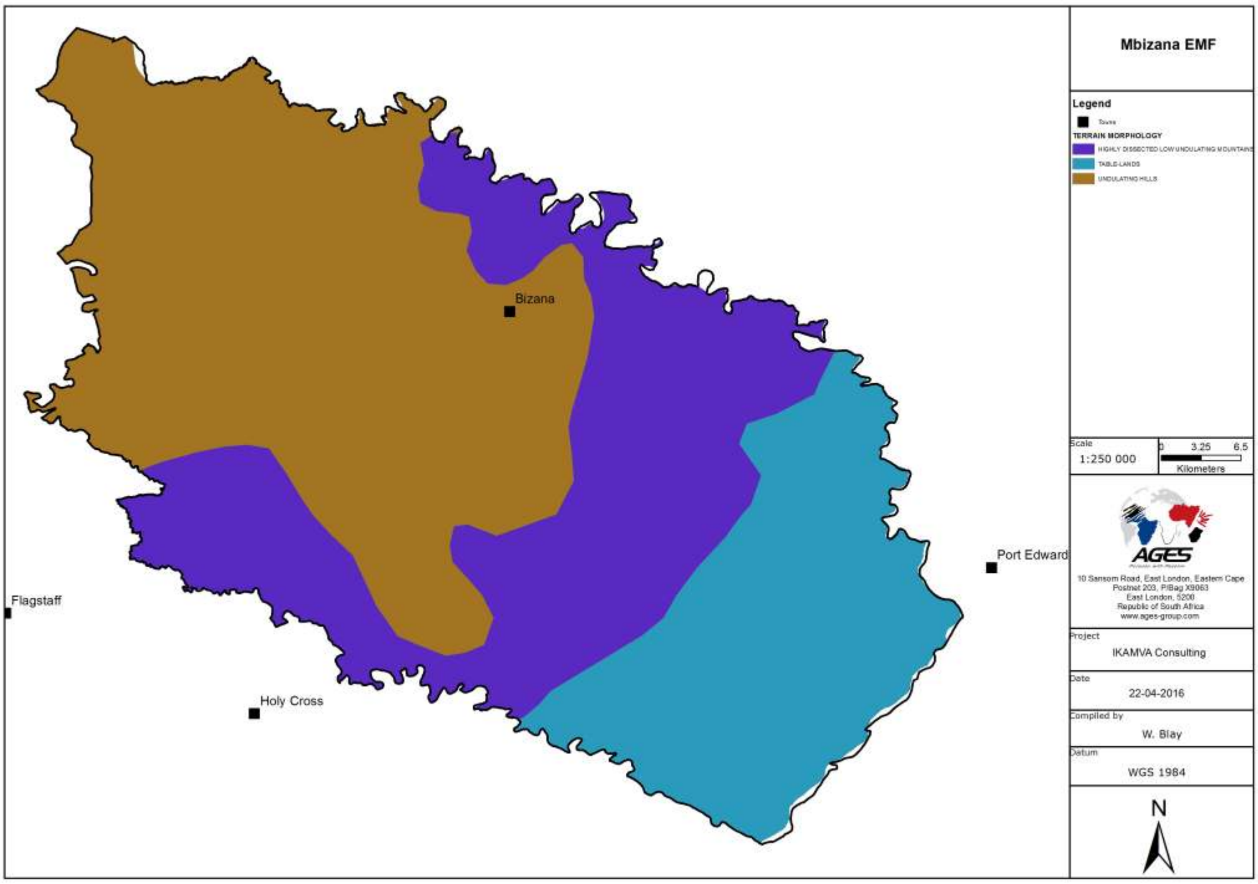

Figure 7: Terrain Morphology

5.2 Land-Use

The Mbizana LM is characterized by six different land-use types as indicated in Figure 8. The majority of the area is defined as vacant land or being unspecified. This is the area where rural communities occur and is combined with the area specified for subsistence farming associated with these communities which is delineated separately in the figure. Small areas are in use for forestry and cultivated land while one area in the north west of the LM is demarcated as a conservation area.

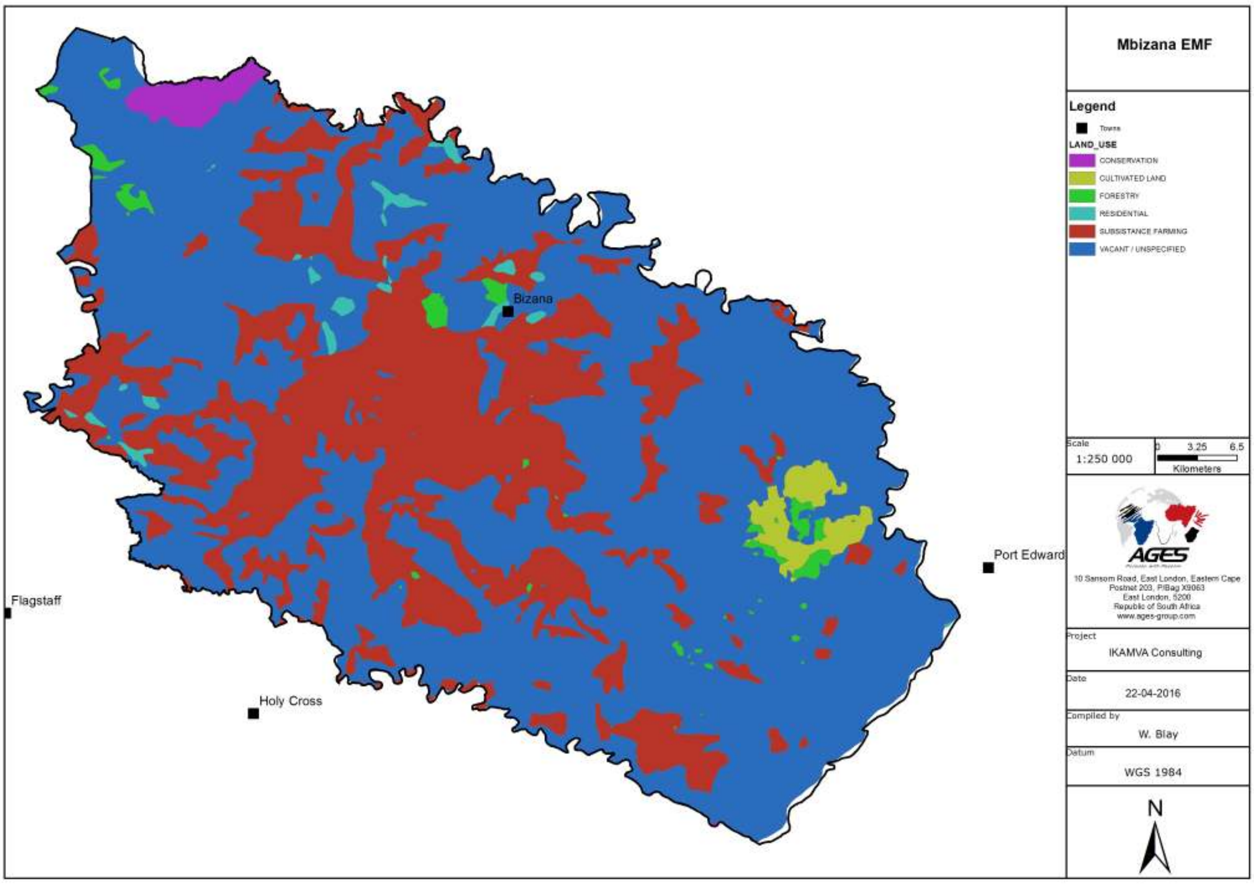

Figure 8: Land use categories

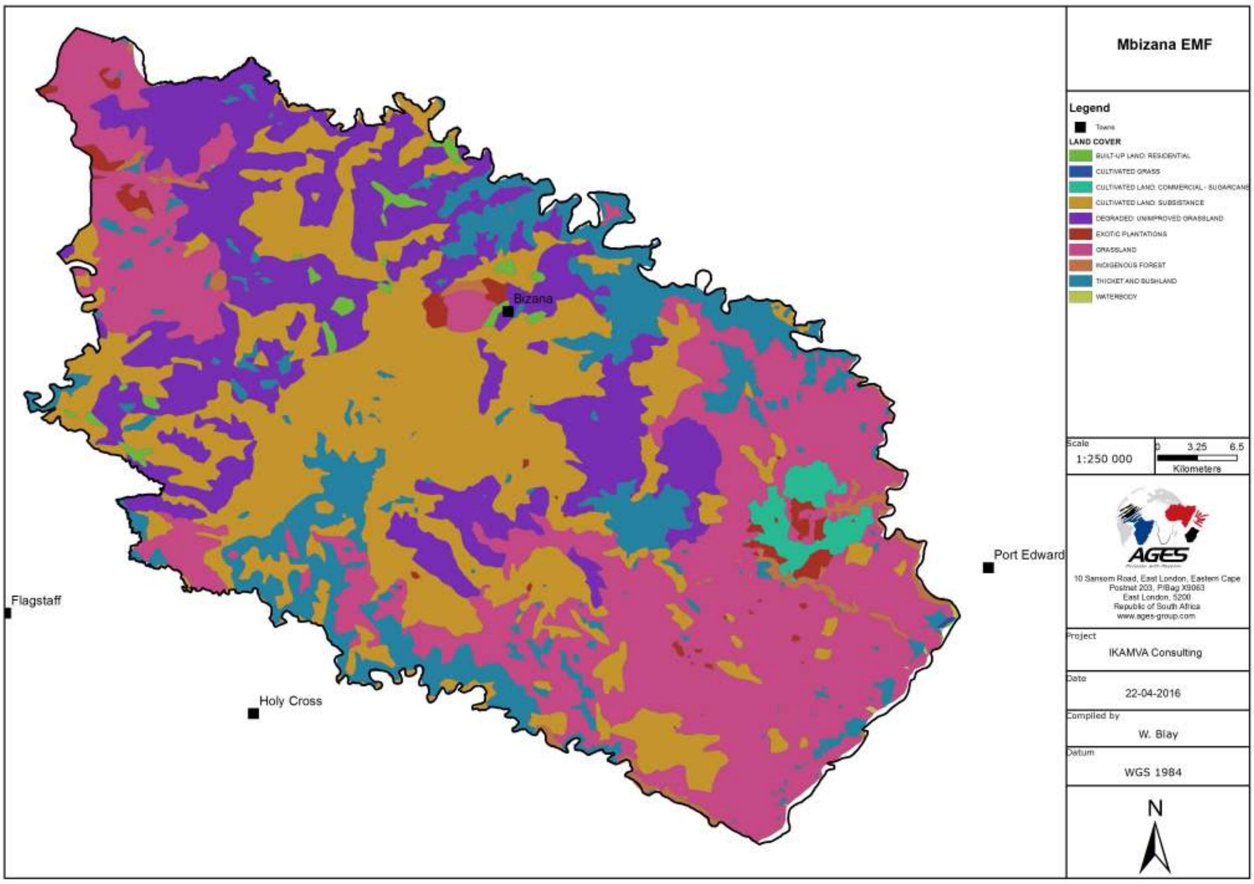

Figure 9: Land Cover

Land cover is sub-divided in 10 categories as indicated in Figure 9. Grassland covers most of the south eastern third as well as the far western part of the LM. Degraded unimproved grassland, is found more in the central part of the LM where is generally surrounds the area delineated as subsistence farming and cultivated land. The majority of the remaining area is covered by thicket and bushland with small areas covered by cultivated commercial land and exotic and indigenous forests as indicated in the figure.

5.3 Soils

Figure 10 gives indication of the broad soil categories associated with the identified Land Types in the study area. The land types have been delineated to differentiate areas with similar terrain morphology, soils, geology and climatic parameters by the Soil and Irrigation Research Institute. Soil land types form an important part of the development potential assessment of a municipal area where the geotechnical characteristics of the different soils can give indication of soil drainage, collapse or erodibility potential.

Broad soil patterns have been defined as listed in Table 1 and occur in the study area as indicated in Figure 10.

Table 1: Broad Soil Categories

Symbol	Description
Aa	Red-yellow apedal, freely drained soils with a humic horizon
Ab	Red-yellow apedal, freely drained soils; red, dystrophic and/or mesotrophic
Ac	Red-yellow apedal, freely drained soils; red and yellow, dystrophic and/or mesotrophic
Ad	Red-yellow apedal, freely drained soils; yellow, dystrophic and/or mesotrophic
Bb	Plinthic catena: dystrophic and/or mesotrophic; red soils not widespread, upland duplex and margalitic soils ra
Fa	Glenrosa and/or Mispah forms (other soils may occur), lime rare or absent in the entire landscape
Hb	Grey regic sands and other soils
Ia	Miscellaneous land classes, undifferentiated deep deposits (Aluvium)
Ib	Miscellaneous land classes, rocky areas with miscellaneous soils (60-80% Rock)

5.3.1 Broad Soil Pattern Aa - Red-yellow apedal, freely drained soils with a humic horizon

The Aa soil pattern occurs in the central part of the study area and is attributed to the following geology types:

- Shale and sandstone of the Ecca Group, Karoo Sequence with dolerite outcrops.

5.3.2 Broad Soil Pattern Ab - Red-yellow apedal, freely drained soils; red, dystrophic and/or mesotrophic

The Ab soil pattern occurs towards the south western boundary of the study area and is attributed to the following geology types:

- Tillite of the Dwyka Group and in the northwest and west shale, mudstone and sandstone of the Ecca Group and dolerite.

5.3.3 Broad Soil Pattern Ac - Red-yellow apedal, freely drained soils; red and yellow, dystrophic and/or mesotrophic

The Ac soil pattern occurs in the north western part of the study area and is attributed to the following geology types:

- Dark-grey shale of the Volksrust Formation, Ecca Group, with dolerite intrusions, and alluvium.
- Dark grey shale of the Ecca Group and dolerite.
- Alluvium, shale of the Ecca Group and dolerite.

5.3.4 Broad Soil Pattern Ad - Red-yellow apedal, freely drained soils; yellow, dystrophic and/or mesotrophic

The Ad soil pattern occurs in only one location near the western boundary of the study area and is attributed to the following geology types:

- Dark-grey shale of the Ecca Group, with dolerite intrusions.

This group of soil patterns constitutes oxidic soils (red or yellow-brown apedal B or red structured B). Oxides of iron accumulate through weathering and impart to many soils a colour which is essentially uniform, at least in the upper solum, owing to the fact that conditions are well drained and aerated. The red colour of hematite signifies conditions that are warmer, drier, more base-rich and less affected by organic matter than those associated with the yellow-brown colour of goethite. Hematite is the stronger of the two pigments and many red soils contain more goethite than hematite. Some soils have an upper yellow-brown and a lower red B horizon. In the former, organic matter and redox conditions have preferentially removed the hematite. Most humic soils have a highly weathered oxidic subsurface horizon whereas oxidic soils may be but are not necessarily highly weathered and are found over a wider spectrum of climatic conditions. A blocky structure in the red structured B is thought mainly to arise from a more pronounced seasonal desiccation than that prevailing in apedal counterparts from which it can be texturally and mineralogically indistinguishable.

Soil forms within this category are: Pinedene, Griffin, Clovelly, Constantia, Bloemdal, Hutton, Shortlands. (Fey, 2010).

5.3.5 Broad Soil Pattern Bb - Plinthic catena: dystrophic and/or mesotrophic; red soils not widespread, upland duplex and margalitic soils rare

The Bb soil pattern occurs in small locations along the northern boundary of the study area and is attributed to the following geology types:

- Mainly dark-grey shale of the Ecca Formation, Ecca Group, with dolerite intrusions, and alluvium.

An absolute enrichment with iron oxides can occur in situations where intermittent wetness from a fluctuating water table gives rise to the reduction and mobilisation of iron and its migration and reprecipitation as mottles, nodules, concretions and vesicular hardpan (ferricrete). A warm, sub-humid to humid climate with a distinct dry season is commonly associated with plinthite formation. Strongest expression occurs in middle to lower slope positions in the landscape. Old erosion surfaces may be preserved by a capping of hard plinthite (also termed laterite). Manganese is associated with iron in some plinthic materials. (Fey, 2010).

Soil forms: Longlands, Wasbank, Westleigh, Dresden, Avalon, Glencoe, Bainsvlei.

5.3.6 Broad Soil Pattern Fa - Glenrosa and/or Mispah forms (other soils may occur), lime rare or absent in the entire landscape

The most dominant soil pattern in the study area is the Fa type which is attributed to the following geology types:

- Grey mudstone and yellow sandstone of the Beaufort Formation; Adelaide Group and dolerite.
- Mainly dark grey shale, medium-grained sandstone and mudstone of the Ecca Group with dolerite.
- Mainly tillite of the Dwyka Formation, with small areas of sandstone of the Natal Group and dolerite.
- Granite.
- Mainly dolerite intrusions, with grey, green and brownish-red mudstone and yellow and grey fine-grained sandstone of the Adelaide Formation, Beaufort Group.

These are lithic soils (lithocutanic B or hard rock) and are youthful either because of limited rock weathering or on account of rejuvenation through natural erosion on steeper, convex slopes, ensuring intimate contact between a surface horizon that is maintained by biological activity and the underlying rock or saprolite. Even where the rock is weathered the subsoil has a predominantly geogenic character, although tonguing of soils and illuviated clay (cutans) into the saprolite may be evident. The saprolitic material may have incipient features such as gleying, calcareousness or softening due to weathering but these are insufficiently expressed to qualify for one of the other distinctive subsurface horizons. Penetration of roots and water is typically non-uniform and restricted to spaces between fragments of rock or saprolite.

Soil forms in this category are Glenrosa, Mispah and Cartref. (Fey, 2010)

5.3.7 Broad Soil Pattern Hb - Grey regic sands and other soils

The Hb soil pattern occurs in small locations along the coast and in one locality inland in the south east of the study area. It is attributed to the following geology types:

- Alluvium with small areas of sandstone of the Natal Group.
- Mainly quaternary sand of the Berea Formation, with small areas of granite and sand- stone of the Natal Group.

This broad soil pattern is typified by cumulic soils (neoutanic or neocarbonate B, alluvium, or regic sand). Many soils are youthful as a result of having formed in recent, unconsolidated sediments such as colluvium, alluvium, or aeolian sand. In some cases, there is clear evidence of incipient soil development in the form of colour variegation caused by cutanic character (textural differentiation, clay skins or lamellae), carbonate accumulation and/or faunal incorporation of darker surface soil. In other cases, this may be barely noticeable.

Soil forms to be expected here are: Tukulu, Oakleaf, Montagu, Augrabies, Dundee, Namib, Vilafontes, Kinkelbos, Fernwood. (Fey, 2010).

5.3.8 Broad Soil Pattern Ia - Miscellaneous land classes, undifferentiated deep deposits (Aluvium)

The Ia soil pattern occurs in small locations along the south western boundary and is attributed to the following geology types:

- Mainly alluvium with small areas of dark grey shale of the Ecca Group, Karoo Sequence and dolerite.
- Tillite of the Dwyka Group covered by alluvium.

5.3.9 Broad Soil Pattern Ib - Miscellaneous land classes, rocky areas with miscellaneous soils (60-80% Rock)

The Ib soil pattern occurs in small locations in the south eastern part of the study area and is attributed to the following geology types:

- Mainly sandstone of the Natal Group, with small areas of granite.

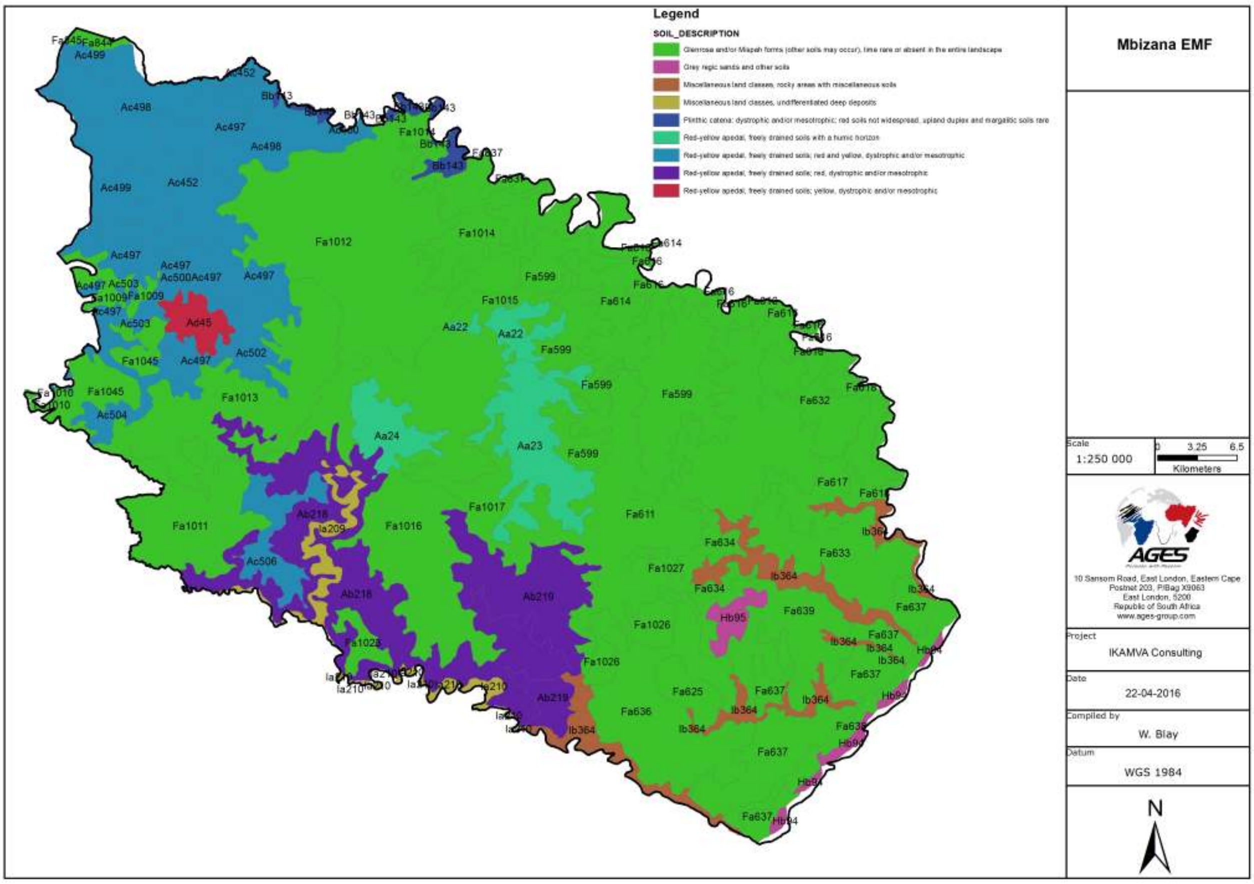

Figure 10: Soil Land Types

Soils with lowest clay content are found along the coast and in a small inland area as defined by the Hb Land Type. These are soils that generally have a clay content of less than 15%. Higher clay content soils are found further inland, mostly defined by the Fa Land Type and is categorised as having a clay content between 15% and 35%. The central and north western part of the LM is covered by higher than 35% soil types as in indicated in Figure 11.

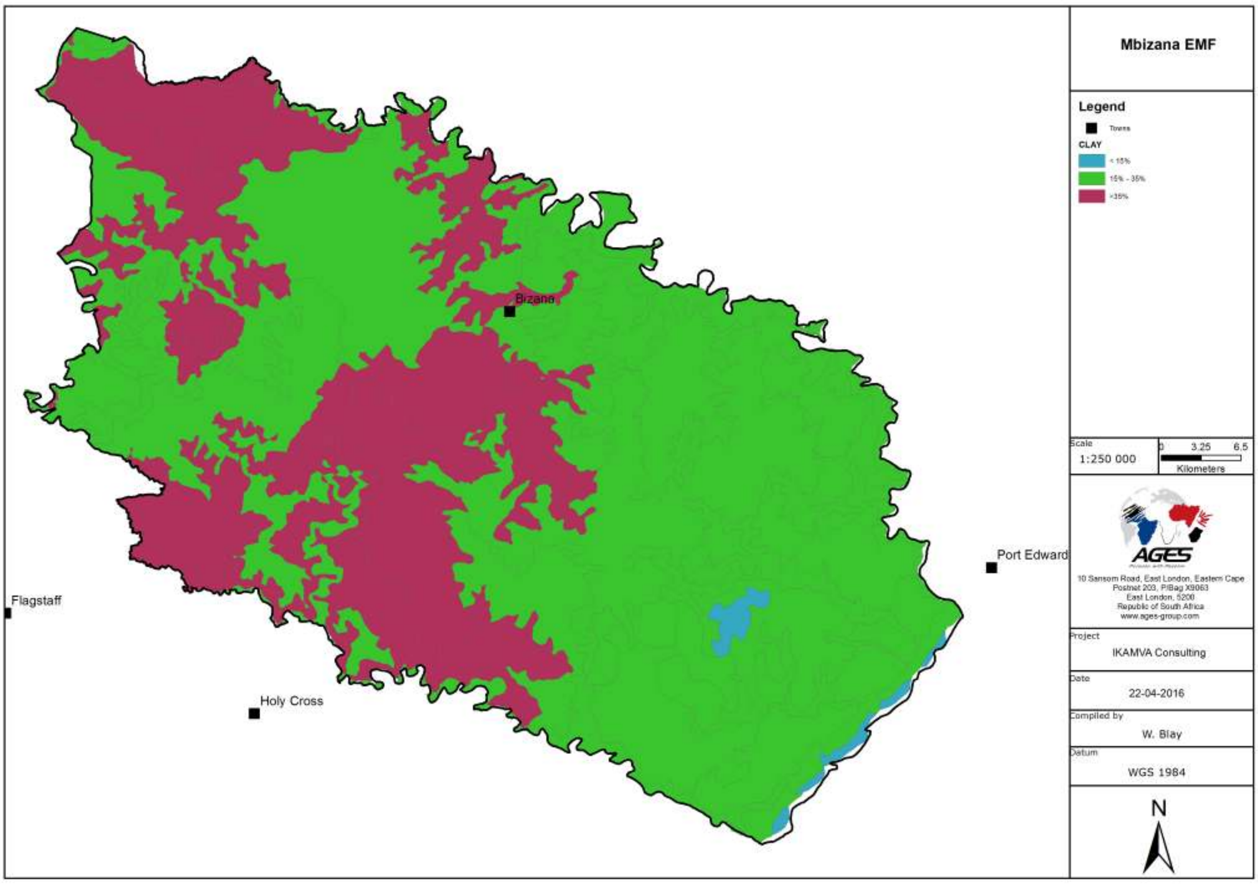

Figure 11: Generalised Soil Clay Content

Soil depth vary across the LM with most soils varying in depth between 450mm and 750mm. Shallow soils are more common in the south of the study area with depths less than 450mm while a large portion of the central part of the study area are typified by soils deeper than 750mm. Figure 12.

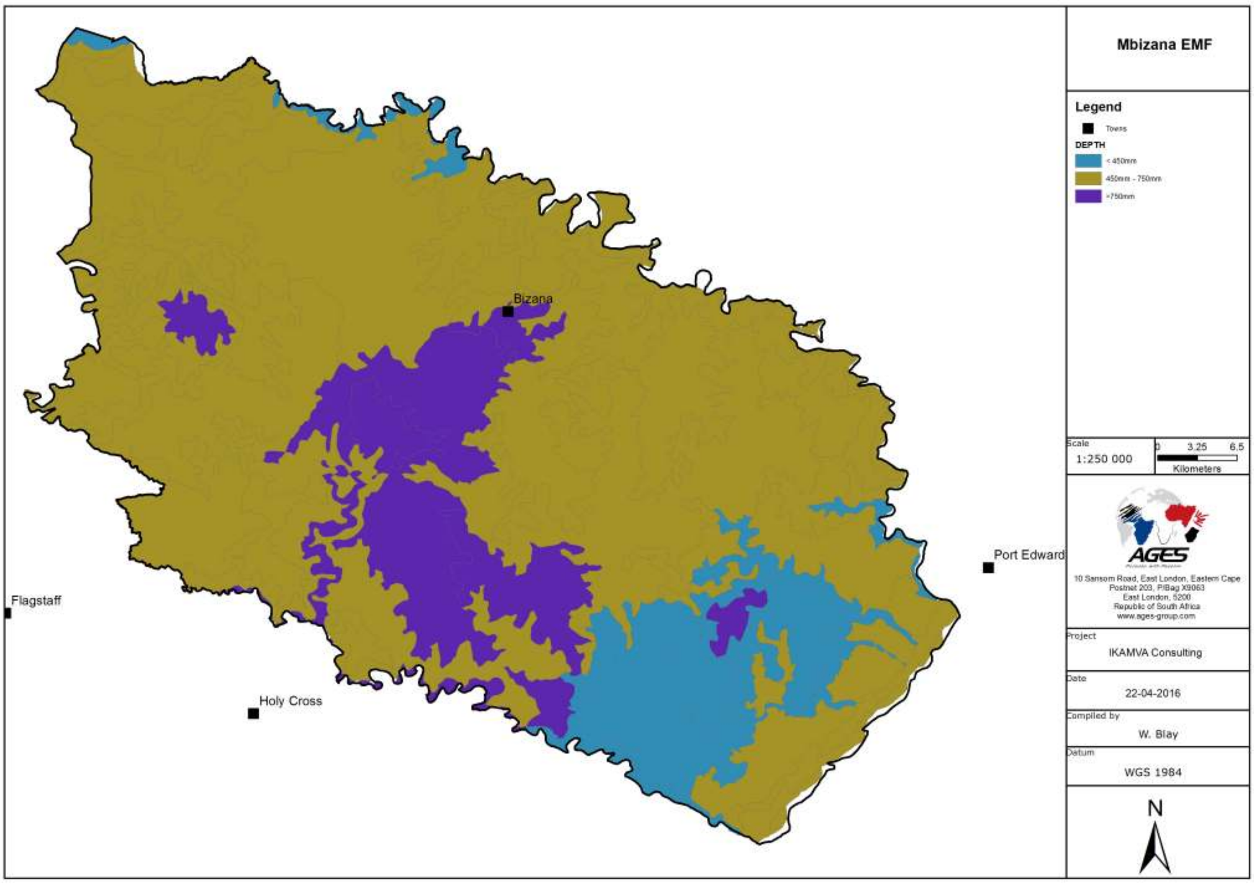

Figure 12: Soil Depth Variance in the Mbizana LM

5.4 Slope Analysis

Figure 13 gives indication of the change in slope angles across the study area. Slopes steeper than 9% and beyond 15% and even 25% are found associated with the drainages of the Mtamvuna River and Mtentu River along the northern and southern boundaries and also in certain central parts of the escarpment within the study area. Most of the study area however is typified by moderate slopes of less than 9% which makes a large part of the Mbizana LM suitable for subsistence farming and small scale land cultivation.

Further studies should include detailed slope analyses and Development Potential Zoning with reference to work done nationally by the Council of Geoscience.

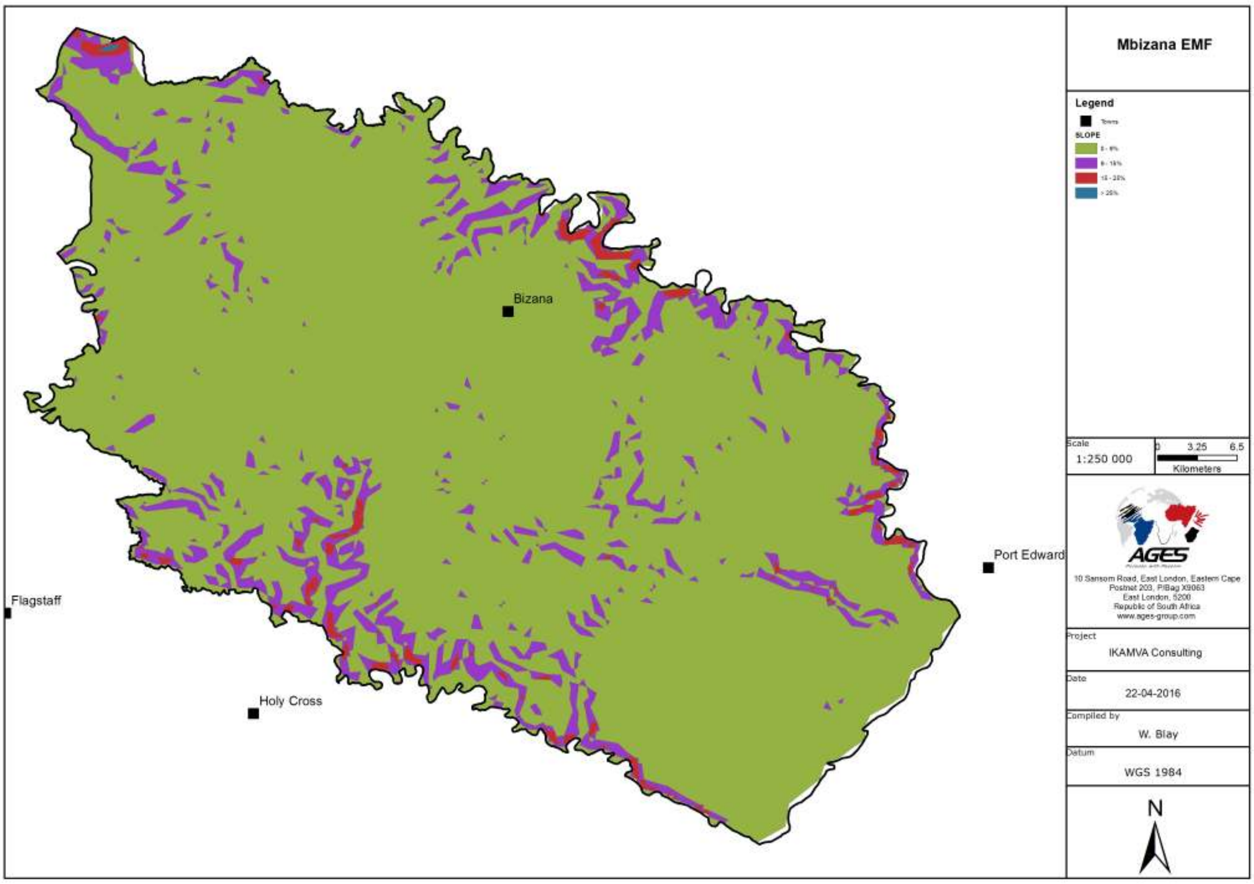

Figure 13: Slope Variance within the Mbizana LM

6 GEOHYDROLOGY OF THE MBIZANA LOCAL MUNICIPALITY

6.1 Integration with DWS National Groundwater Strategy (NGS)

Past neglect and groundwater's private status under the previous Water Act (Act 54 of 1956) have caused groundwater aspects not being an integral part of the development and management of South Africa's water supply projects. Strategies to include groundwater into the National Water Resource Strategy (NWRS) have therefore been receiving attention by DWA to ensure that this is rectified. Historically, groundwater has been very poorly managed in South Africa, resulting in the resource being wrongly discredited as unsustainable. (Groundwater Management Strategy, Edition 1, March 2004).

Various factors account for the history of poor management. These include:

- Lack of hydrogeological knowledge and awareness
- Historical private status of groundwater, resulting in limited control of abstraction.

Guiding principles were presented by DWA during the Water Law Review, and included in the Water Services Act and the National Water Act (Act 36 of 1998) as well as guidelines presented in the draft national water resource management strategy document. Key guiding principles for this work included:

- The purpose of the National Water Act (Act 36 of 1998) must be followed, including redressing the results of past racial and gender discrimination.
- Water resource management is based on principles of equity, optimal use, sustainable use and IWRM.
- The government, through the Minister of DWAF, is the public trustee of South Africa's water resources.
- Water resources will be managed by decentralised CMAs, which will be responsible for the water resources in the 19 demarcated water management areas.

(Groundwater Management Strategy, Edition 1, March 2004).

In the National Groundwater Strategy, it is stated that the risk of over-use must be taken seriously, and appropriate management plans for each borehole or well field must be formulated. Proper authorisation and licensing of abstraction will protect the resource against unauthorised over-exploitation. To assist in minimising abstraction-induced stress on an aquifer, the following could be introduced:

- Water demand management, to reduce total consumption by introducing various incentives to save water;
- Technical solutions, to reduce loss and leakage and improve the usefulness of the same volume of water;
- Realistic tariffs, to put water in line with other commodities and encourage consumers to find ways to reduce water consumption, and
- Involvement of all stakeholders in decision-making, especially at local level through user associations.

(Groundwater Management Strategy, Edition 1, March 2004).

The following five core strategies have been identified as part of the National Groundwater Strategy as the most important with regard to initiating the required change: (Groundwater Management Strategy, Edition 1, March 2004).

- Integrate groundwater into the management of water resources for the benefit of all of South Africa's peoples;
- Promote groundwater so that water resource managers, water users and the public are more aware of the role, occurrence and value of groundwater;
- Encourage and enable hydrogeologists to work outside their line function, and be integrated into the broader water resource planning and management functions;

- A larger, skilled and experienced specialist hydrogeological workforce is required, and
- Groundwater monitoring, and development of a hydrogeological information system, are required to assist in the provision of data to those who need it.

In the 2007 revised framework for a National Groundwater strategy, it is stated that the aims of the National Groundwater Strategy should be that:

- Groundwater as a resource is given its rightful status alongside surface water, helping to meet the growing water demand as a recognised strategic resource within an integrated water resource management approach.
- The knowledge and use of groundwater is increased along with the capacity to ensure sustainable management.
- Pro-active groundwater management programmes are developed and implemented at required water resource management levels, focusing on both quantity and quality aspects.

(A Framework for a National Groundwater strategy, Feb, 2007).

The objectives of the National Groundwater Strategy are defined in this document that it should be to:

- Assess and describe the broader strategic aspects shaping the groundwater sector, with an emphasis on integrated water resource management.
- Appraise the ability of existing water resource management institutions to coordinate and administer all aspects of groundwater management at all three levels of water resource management.
- Bring about a change in mindset. Attitudes towards groundwater, at all levels, must change fundamentally.
- Bring groundwater within the reach of those who do not have ready access to water – particularly resource poor farmers and the very poor that require sufficient water to achieve a reasonable standard of living.
- Grow investment in groundwater. Ensure that sufficient funds are allocated to the development and use of the groundwater resource at all levels; research, information, development and use.
- Improve knowledge of the resource, reliability of information and access to information. Improve information sharing between groundwater management and water services institutions.
- Ensure that regulation and other measures are in place to protect against over-exploitation and pollution.
- Ensure that programmes are in place to adequately monitor the resource status (quantity and quality).
- Create an enabling environment - through Strategies, Guidelines, and other communications.
- Ensure a sound institutional platform (especially within DWS).
- Build hydrogeological capacity in South Africa.

(Copied directly from "A Framework for a National Groundwater strategy, Feb, 2007").

6.2 Previous Studies

In 2002 Khulani VSA Groundwater Consultants (Pty) Ltd. conducted a feasibility study aimed at identifying additional raw water supply sources for future water supply. The feasibility study formed part of another feasibility study conducted by Bigen Africa Consulting Engineers.

The purpose of the study was to assess groundwater potential in the Mbizana area at a feasibility level for a first phase and ensure that all major issues relating to groundwater supply were identified. The results of the study were aimed at enabling recommendations to be made for development options of future raw water supply sources.

The feasibility study included a basic desktop geohydrological characterisation of the study area. Findings from the study concerning geology were that:

- "The study area (Mbizana Magisterial District) is underlain by sedimentary rock."
- Yields of 2.0 l/s are obtainable and can be as high as 12.0 l/s in exceptional cases within the sedimentary rock.
- The average expected yield from these fractured rock aquifers would however be in the range of 1.5 l/s.
- The occurrence of dolerite intrusions in the study area raises the average yields and approximately 20 % of the boreholes targeting the dolerite intrusion influence zone yield more than 5.0 l/s.
- Borehole data available for this study indicated that the average discharge rate of a borehole is 0.24 l/s.

Also it was found from available groundwater chemistry data that the Electrical conductivities (EC) for the area rarely exceeded the maximum acceptable limit for human consumption. EC is regarded as a good indicator of general water quality. It was found that the groundwater in the area had a predominantly calcium-magnesium bicarbonate type character. Sodium and chlorine enrichment also occurred to some extent, caused by Ionic exchange in the groundwater flow paths. Such enrichment and Ionic exchange is indicative of active groundwater circulation. The general groundwater quality in the study area was found to be of an acceptable quality.

The feasibility of groundwater target areas or schemes were determined by a hierarchy of considerations. The proximity to existing infrastructure (pipelines etc.) as well as logistical ease of access were the primary considerations during the selection of suited locations for a groundwater scheme. Several geological targets such as lineaments, faults and dykes were identified where they crossed plateaus where villages are located and according to the study represented priority targets as such. The possible issues of land ownership, site access and need to construct access roads for the drill rigs to reach some of the groundwater priority locations were also raised.

Additional information reported in this chapter was sourced from the ANDM Groundwater Management Plan (2012) as well as numerous groundwater supply projects completed by AGES in the LM.

6.3 Hydrogeological Units

According to the hydrogeological map 3126 QUEENSTOWN the entire project area is underlain by predominantly argillaceous rocks (shale, carbonaceous-shale, clay-stone, mudstone and siltstone). Groundwater occurrences are expected to be in intergranular and fractured zones, with yields at successful boreholes expected between 0.5 and 2.0 litres per second over a 12 hour duty cycle. Increased yields can be expected in localised zones where shallow fracturing is prominent, especially in association with dolerite intrusion. Tlite also occurs in the project area.

Steep slopes and high run-off rates will influence groundwater recharge. The increased precipitation associated with mountainous areas will also influence groundwater recharge, especially in shallow weathering and fracturing.

Based on site observations and according to the geological and hydrogeological maps the groundwater potential of the project area is deemed to be MODERATE. This moderate potential is expected to be higher in zones associated with dolerite intrusion and faults as well as shallow fracturing and weathering expected associated with valley slopes and floors. Exploration drilling was aimed at intersecting fracture zones at greater depths to ensure sustainable long term abstraction.

Figure 14 gives indication of the different hydrogeological units defined by the published hydrogeological map for the area.

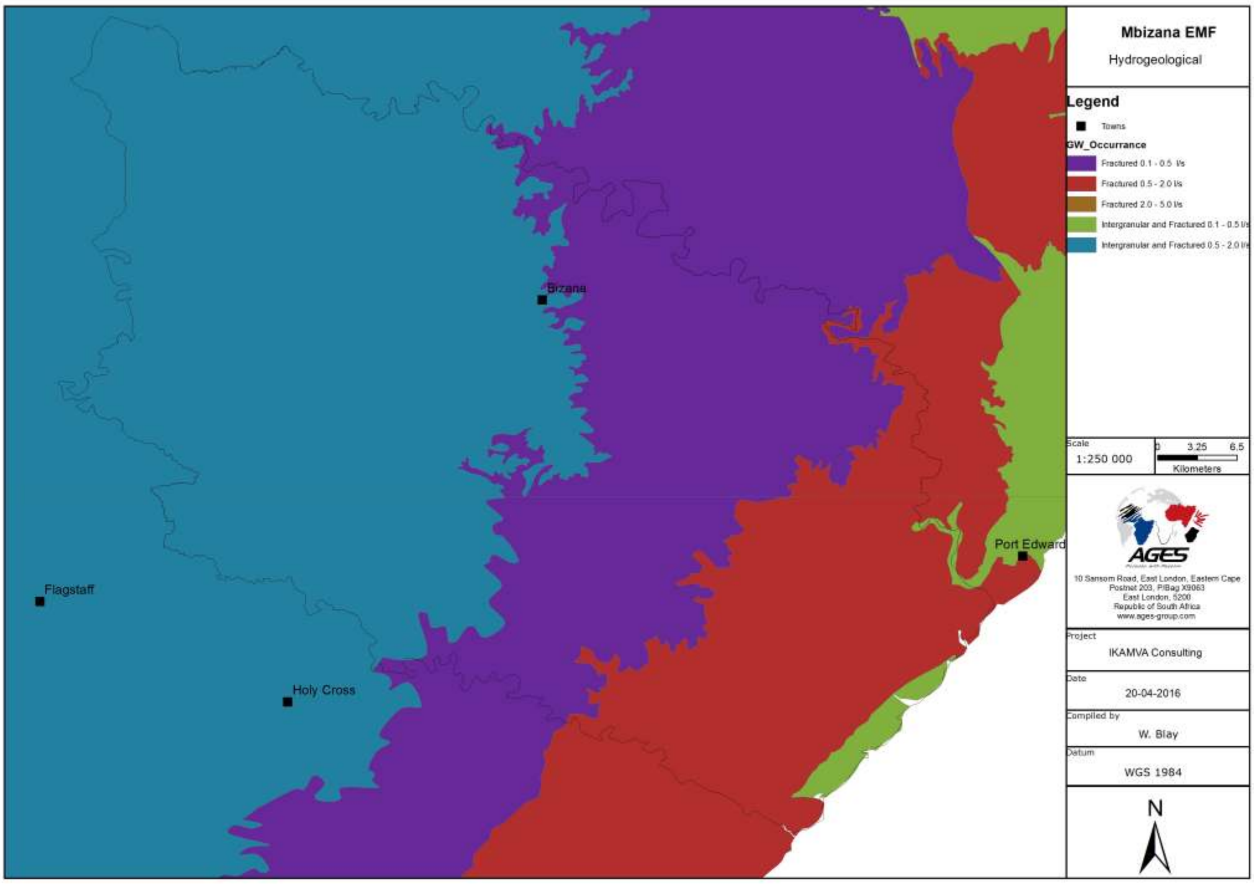

Figure 14: Hydrogeological Units within the Mbizana LM

6.4 Groundwater Resource Units

Five Groundwater Resource Units (GRU) were delineated in the 2012 DWS groundwater reserve study of which only two occur in the Mbizana LM. The GRU's are referenced in the following list while a sixth GRU was proposed as part of the ANDM Groundwater Management Plan. Figure 15 indicates the spatial distribution of the delineated GRU's.

1. *Lower Karoo GRU*
2. *Middle Karoo GRU*
3. *Upper Karoo GRU*
4. *Msikaba GRU*
5. *Cederville Valley GRU*
6. *Insizwa Complex GRU*

Only the Lower Karoo and Msikaba GRU's occur in the Mbizana LM as indicated in the following Figure.

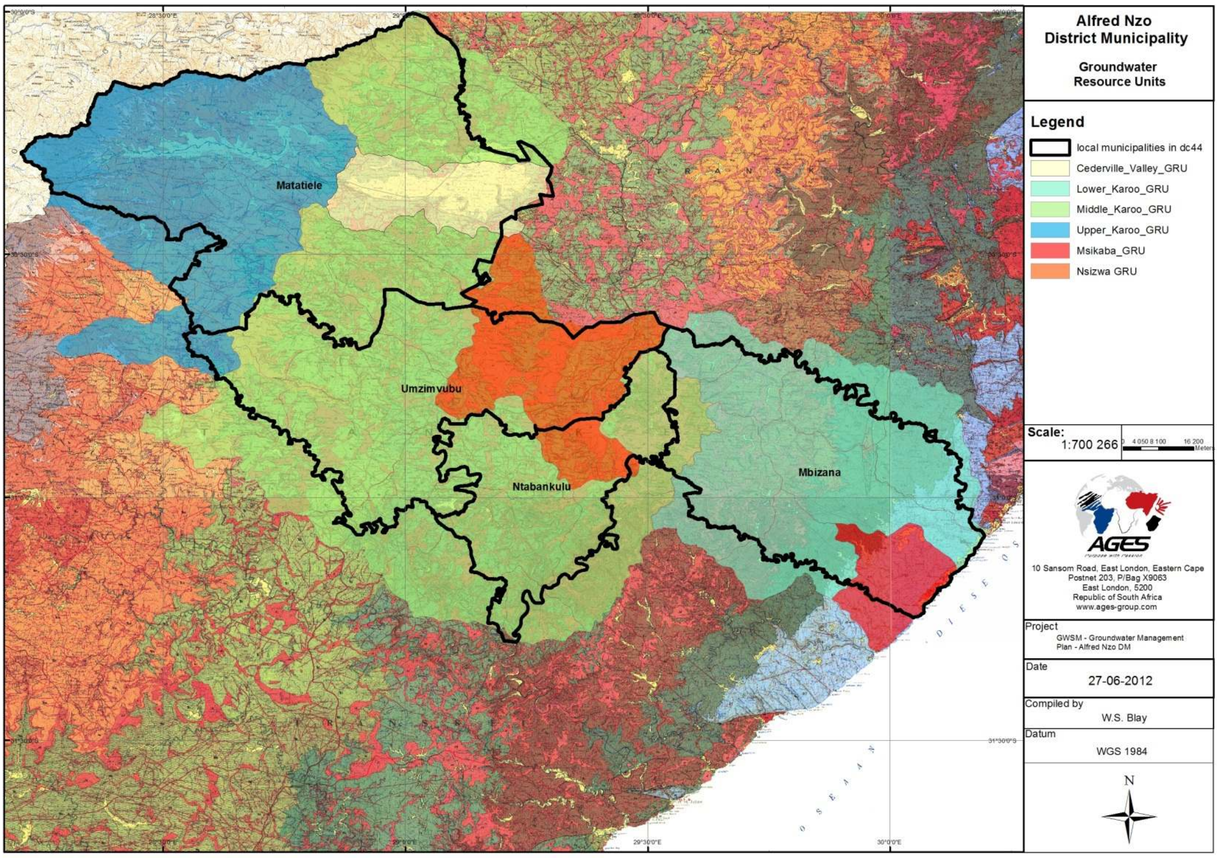

Figure 15: Groundwater Resource Units

The following table was given in the Groundwater Management Plan Report to define groundwater quality characteristics of the two GRU's that occur in the Mbizana LM.

Table 2: Water Quality per Groundwater Resource Unit

Groundwater Resource Unit	Water Quality Characterisation
Lower Karoo	The groundwater samples indicate two dominant water types, a sodium bicarbonate and a sodium chloride water type. An even distribution of water types relate to both a recently recharge (bicarbonate dominated) water and an older evolved (chloride dominated) water. The overall or regional groundwater quality is considered to be good. Eelements of concern are total dissolved solids, electrical conductivity, chloride, nitrate, sodium, sulphate and ammonia
Msikaba	The regional groundwater quality is considered to be good. The average fluoride concentration is beyond (above Class II) the recommended limit for drinking water. The most noticeable elements of concern are fluoride and nitrate although only a limited number of samples have concentrations above and beyond acceptable drinking water quality guideline limits. Elevated fluoride concentrations are expected since the natural background concentration values for fluoride are elevated whereas elevated nitrate concentrations are probably due to anthropogenic activities

6.5 Community Groundwater Potential

Using outcomes of the groundwater surveys that were carried out as part of the ANDM GMP, groundwater potential per community was defined. Communities are ranked as having either HIGH, MODERATE or LOW groundwater potential. This is indicated in Figure 16.

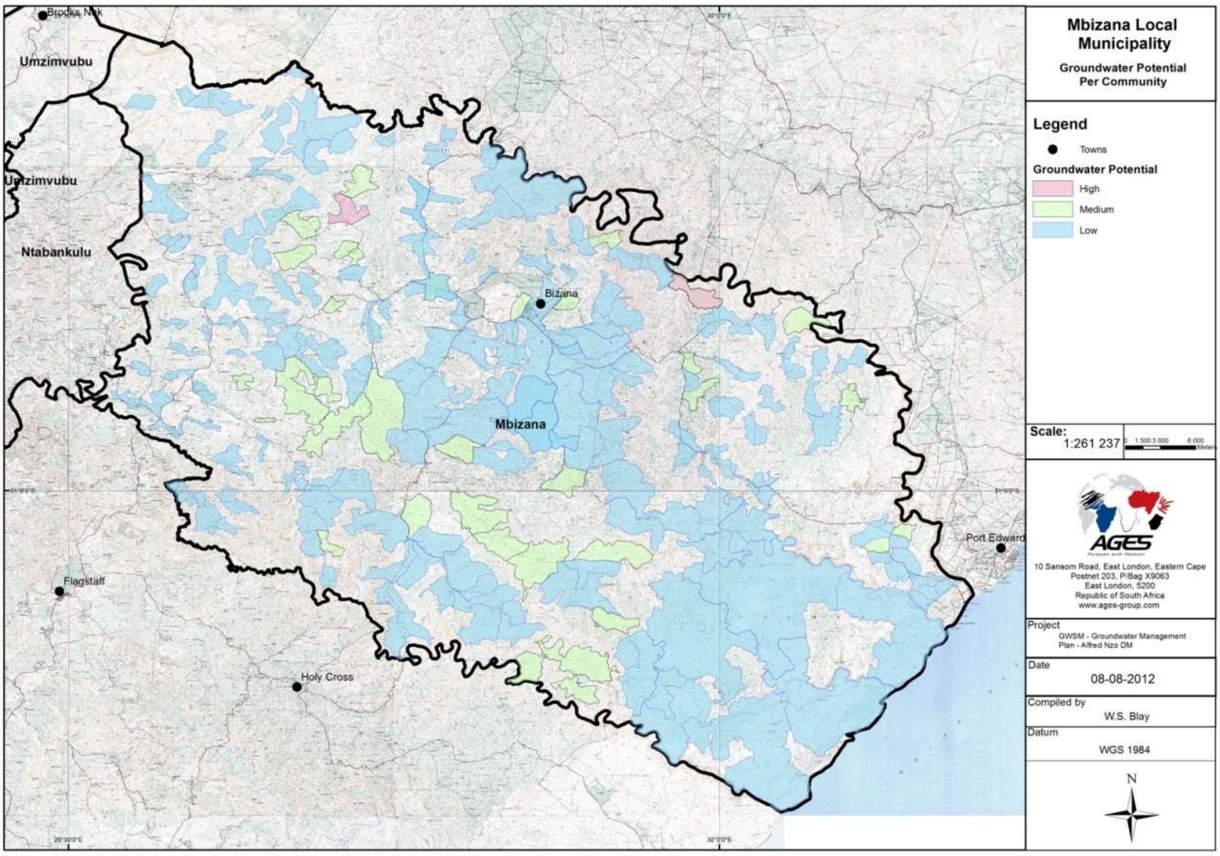

Figure 16: Groundwater Potential per Community

The following Graph indicates the distribution of groundwater potential per village per LM as reported in the Groundwater Management Plan.

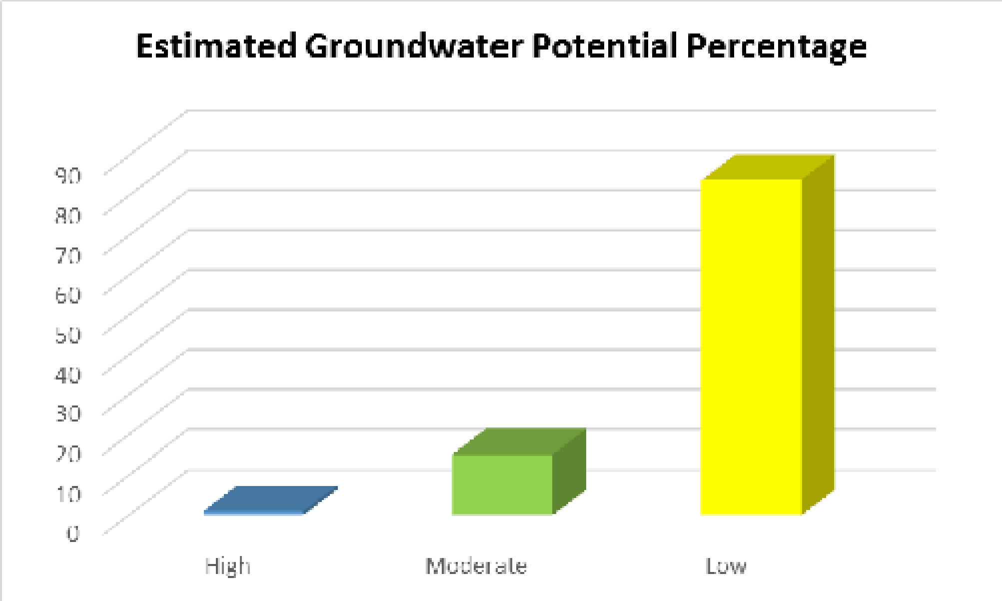

Figure 17: Village Groundwater Potential Percentage

6.6 Groundwater Reserve

The following is confirmed as reported in the Groundwater Management Plan of 2012.

The National Water Act of South Africa (Act No.36 of 1998) promotes protection of water resources for their sustainable utilization. In South Africa, the protection of water resources is developed and encompassed within the Resource Directed Measures (RDMs). In essence, the resource directed measures are the tools aiming at protection of water resources and these tools entail three protection mechanisms i.e. water resource classification, quantification of the reserve and setting of Resource Quality Objectives (RQOs).

The RDMs studies are required for any catchment prior to water use licensing. There is a need to conduct water resource protection studies to ensure long-term sustainability of the water resources whilst people benefit from them. The process of determining the reserve is part of a broader methodology, which is prescribed for RDM determinations.

It is noted that for this study only a RAPID estimate of the groundwater reserve is made. The RAPID reserve determination includes field trips to each catchment to assess the present state with emphasis on possible individual licence applications. Low impacts, in unstressed catchments and/or catchments of low ecological importance are expected and will be addressed accordingly.

Rapid level assessments could suffice in low usage areas, in low stress areas or in instances were usage is expected to have limited impact. Assessments that are more detailed could be undertaken in areas where specific problems occur or in areas where the underlying groundwater system is clearly stressed. This will form part of future phases or through integration with the regional DWA reserve determination project for the Eastern Region.

6.7 Groundwater Balance

The area of the investigation is located inbetween the Eastern Cape and KwaZulu-Natal provinces and covers an area of 3131 km^{2}. Quaternary catchments are divided into nine main sub-areas for the purpose of this investigation. The sub-areas are the T40 A, T40C, T40D, T40E, T60A, T60B, T60C, T60D, and T32G as indicated in Figure 18.

The sustainable of the aquifer is determined by the replenishment rate from rainfall and the reservoir storativity to buffer drought effects. The evaluation of the rainfall is done with reference to the variability and the probability of dry cycles occurring, which could influence the sustainability of the aquifer.

Data from the different rainfall stations were used as per catchment and have rainfall with a comprehensive data set.

The data from another rainfall station that are situated closer at the catchments were also used. An average annual rainfall of 997 mm per year was recorded over a 81 year period at the rainfall stations indicated in Figure 18.

For each rainfall station, a 95% of assurance rainfall was used and the averages determined.

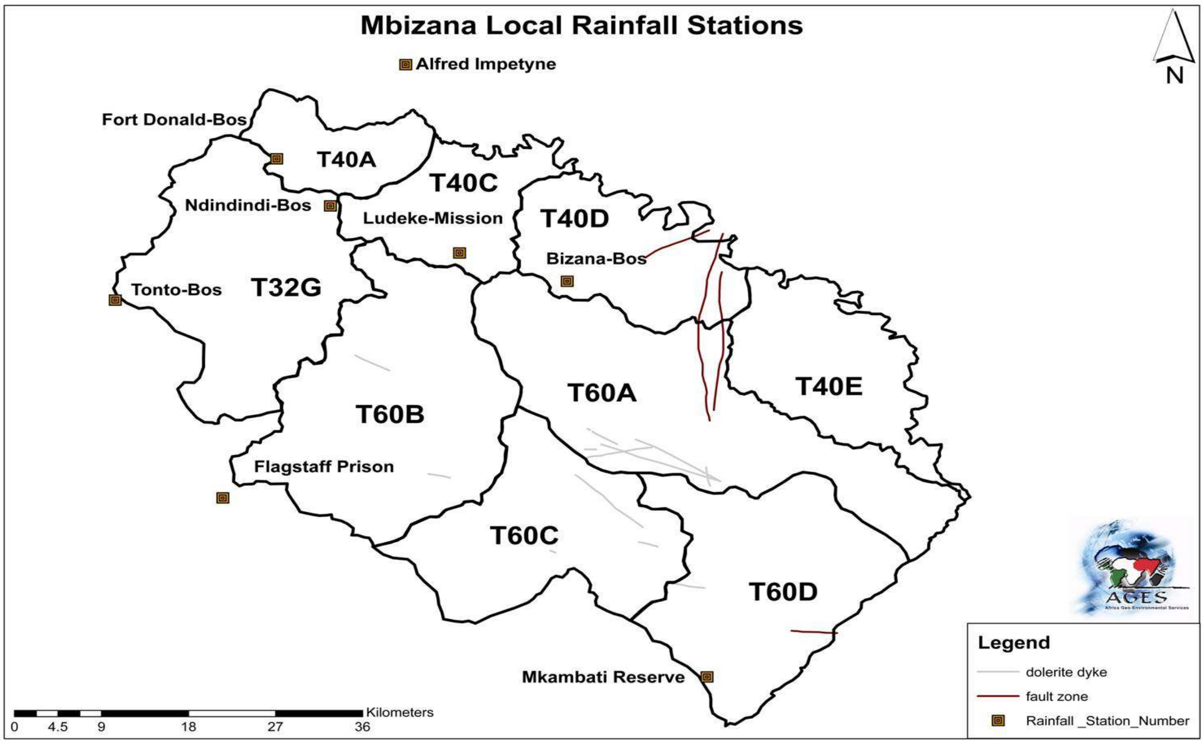

Figure 18: Distribution of Rainfall Stations

The chlorine method is used to verify or assure recharge on each catchment per boreholes and existing streams for each catchment as indicated in the following table.

Table 3: Chlorine method used to determine recharge percentage for each catchment.

Catchment ID	Recharge % of Streams and Boreholes		
	Average	Min	Max
T40A	15	8	
T40C	7	1	14
T40D	4	0	8
T40E	3	0	7
T60A	5	1	
T60D	5	1	
T60C	3	3	3
T60B	9	0	
T32G	15	1	

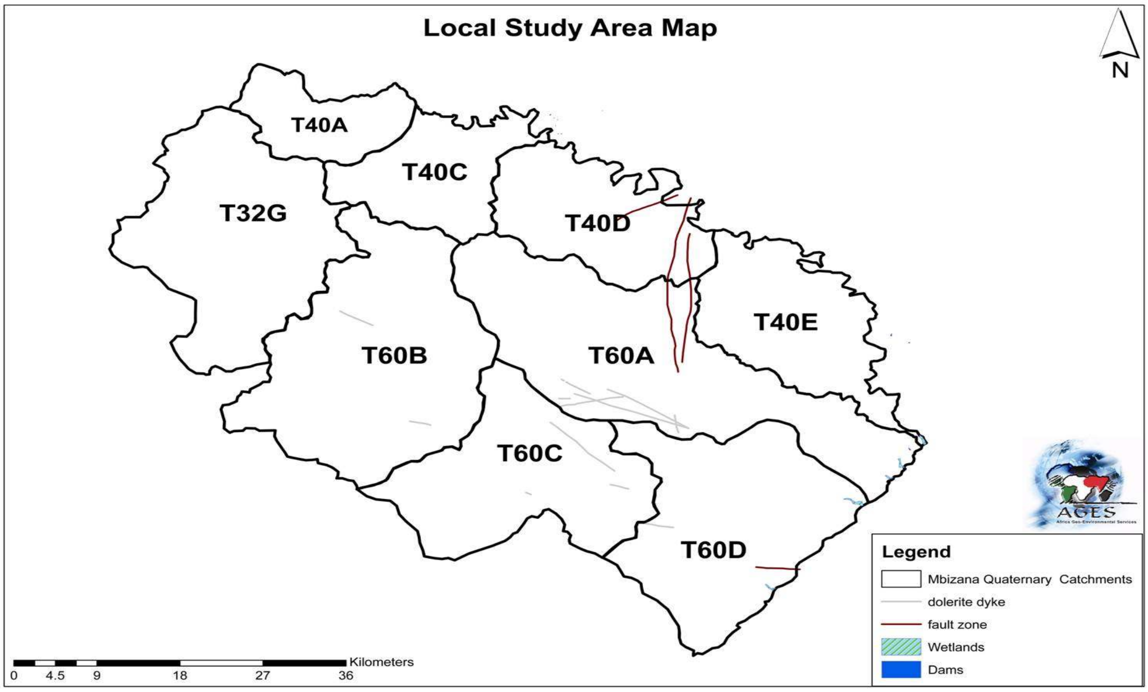

Figure 19: Quaternary Catchments in the Mbizana LM

Based on a groundwater flow balance assessment, the quaternary catchments were classified based on the ratio of outflow/inflow before base flow losses or actual base flow takes place. From the assessment, the groundwater component in the Mbizana Catchments is mostly good and all catchments have low stress levels.

Outputs from the DWS developed GRDM software were used to define allocatable groundwater volumes per GRU as indicated in the Figure 20.

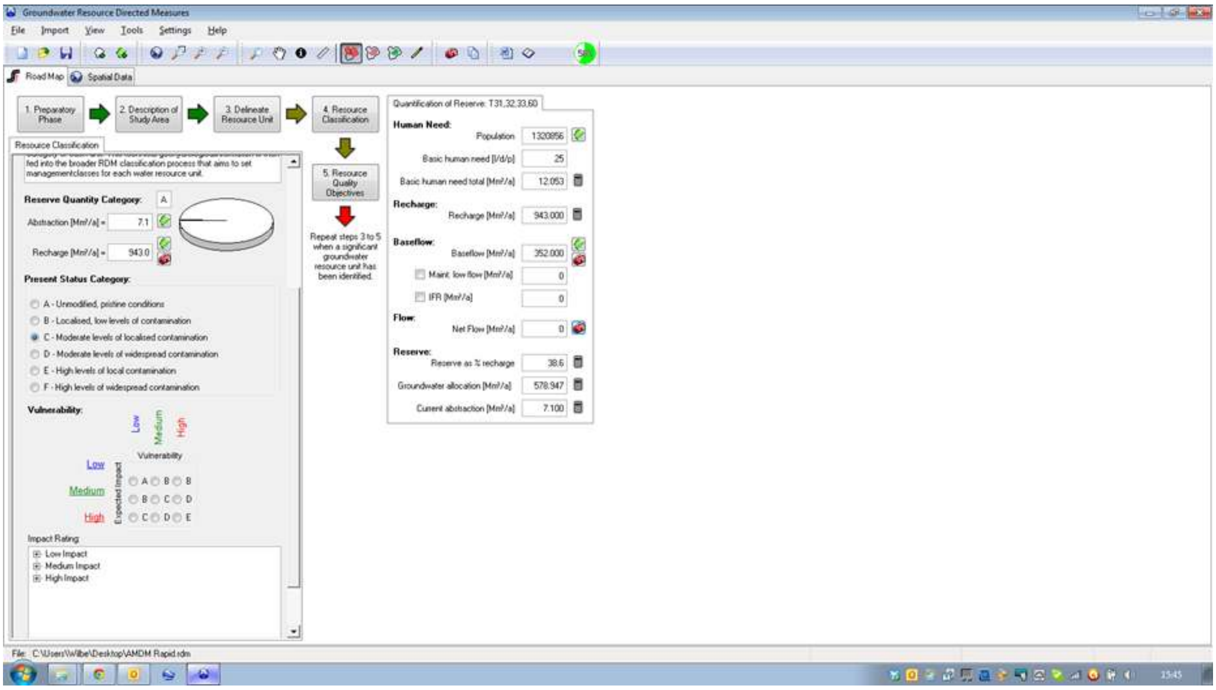

Figure 20: GRDM Software Output

As reported earlier - Table 4 summarises allocatable groundwater volumes for each of the Groundwater Resource Units based on current abstraction volumes as well as based on a maximum scenario where all communities in the ANDM are fully supplied by groundwater. These figures illustrate that sufficient groundwater sources occur in the ANDM to supply in the total water demand of the whole DM without stressing any of the aquifers, providing well-field layouts and proper groundwater management and monitoring systems are in place.

Table 4: Allocatable Groundwater Volumes per Groundwater Resource Unit

Groundwater Resource Unit	Reserve As % Recharge	GW Allocation (Mm^3/a)	Current Abstraction (Mm^3/a)	Estimated GW Abstraction after equipping (Mm^3/a)	Total Abstraction (Mm^3/a)	Total abstraction as % of Groundwater Allocation	Final Available GW after Abstraction (Mm^3/a)
Cederville Valley	28.5	20.08	0.30	0.78	1.08	5.4	19.30
Lower Karoo	36.9	175.77	1.40	8.07	9.47	5.4	167.70
Middle Karoo	37	220.24	3.40	9.45	12.85	5.8	210.79
Upper Karoo	42.7	73.11	1.10	5.97	7.07	9.7	67.14
Msikaba	37.7	36.71	0.10	0.89	0.99	2.7	35.82
Nsizwa Complex	34.6	53.05	0.70	3.37	4.07	7.7	49.67
	TOTAL	**578.947**	**7.00**	**28.53**	**35.53**	**6.1**	**550.42**

The groundwater resource is significantly under-utilized in the Lower Karoo as well as Msikaba Resource Units which constitutes the entire Mbizana LM. The estimated groundwater abstraction is considerably less than the recharge and available groundwater volumes. The stress index classification indicates the Lower Karoo and Msikaba GRU's as both being unstressed or Category I systems. (DWS, Bay Technologies, 2012)

6.8 Existing Boreholes

Figure 21 gives indication of the relative abundance of boreholes and springs throughout the study area. Most of the groundwater point sources are springs

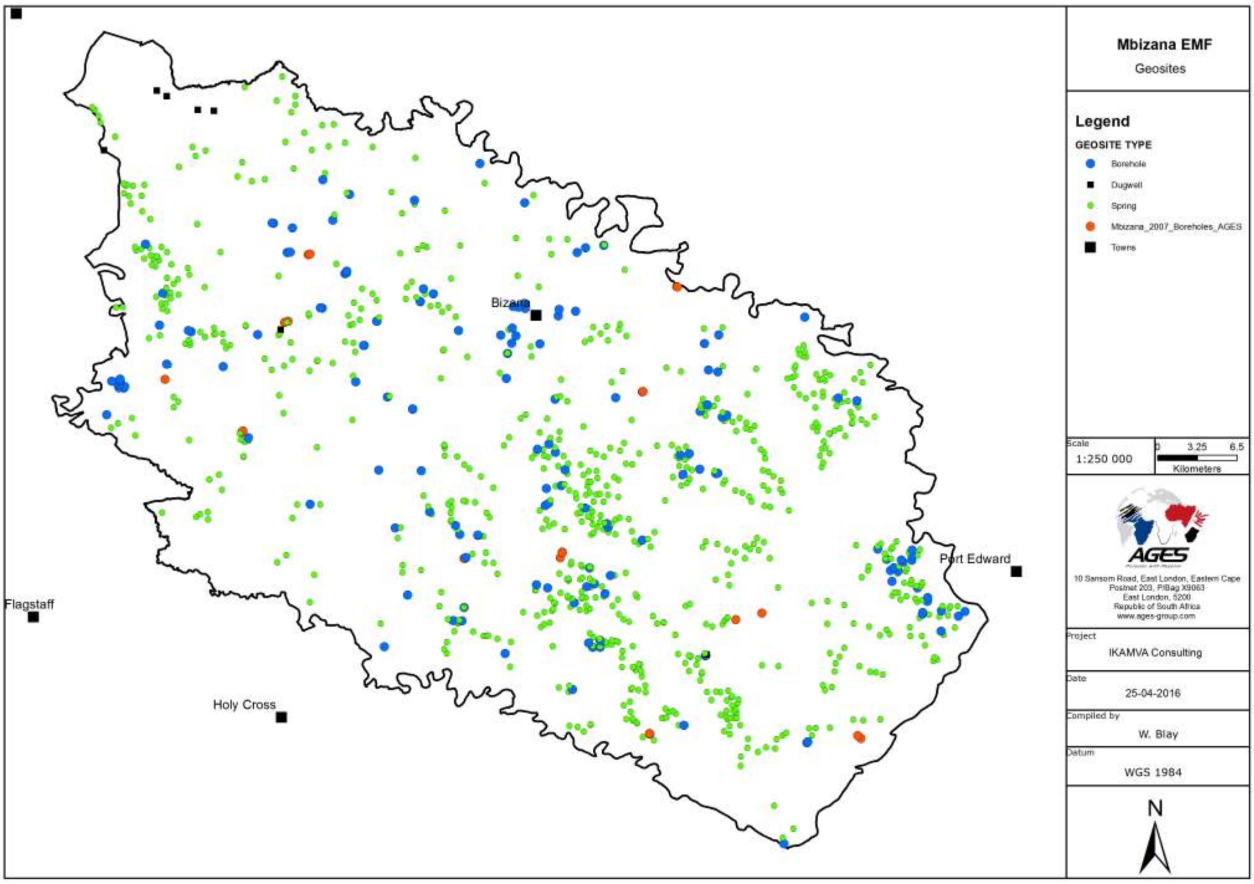

Figure 21: Distribution of existing Boreholes and Springs

Summarised data for the Matatiele Local Municipality is indicated below where it can be seen that although there are 123 existing boreholes in the LM, only 54 boreholes are currently in use while 51 are unused and the remaining 18 being destroyed. Unused boreholes should first be investigated for possible inclusion into new groundwater development projects before new boreholes are drilled.

Table 5: Number of Geosites

MBIZANA LOCAL MUNICIPALITY	
GEOSITE TOTAL	
Boreholes	123
Dugwell	7
Sinkhole	1
Spring	681
Well Point	1
	813

Table 6: Geosites Destroyed

MBIZANA LOCAL MUNICIPALITY						
GEOSITES DESTROYED						
	Handpump	*Other*	*Piston*	*Play Pump*	*Submersible*	*Windpump*
Boreholes	9	1	1	1	3	3
Dugwell	-	-	-	-	-	-
Sinkhole	-	-	-	-	-	-
Spring	-	-	-	-	-	-
Well Point	-	-	-	-	-	-
	9	**1**	**1**	**1**	**3**	**3**
					Total Geosites Destroyed	**18**

Table 7: Geosites Unused and in Use

MBIZANA LOCAL MUNICIPALITY						
GEOSITES UNUSED						
	Handpump	*Motorized Mono*	*No Equipment*	*Other*	*Submersible*	*Windpump*
Boreholes	11	1	32	1	4	2
Dugwell						
Sinkhole						
Spring			2			
Well Point						
	11	**1**	**34**	**1**	**4**	**2**
					Total Geosites Unused	**53**

MBIZANA LOCAL MUNICIPALITY						
GEOSITES IN USE						
	Handpump	*Motorized Mono*	*No Equipment*	*Other*	*Piston*	*Submersible*
Boreholes	33	2	-	-	1	18
Dugwell	-	-	6	-	-	-
Sinkhole	-	-	1	-	-	-
Spring	2	-	662	14	-	2
Well Point	-	-	-	1	-	-
	35	**2**	**669**	**15**	**1**	**20**
					Total Geosites In Use	**742**

A comprehensive hydrocensus was conducted for the study area as described in the Methodology of section 4.1. The hydrocensus was conducted per Ward and all Wards within the Mbizana local Municipality were completed during the hydrocensus. In total 25 Wards were completed.

A total of **940** Geosites were identified during the Hydrocensus and their information captured to the GRIP EC electronic database. In this section some statistics of the boreholes in the study area are also displayed in the graphs below.

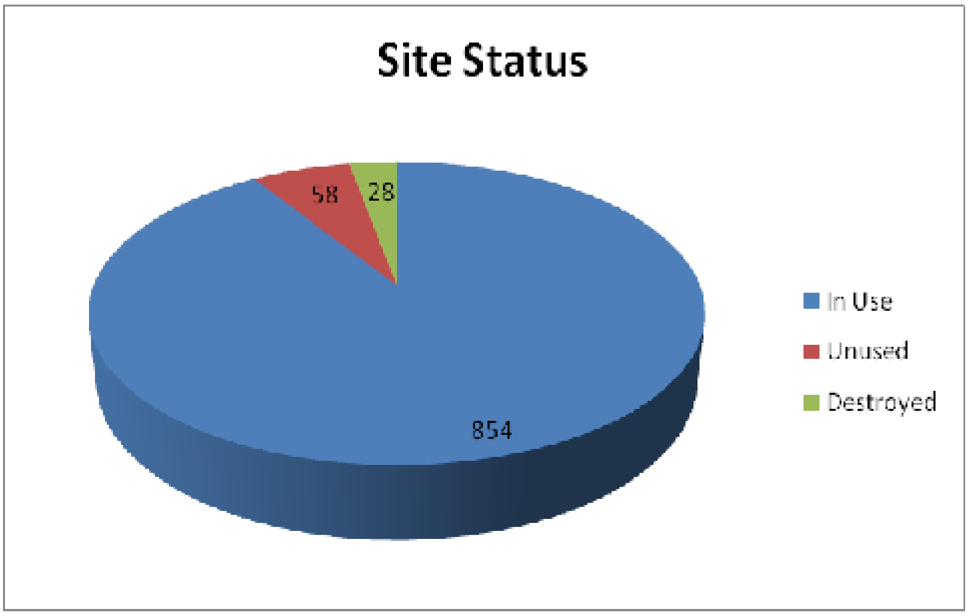

Figure 22: Pie-chart indicating the status of use of all boreholes in Mbizana project area

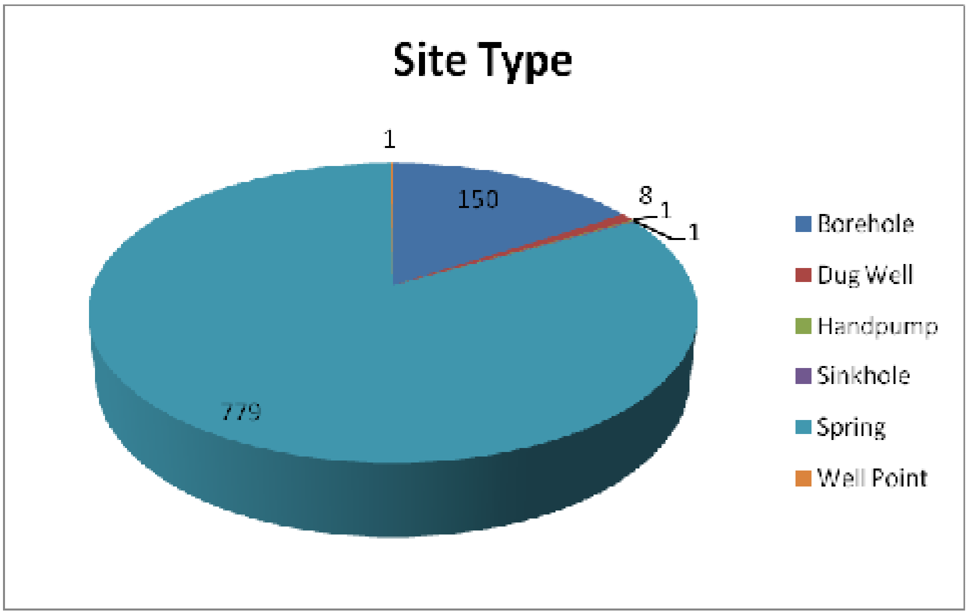

Figure 23: Chart indicating the variation in Type of Geosite found during Hydrocensus

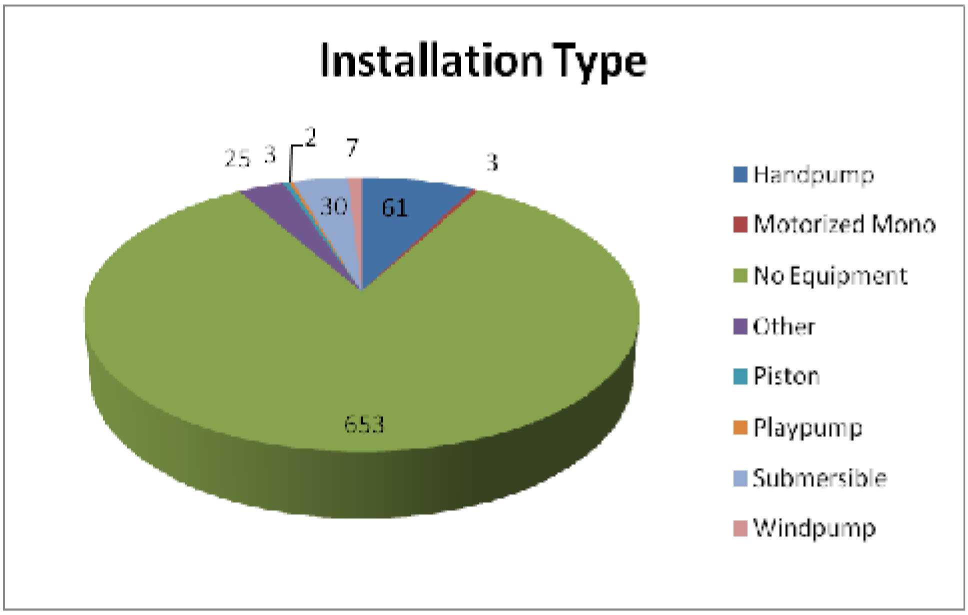

Figure 24: Pie-chart indicating the counted type of borehole installation encountered

From all boreholes a maximum Borehole depth of 160 mbgl was noted, a minimum depth of 4 mbgl and the boreholes have an average depth 68.52 mbgl.

The boreholes have a maximum static water level depth of 45 mbgl, an artesian (spring) condition at minimum due to some geosites being fountains and an average water level depth of 18.5 mbgl.

6.9 Groundwater quality

During DWS investigations and Hydrocensus a water sample was taken per Geosite from a total of **875** Geosites. The water samples were submitted to laboratories to be analysed as far as their physical, chemical and microbiological qualities are concerned.

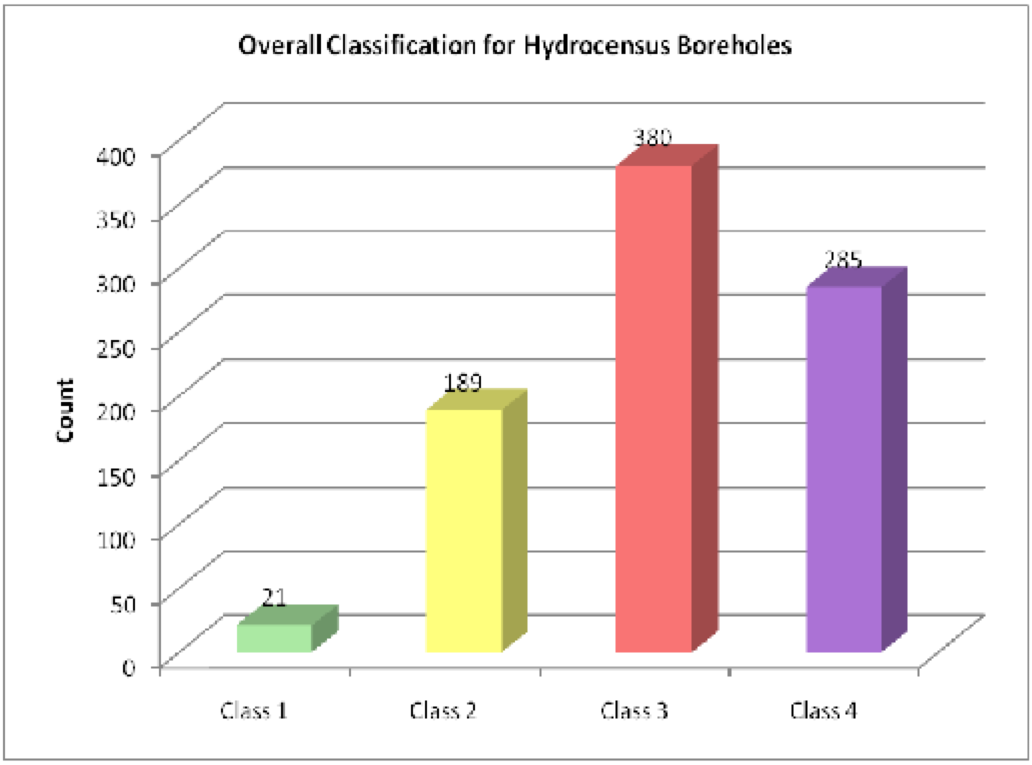

Figure 25: Bar Graph count of Overall Classifications of sampled HC Geosites

The Overall water quality according to DWAF water quality guidelines of all sampled Geosites are displayed in Figure 25. The Counted number of samples are displayed for each water quality class. As is evident from the graph the general water quality is of a Poor (Class 3) quality.

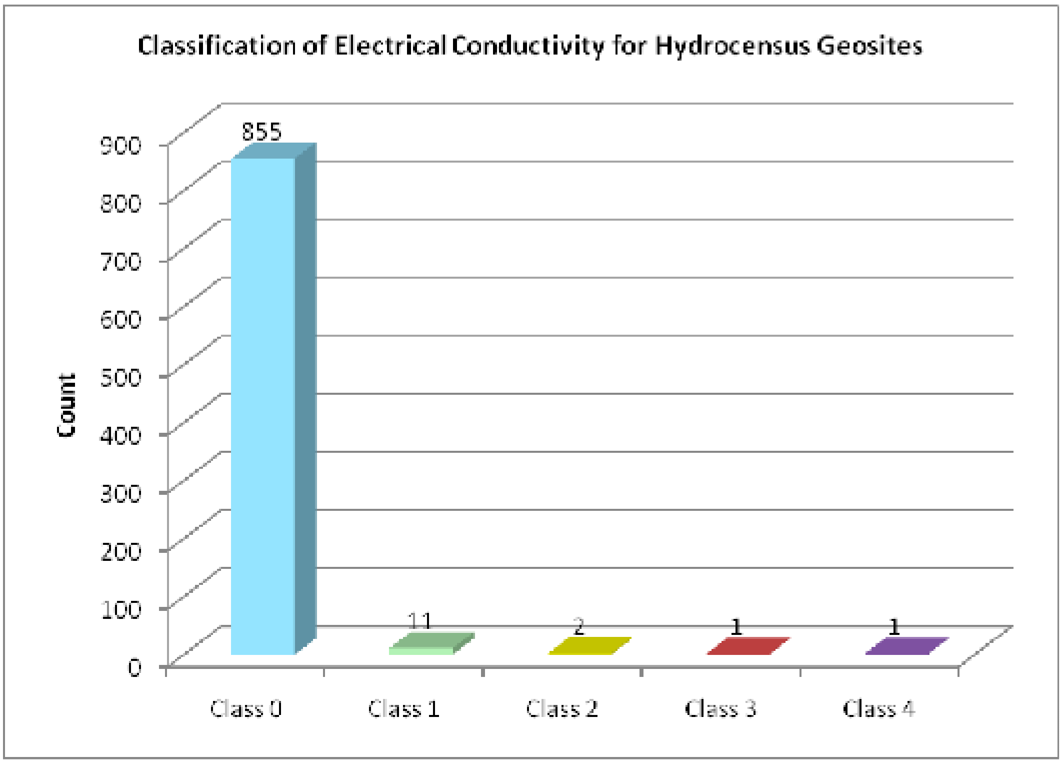

Figure 26: Electrical Conductivity results sample count per Water quality Class

Electrical Conductivity uses the ability of the water to conduct a current as indication of the dissolved ions and particles in the water. It is seen as a good general indicator of water quality in terms of its macro- and trace-element chemistry. A total of **870** samples were analysed for EC and **855 (98 %)** of the samples classifies as DWAF Drinking Class 0(Natural Water quality) for this constituent. This indicates that generally the whole Mbizana Local Municipality is pristine in terms of contamination from industrial activities which produce a range of macro element based chemicals often polluting aquifers. Interesting to note is that given the significant proportion of land cover which has been cultivated, there is little trace of agricultural activity in the sampled groundwater chemistry when Nitrogen and Phosphates concentrations are classified.

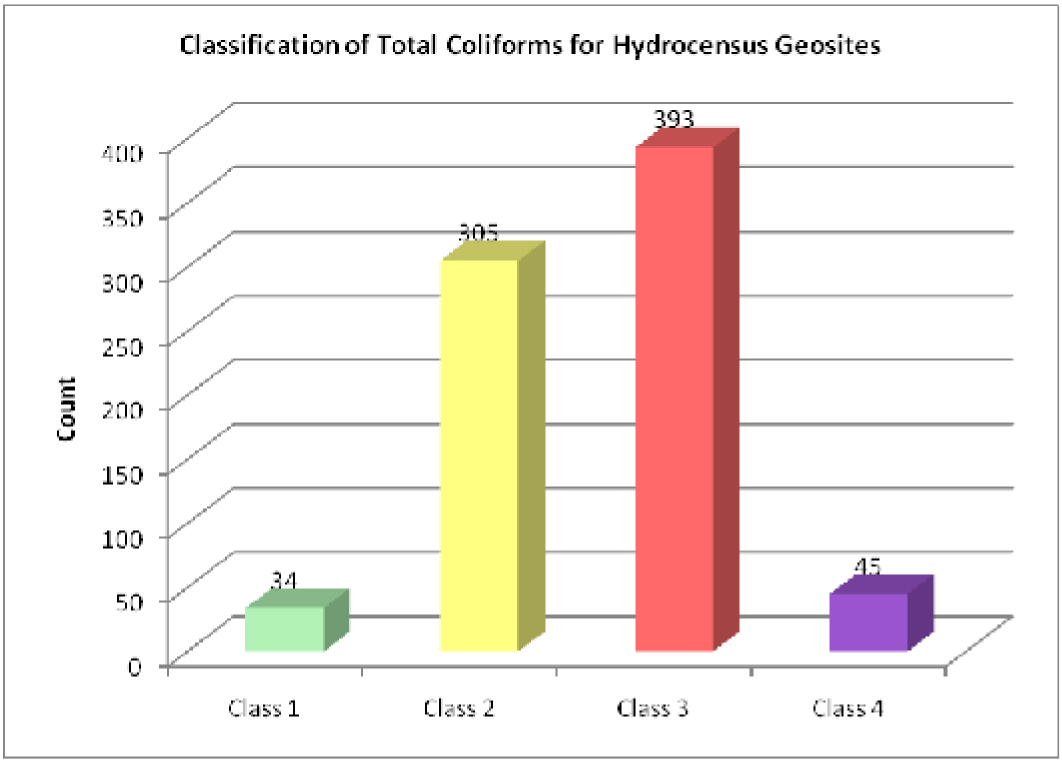

Figure 27: Total Coliforms results sample count per Water quality Class

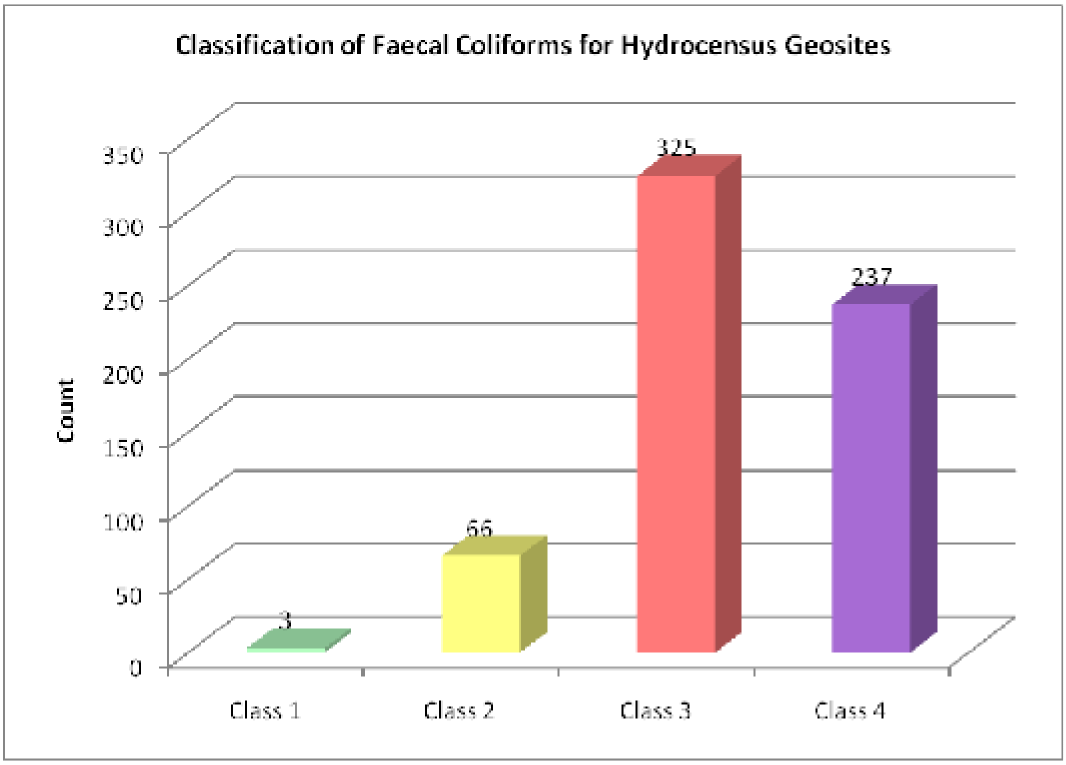

Figure 28: Faecal Coliforms results sample count per Water quality Class

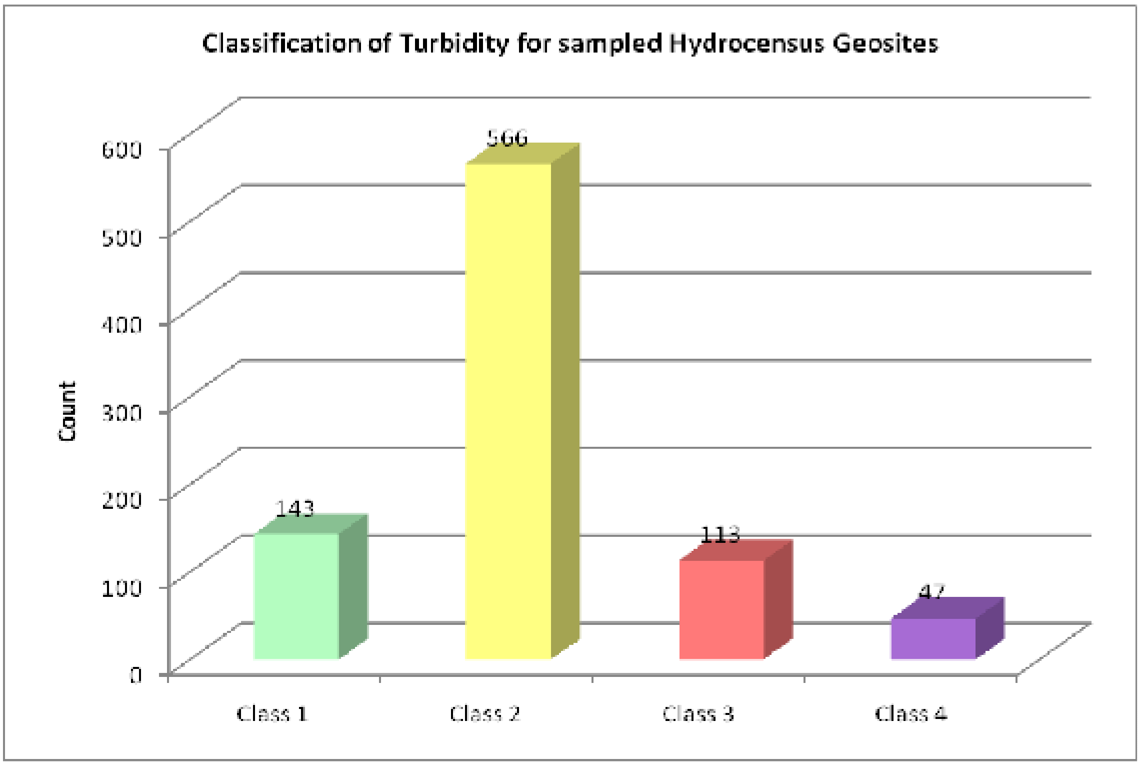

Figure 29: Turbidity Count results per Water quality Class

The constituents Total Coliforms, Faecal Coliforms and Turbidity have had the most pronounced negative effect on the overall water quality for the entire study area and their class counts are displayed in the above graphs. Total and Faecal coliform contamination are due to the presence of humans and animals at the water source. Often Coliform contaminated surface water sources such as dams or streams contaminate the groundwater via infiltration through the subsurface to the aquifer.

The positive aspect is that Total and Faecal Coliforms are some the constituents that are most easily treated prior to human consumption. Chlorination is the preferred and most cost effective method of treatment for Coliforms and can be implemented in a range of ways.

6.10 Groundwater Importance

In summary it can be said that, although low yielding in general, groundwater is a major domestic water source for rural communities in the study area although most use is historically from springs. Numerous groundwater supply projects for villages, schools and clinics are in progress where low yielding boreholes are sufficient to deliver sustainable water supply solutions. This indicates that groundwater will remain a major water source for the Mbizana LM and the importance thereof should be noted in water services planning and future monitoring and management programmes.

7 STUDY GAPS AND RECOMMENDATIONS

For the purpose of the EMF Status Quo Report, it is concluded that sufficient geological metadata and information have been sourced and referenced for the purpose of the current study.

The following study gaps can be listed for inclusion in additional more detailed studies in future:

1. More detailed mineral potential study based on research with reference to possible PGM deposits associated with the Insizwa Complex located just outside the northern boundary of the Mbizana LM as well as the extent of aggregate material that can be sourced from dolerite and tillite outcrops throughout the study area.

2. Further studies should include detailed slope analyses and Development Potential Zoning with reference to work done nationally by the Council of Geoscience.

3. The status of groundwater in water services development planning should be verified to ensure that the importance of the source for long term water supply to rural communities and facilities are known and taken into account in future planning.

8 METADATA

The following table gives indication of all data that was sourced and referenced for the compilation of this report. Figures and tables where this information was applied are also indicated.

Table 8: Summary of Data Sources and Referenced

METADATA REPORT - GEOLOGY SPECIALIST STUDY		
Feature	**Source**	**Figure**
Boundaries	Downloaded from: http://www.demarcation.org.za/index.php/downloads/boundary-data/eastern-cape-4/	1
Mbizana Geology	Council for Geoscience. 2016. Geological Shape Files for Mbizana, 1:250 000 scale. Council for Geosciences, Pretoria, South Africa.	2 to 5
Mineral points	Council for Geoscience (Geological Survey) South Africa. 2001. Digital Metallogenic Map of South Africa and The Kingdoms of Lesotho and Swaziland, 1:1000 000 scale. Compiled by: J.E.J. Martini, C.J. Vorster, W.R. Oosterhuis and L.G. Wolmarans	6
Terrain Morphology	Environmental Atlas data	7
Land Use		8
Land Cover		9
Soil Land Types		10
Soil Clay Content		11
Soil Depth		12
Slope Variance		13
Hydrogeological Units		14
Groundwater Resource Units	Alfred Nzo District Municipality Groundwater Management Plan, 2012	15
Groundwater Potential		16
Groundwater Potential derived dat		17
Rainfall Stations	Requested from Department of Water Services (DWS).	18
Quarternary Catchments	Requested from Department of Water Services (DWS).	19
Geosites	National Groundwater Archive (NGA) 2016 & Groundwater Resource Information Project (GRIP), 2008	21

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