TRANSNET

SCOPING AND ENVIRONMENTAL IMPACT ASSESSMENT

Scoping and Environmental Impact Assessment for the proposed Manganese Export Facility and Associated Infrastructure in the Coega Industrial Development Zone, Port of Ngqura and Tankatara area

DRAFT EIA REPORT

CHAPTER 8:

GEOHYDROLOGICAL ASSESSMENT

Summary

The prime objective of the groundwater specialist study is to assess the baseline groundwater conditions at the study site and the potential groundwater impacts associated with the proposed Manganese Ore Export Facility. The geohydrological report is based on existing data and literature, as well as a site visit. No additional boreholes were drilled nor were pumping tests of existing boreholes completed.

The geology which extends across the largest portion of the Coega Industrial Development Zone (IDZ) is the Bluewater Bay Formation (T-Qb), which comprises coastal limestone. This formation is underlain by the marine deposits of Alexandria Formation (Ta), which is then underlain by the mudstones of the Sundays River (Ks) and Kirkwood (J-kk) Formations. The basal bedrock to all these formations (which are essentially flat-lying) are the quartzites of the Peninsula Formation (Pe) of the Table Mountain Group. The Peninsula Formation is exposed at Coega Kop. The Coega River valley floor is in-filled with alluvium. Close to the Port of Ngqura, calcareous wind-blown sands occur (the Salnova Formation – Qs). The coastal dunes and Tankatara area comprise sand deposits of Tertiary / Quaternary age (T-Qg), similar to that of the Salnova Formation. The Coega Fault occurs in the south-western portion of the Coega IDZ.

The Department of Water Affairs (DWA) has geohydrologically classified the area as a fractured aquifer with a low borehole yield (0.1 – 0.5 ℓ/s). This refers to the borehole yields of the shallower geological formations. No intergranular aquifers are mapped by DWA for the area. Note the deeper Table Mountain Group Aquifer (known as the Coega Ridge Aquifer) is typically higher yielding than 0.1 – 0.5 ℓ/s. A zone around the Coega Fault is defined as having a higher borehole yield of 0.5 – 2.0 ℓ/s. The Sundays River (Ks) and Kirkwood (J-kk) Formations are essentially impermeable and form a confining layer over the Coega Ridge Aquifer. The groundwater within the upper formations is saline (and in terms of domestic supplies is classified as "dangerous water quality") and groundwater is not used in the area.

The potential impacts associated with the proposed development on groundwater can be associated with: dust fall out; stockpile leachate; stormwater outflows, accidental oil spillages/fuel leakages and proposed ancillary activities at the compilation yard. All of these potential sources of pollution need to be managed and potential impacts minimized. However none of these sources are considered a direct geohydrological threat as the upper geological layers contain very little groundwater and the shallow groundwater is saline. In addition, these upper clay rich formations may also prevent any contamination from reaching the important bedrock aquifer.

Groundwater may provide base flow to the Coega River, thus groundwater recharge and flow paths should not be negatively impacted by pollution. The plan for infiltration of "clean stormwater" is supported. It is also important to ensure that the groundwater recharge and superficial groundwater are not negatively impacted given that the Coega Ridge Aquifer occurs at depth and it is an important source of groundwater. A pre-cautionary approach therefore needs to be taken and the existing groundwater levels and quality must not be negatively impacted. With mitigation, the impacts associated with the proposed activities on groundwater are predicted to be of **low to very low** significance. The impact assessment of the proposed development on groundwater would remain the same if different positions are selected for the conveyor route and compilation yard (i.e. alternative options). The reason for this is that the groundwater importance essentially remains the same across the Coega IDZ.

If groundwater is to be considered for use at the site, then abstraction of groundwater from the Coega Ridge Aquifer will have to be considered as the upper aquifer is low yielding and saline. A separate study will be required to investigate the feasibility (and acceptability) of abstracting groundwater from the Coega Ridge Aquifer.

The existing groundwater monitoring must continue and the monitoring network increased in the vicinity of the manganese ore stockpile and compilation yard.

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CHAPTER 8: GEOHYDROLOGY

This chapter presents the geohydrological specialist study undertaken by Julian E. Conrad and Lesley Gibson from GEOSS - Geohydrological& Spatial Solutions International (Pty) Ltd., under appointment to CSIR, as part of the Environmental Impact Assessment (EIA) for the proposed manganese ore export facility and associated infrastructure in the Coega Industrial Development Zone (IDZ), Port of Ngqura and Tankatara area (**Map 8.1**).

8.1 INTRODUCTION AND METHODOLOGY

8.1.1 Scope and Objectives

The prime objective of this specialist study is to assess the baseline groundwater conditions at the study site and the potential impacts of the proposed Manganese Ore Export Facility on groundwater (**Map 8.2**). Map 8.2 shows the distribution of the Industrial Development Zones, main infrastructure, sampling points and data points from the National Groundwater Archive. The site allocated to the manganese ore stockyard is located north of the N2 national freeway and the Coega Salt Pans, and will be situated on undeveloped land. The Tankatara property is also taken into consideration when describing geohydrological conditions.

8.1.2 Terms of References

The following Scope of Work is based on the Terms of Reference (ToR), which have been specified for this specialist study on groundwater:

- Hydrogeological characterisation of aquifers (types, sensitivity, vulnerability, recharge, flow direction and flow into the ocean,) and groundwater (quality, quantity, use, potential for industrial or domestic use) in the area surrounding the proposed development;
- Impact of manganese ore spills (manganese ore handling, conveyors, rail cars) and dust fall-out from manganese ore stockpiles on groundwater;
- Impact of leachate from stockpiles on groundwater;
- Downstream impact of stormwater run-off from the various areas of the proposed temporary and permanent manganese ore export facilities on groundwater;
- Implications for groundwater usage (if any) in the locally affected area;
- Assess the consequences and significance of potential groundwater contamination;
- Recommend mitigation and remedial measures to reduce potential impacts on the groundwater regimes for the proposed facilities;
- Recommend groundwater management and monitoring for the proposed site.

8.1.3 Approach and Methodology

The issues to be investigated as part of the groundwater specialist study include the following:

- Impact of dust fall-out from manganese ore dust on groundwater (the impact assessment will include results from the atmospheric modelling study, which will identify potential fall-out of pollutants and dust onto surface water bodies, leading to potential infiltration to groundwater).

- Impact of leachate from stockpiles on groundwater
- Downstream impact of stormwater run-off from the terminal on groundwater (if any).
- Implications for groundwater usage (if any) in the locally affected area.

A number of tasks were completed during the study and these included:

Task 1: Obtaining all relevant data to the project (i.e. obtaining data from the National Groundwater Archive (NGA), the Water Quality Management System (WQMS), the Water Information Management System (WIMS) and the Water Authorisation and Registration Management System (WARMS)). The specialist also obtained relevant geological and geohydrological maps and searched for relevant geohydrological reports.

Task 2: A site visit was undertaken on the 24th – 26th April 2012 and a hydrocensus was completed (i.e. a visit to all boreholes within the study area to measure yields and water quality (pH, electrical conductivity (EC), total dissolved solids (TDS) and oxygen reduction potential (ORP)). This also assisted with confirmation of groundwater use in the area. The potential impacts from the proposed project on the groundwater, using international and national standards as a benchmark where relevant, have been identified.

Task 3: Analysis of all the data using geohydrological methods.

Task 4: Documentation of the results in a report. Management actions to avoid/reduce negative impacts are outlined. Monitoring requirements, to ensure that the proposed management actions are adhered to, are provided and the certainty of the potential impact predictions has also been assessed.

8.1.4 Assumptions and Limitations

The geohydrological appraisal is based on previous studies and available literature. There is on-going monitoring of groundwater resources in the Coega IDZ and dedicated monitoring boreholes are used for this purpose. These boreholes provide useful information. It is not the intention of this study to drill new monitoring boreholes or to expand the existing monitoring network. However the monitoring network will be reviewed and recommendations made with regard to enhancing the network as part of this specialist study. The main assumption is that previous work completed is correct and that geological and geohydrological conditions are fairly homogenous across the study area.

8.1.5 Source of Information

The geological information has been obtained from geological maps of the Council for Geoscience. The groundwater related data and maps have been obtained from the Department of Water Affairs and mainly from the work of SRK Consulting (2006, 2009 and 2011). A surface hydrology report by Scherman (2010) was also reviewed.

8.1.6 Declaration of independence

The declaration of independence by the geohydrological specialist is provided in Box 8.1 below:

BOX 8.1: DECLARATION OF INDEPENDENCE FOR GEOHYDROLOGICAL IMPACT ASSESSMENT

I Julian E. Conrad declare that I am an independent consultant and have no business, financial, personal or other interest in the proposed manganese ore terminal, Port of Ngqura, application or appeal in respect of which I was appointed, other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of my performing such work.

Name: Julian E. Conrad (SACNASP: 400159/05)

8.2 DESCRIPTION OF PROJECT ASPECTS RELEVANT TO GEOHYDROLOGICAL IMPACTS

Broadly speaking groundwater can theoretically be impacted in two ways by the proposed project, namely:

- Over-abstraction (i.e. groundwater abstraction exceeds recharge rates) which can result in the alteration of groundwater flow directions, groundwater gradients etc.
- Quality deterioration (i.e. anthropogenic activities negatively impacting groundwater quality).

Currently there is no groundwater use in the IDZ and Tankatara area from the shallow or deeper aquifers.

The proposed Manganese Ore Export Facility (including the compilation yard, stockyard etc.) and associated activities can potentially impact the groundwater quality of the shallow aquifer. Possible contamination sources include: dust fall out; stockpile leachate; stormwater outflows and oil spillage/fuel leakage associated with the compilation yard and stockyard workshops. Although the upper aquifer is saline and not recommended for use, it overlies a high yielding and good quality aquifer and a pre-cautionary approach is recommended. Thus all potential groundwater polluting activities need to be mitigated.

8.3 DESCRIPTION OF THE AFFECTED ENVIRONMENT

8.3.1 Geological Setting

The bedrock around Port Elizabeth consists of the Peninsula Formation (Pe) quartzitic sandstones of the Table Mountain Group (TMG). This formation consists of coarse-grained super-mature quartzitic sandstone and is relatively resistant to erosion. It forms the bedrock of Algoa Bay and emerges as outcrops in the bay as the islands of St Croix, Jahleel, Bird and Brenton and inland as the Coega Kop. The areas between these islands are filled with recent marine deposits (Alexandria Formation (Ta)), which directly overlie the mudstone of the Sundays River (Ks) and

Kirkwood Formation (J-kk). The geology of the Coega IDZ is characterised by coastal limestone (Bluewater Bay Formation (T-Qb) and Tertiary sands (T-Qs), overlaid by calcareous sands (Salnova Formation - Qs) blown onshore. (SRK, 2006 & 2007; CES, 2008 & Almond, 2010). The geology is shown conceptually on Figure 8.1 (generalised west-east cross section across the study area) and is depicted on Map 8.3. The cross-section line is not shown on the geological map, as this figure is a conceptual cross-section and is therefore neither to scale nor based on an exact profile line.

The Salnova Formation contains a wide range of sandy and conglomeratic beach deposits, and it also outcrops at different points along the coastline stretching from the Marine Growers abalone farm towards Mellville in the north-east.

The limestone-rich estuarine and coastal marine sediments of the Alexandria Formation (Ta) overlie a large part of the study area, with an average thickness ranging from 7 m to 10 m. package of calcretes, shelly sands, gravels, silts and clays which is underlain directly by the Sundays River and Kirkwood Formations. The Alexandria Formation rocks have a low permeability, leading to a high residence time of the groundwater in contact with the host rock, which results in increased potential for leaching salts from the formation. Groundwater yields are therefore generally limited and of poor quality.

The Kirkwood Formation (J kk) and Sundays Formation (Ks) underlie the majority of the study area at depth; however they largely occur at or near the surface along the Coega River Valley and Brakrivier margins. The Kirkwood Formation mainly consists of low permeability reddish-brown mudrocks with some greenish-grey sandstones, whilst the Sundays River Formation mainly consists of grey to greenish-grey mudrocks and some sandstones. The Sundays River and Kirkwood Formations range in thickness from approximately 10 m in the vicinity of Coega Kop > 1 000m towards the centre of the Algoa Basin to the south.

Table 8.1 lists the geological formations within the study area (SRK, 2006).

Table 8.1 Geological description of the geological formations found within the study area

Age	Group	Formation	Symbol	Description
Quaternary				Alluvium
		Salnova	Qs	Marine estuarine sand and gravel
			T-Qg	Intermediate and low-level fluvial terrace gravel
		Bluewater Bay	T-Qb	Alluvial sheet gravel and sand
Tertiary		Alexandria	Ta	Calcareous sandstone, shelly limestone and conglomerate
Cretaceous	Uitenhage	Sundays River	Ks	Greenish-grey mudstone & sandstone
		Kirkwood	J-Kk	Reddish and greenish mudstone & sandstone
Ordovician	Table Mountain	Peninsula	Op	Quartzitic sandstone

The Coega Fault extends from west of the Groendal Dam eastwards towards the coast, dipping at between 30° and 60° for about 120 km. It is a normal tensional fault with a vertical southward throw of 500 m to 1 000 m. This geological feature will be taken into account during the design of large structures by means of conducting geotechnical investigations within the area concerned.

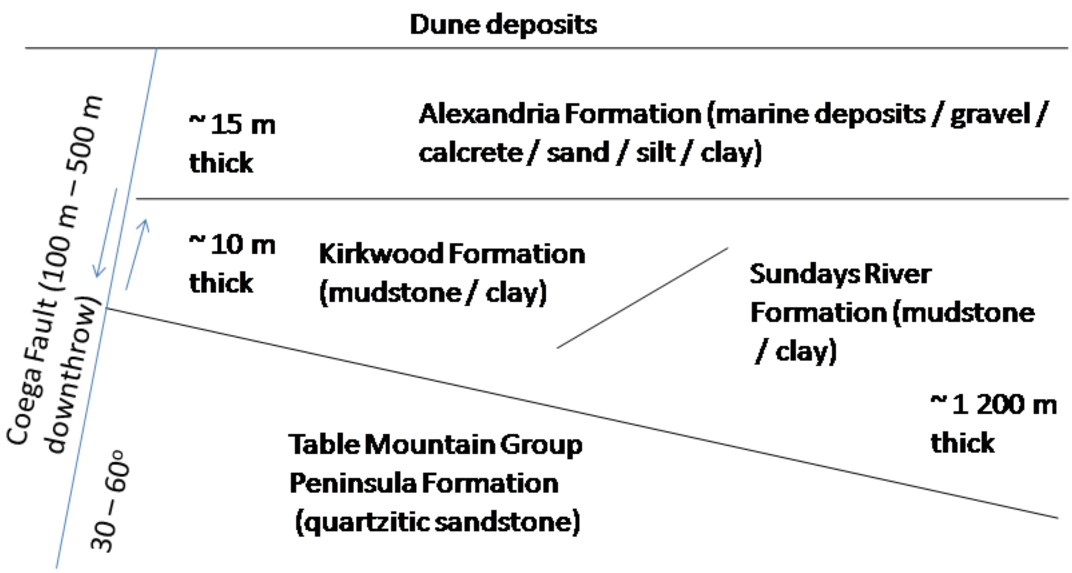

Figure 8.1 Conceptual geological setting (in cross-section: West – East)

In the south-eastern coastal region, sandy soils with variable depth and deep red sandy clay loams overlying limestone, are common. The southern coastal belt is characterised by coastal sands and sandy soils, lime-containing lithosols and weakly developed soils on rock.

8.3.2 Surface water

The Coega catchment area is approximately 45 km long, 15 km wide and has a total area of about 550 km^2. The Coega River, which is a relatively small sand-bed river, is the most significant surface water feature associated with the Coega IDZ. The Coega River classification, based on preliminary river classification guidelines, ranges from moderately modified (i.e. C classification) in the upper reaches to critically modified (i.e. F classification) in the lower reaches at the salt works facility. (SRK, 2007)

The IDZ is underlain by calcrete, sand and gravel deposits which, in turn, overlie low permeability clays. These clays limit the vertical infiltration of rainwater and induce a horizontal groundwater flow towards the river channel. Consequently, rapid run-off takes place following precipitation. Due to the limited infiltration of rainfall, a significant fluctuation in groundwater level does not occur. Any contaminants originating from the planned large-scale industrial development could infiltrate the sandy subsurface but would eventually emanate in seepage in the Coega River and beach environments rather than contaminating the groundwater.The hydrochemistry of the Coega River water is dominated by sodium and chloride with the actual concentrations dependent of the flow volume and distance from the sea.

No surface water is currently utilised in the remainder of the IDZ, nor is it intended that surface water be utilised in the future.

8.3.3 Groundwater

8.3.3.1 Occurrence

The south-western portion of the IDZ falls within the Uitenhage Subterranean Groundwater Control Area (USGWCA). The extent of the USGWCA is shown on Map 8.1. The Uitenhage Artesian Basin (UAB) is a complex, fractured rock aquifer and South Africa's most important artesian groundwater basin. It covers an area of approximately 3 700 km^2 in the Uitenhage and Port Elizabeth districts. The UAB is sub-divided hydrogeologically by the Coega Fault (see Map 8.3) into two main aquifer systems, namely:

- the relatively shallow <u>Coega Ridge Aquifer</u> north of the Coega Fault (Figure 8.2), and
- the deeper <u>Swartkops Aquifer</u> to the south of the fault. The Swartkops Aquifer is further sub-divided into the:
    - Kruisrivier Unit and
    - Bethelsdorp Unit.

The two aquifer systems (i.e. Coega Ridge Aquifer and the Swartkops Aquifer) function independently from one another, with boreholes in one unit not being impacted by abstraction from boreholes in another unit. Large scale abstraction occurs from the Coega Ridge Aquifer (e.g. at Uitenhage, Sandfontein, Amanzi Estate, Coega Kop and Wells Estate) and in the past, this deeper artesian aquifer has been over-exploited, resulting in a reduction of artesian yields.

A strong degree of hydraulic connectivity exists between the boreholes along the Coega Ridge. This artesian system was protected under Government Proclamation No. 260 of 1957 and No. 958 of 1958 when the USGWCA was proclaimed. However the rights of access to this water will have altered in the light of the National Water Act (Act No. 36 of 1998). The groundwater quality from the Coega Ridge Aquifer is ideal for domestic purposes.
The Department of Water Affairs (DWA) geohydrological map of the area indicates that the major portion of the study area is underlain by a fractured aquifer and borehole yields in the range of 0.1 ℓ/s to 0.5 ℓ/s. The aquifer yield is slightly higher (0.5 ℓ/s to 2.0 ℓ/s) in the vicinity of the Coega Fault. Map 8.4 indicates the aquifer type and associated borehole yields.

According to SRK (2007 & 2010), the study area is underlain by a shallow primary alluvial aquifer which generally occurs within 3 m to 5 m below the surface, i.e. just as above the interface of the permeable sands and underlying impermeable clays (SRK, 2007). The groundwater flows in the same direction as the surface water drainage, which is towards the southeast of the study area. It is understood that groundwater levels do not fluctuate significantly (low transmissivity and storage) as a result of reduced infiltration of rainfall. These levels are nevertheless expected to rise and fall between 3 m and 4 m during substantial rainfall.

Beneath this low yielding aquifer is an impermeable layer (i.e. an aquiclude) which consists of a series of eastward-thickening Cretaceous formations (Uitenhage Group), up to 1 200 m thick near the coast (see Table 8.1) and confines the deeper aquifer, resulting in artesian conditions occurring on drilling into the Table Mountain Group Coega Ridge Aquifer (TMGA). It is understood to generate limited amounts of poor quality water (Maclear, 2004).

Groundwater is currently not utilised in the IDZ, nor is it recommended that the shallow aquifer be utilised in the future.

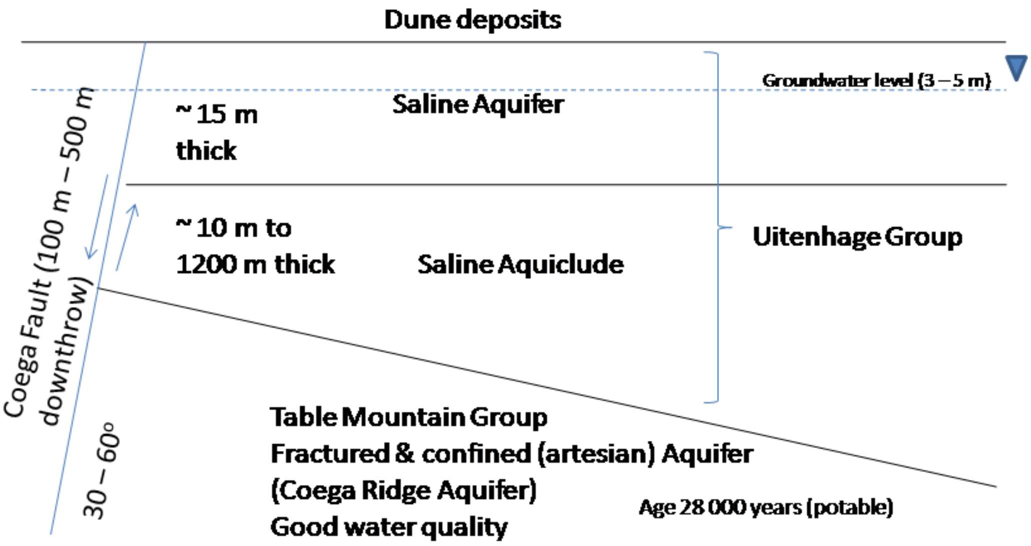

Figure 8.2 Conceptual hydrogeological setting (in cross-section West - East)

Groundwater levels at Coega are generally about 3 to 7 m below surface (**Table 8.2**), i.e. above the contact between the permeable sands and the underlying impermeable clays. **Map 8.5** shows the regional depth to groundwater level, as well as groundwater levels measured in boreholes. **Map 8.6** shows the groundwater level as metres above mean sea level. The groundwater flow direction is to the southeast, following the surface water drainage direction and is indicated on **Map 8.6**.

Table 8.2 Monitoring borehole details and water levels (SRK, 2011)

Borehole_ID	Latitude (south)	Longitude (east)	Description	Water level (mbgl)*	Average Water level (2011) (mamsl)**
CM-1	33.7580	25.6649	Coega Brick (not usable)	-	-
CM-2	33.7576	25.6463	Coega Post Office	3.70	17.49
CM-3	33.7578	25.6218	Swartkoppe Farm	6.82	23.38
CM-4	33.7412	25.5974	DW Steenmakery	6.96	33.44
CBM-1	33.7598	25.6715	Coega Brick	3.23	17.98
CBM-3	33.7560	25.6665	Quarry	3.66	21.52
CBM-14	33.7606	25.6583	Coega Brick	4.09	11.26
BH 302/42/1	33.7711	25.6251	TMG Aquifer	artesian	-
BH 314/0/1	33.7658	25.6128	TMG Aquifer Coegakop	artesian	-

* = metres below ground level ** = metres above mean sea level.

8.3.3.2 Groundwater Quality

Monitoring of the shallow groundwater quality has taken place in the area since 2000 (SRK, 2011). The monitoring activities include:

- Groundwater monitoring at seven boreholes, six times a year.

- Surface water monitoring at nine points along the Coega River, six times a year and
- Sediment sampling at 15 points along the Coega River once a year.

The shallow groundwater is consistently characterised by a high salinity (electrical conductivity (EC) range is 1 148 mS/m to 5 480 mS/m), a high total dissolved solids content (TDS range = 6 904 mg/ℓ to 39 170 mg/ℓ), and the presence of microbiological contamination.

The 90th percentile values for parameters measured in existing groundwater monitoring boreholes within the Coega IDZ are presented in **Table 8.3.** Refer to **Table 8.2** for the location of those boreholes (note that the two artesian TMGA boreholes are not part of the regular monitoring that occurs within the Coega IDZ). The poor quality of the shallow aquifer is evident. Drinking water standards are also listed in **Table 8.3** and the results that exceed the standards are indicated in a bold typeface. From **Table 8.3** is can be seen that the groundwater has already been impacted by anthropogenic activities. Note there are high nitrate + nitrite concentrations; microbiological contamination and diesel and gasoline present in some of the groundwater samples. The hydrochemistry of the shallow groundwater is dominated by sodium and chloride with naturally occurring concentrations of calcium, magnesium, potassium, phosphorous, manganese, iron and aluminium. These trace metal concentrations are believed to occur as a result of the natural soil-water interactions, as opposed to industrial pollution (SRK, 2007).

Due to the water quality issues (**Map 8.7**), neither the surface water nor the shallow groundwater is considered as an exploitable water resource. The underlying clays results in an aquiclude that confines (and protects) the underlying Coega Ridge Aquifer (Table Mountain Group) which generally produces artesian water of potable quality. Groundwater quality in the Coega Ridge Aquifer deteriorates relatively little along the flow path from west to east and has been carbon fourteen dated at 28 000 years near Coega Kop. In general, the water is mildly acidic as is typical of groundwater derived from the Table Mountain Group Aquifers. Scherman (2010) refers to the groundwater within this system as excellent (potable water quality), with a requirement for hardening as a result of the corrosive and acidic characteristics of the aquifer.

8.3.3.3 Groundwater Vulnerability and Classification

Although the groundwater levels are shallow and soils are permeable in places, indicating that the groundwater will be vulnerable to surface and sub-surface based contamination sources, the shallow groundwater is actually saline and very limited. Given that the regional flow direction of the deeper Coega Ridge Aquifer is towards the coast, and that the aquifer is (a) protected by an aquiclude (a thick clay layer), and (b) is an artesian system, the potential for contamination of this aquifer is practically non-existent (i.e. not vulnerable to contamination). The deeper artesian aquifer is currently being considered as a source of water for the City of Port Elizabeth (Kainossa Consulting, 2012, pers. comm.), thus strict measures need to be in place to ensure that groundwater contamination of the Coega Ridge Aquifer is prevented. A precautionary approach is recommended and all measures must be taken to prevent further contamination of the shallow aquifer.

Detailed attention was not given to the deeper lying Coega Ridge Aquifer as a potential source of water for use on the site and a separate study will be required to address this question, as many factors need to be taken into consideration.

8.3.3.4 Groundwater Importance

From the socio-economic perspective the shallow groundwater is not utilized. It is not used for domestic purposes, municipal supply or for agricultural purposes. This was confirmed during a field visit on the 24th – 26th April 2012. All borehole data was obtained from the National

Groundwater Archive (NGA) and checked in the field. The high salinity of the shallower groundwater renders it unfavourable as a source of water.

The TMGA occurs at significant depth and is protected by an aquiclude. However it is an important aquifer to protect as it is high yielding and of ideal quality.

Groundwater may play a role into providing base flow to the Coega River, especially in low rainfall periods, as the groundwater level is shallow. The implication of groundwater contributing to the surface water is that it can act as a pathway and "transport medium" for potential contamination to the surface water resources.

Table 8.3 The 90th percentile values for groundwater parameters measured at monitoring boreholes (SRK, 2011).

PARAMETERS	UNITS	SABS 241				CM-2	CM-3	CM-4	CBM-1	CBM-3	CBM-14
		Acc. Lim.		Max. Lim.							
PHYSICAL PARAMETERS											
pH	standard units	5.0	9.5	4.0	10.0	8.00	7.90	7.82	7.95	7.74	7.95
Conductivity at 25˚C	mS/m		150		370	2390.00	1148.00	1386.30	5480.00	4345.60	1579.00
Apparent Colour	Pt – Co units		20.0		50.0	451.40	312.40	269.00	464.60	500.00	500.00
Turbidity	NTU		1		10	142.80	193.20	234.70	180.00	456.00	180.00
Total dissolved solids at 180˚C	mg/L		1 000		2 400	14972.00	6904.00	8114.00	39170.00	31531.80	9554.40
Total Alkalinity	mg/L		n/s		n/s	1877.10	157.00	472.60	406.00	665.80	558.00
Carbonate Alkalinity	mg/L		n/s		n/s	0.00	0.00	0.00	0.00	0.00	0.00
Bicarbonate Alkalinity	mg/L		n/s		n/s	2288.72	191.54	535.67	491.17	708.40	669.78
Carbonate Hardness	mg/L		n/s		n/s	1877.10	161.00	489.30	408.60	665.80	558.00
Non-carbonate hardness	mg/L		n/s		n/s	2171.20	1818.00	2028.40	8838.60	8517.90	2396.60
Total Hardness	mg/L	20	300		650	3634.70	1950.00	2499.80	9524.50	8964.80	3300.50
Chemical Oxygen Demand	mg/L		n/s		n/s	379.60	317.00	257.60	726.50	644.40	259.00
CHEMICAL PARAMETERS											
Chloride	mg/L		200		600	7160.00	3529.10	4415.70	22174.40	15320.00	5434.50
Sulphate	mg/L		400		600	1761.50	563.00	1049.00	3138.80	3395.00	868.00
Fluoride	mg/L		1.0		1.5	6.66	3.44	3.00	5.78	5.96	3.00
Calcium	mg/L		150		300	453.04	382.00	303.06	1024.20	1240.80	625.50
Magnesium	mg/L		70		100	644.59	254.54	406.60	1835.00	1390.42	467.50
Sodium	mg/L		200		400	4960.50	2194.00	2263.60	10723.50	8713.80	1967.50
Potassium	mg/L		50		100	129.00	70.00	52.40	356.50	252.60	76.50
Phosphorus (total)	mg/L		n/s		n/s	3.00	1.49	1.70	5.26	7.99	3.18
Iron (total)	mg/L		0.20		2.00	1.84	1.65	1.82	2.21	2.66	2.64
Manganese (total)	mg/L		0.100		1.00	0.36	0.86	0.39	1.22	0.30	0.64
Aluminium (total)	mg/L		3.00		5.00	3.33	3.12	2.99	4.09	5.79	4.65
Boron	mg/L		n/s		n/s	6.05	1.00	2.08	6.61	6.10	2.16
Chromium	mg/L		0.1		0.5	0.11	0.11	0.11	0.11	0.11	0.11
Mercury	mg/L		2.0		5.0	0.00	0.00	0.00	0.00	0.00	0.00

PARAMETERS	UNITS	SABS 241				CM-2	CM-3	CM-4	CBM-1	CBM-3	CBM-14
		Acc. Lim.		Max. Lim.							
Lead	mg/L		0.050		0.100	0.18	0.11	0.09	0.34	0.31	0.09
Zinc	mg/L		5.00		10.0	0.07	0.06	0.06	0.08	0.08	0.05
PARAMETERS	**UNITS**	**SABS 241**				**CM-2**	**CM-3**	**CM-4**	**CBM-1**	**CBM-3**	**CBM-14**
		Acc. Lim.		Max. Lim.							
NUTRIENTS											
Nitrate & Nitrite	mg/L		10.0		20.0	76.60	18.70	14.82	80.02	61.00	13.73
Ammonia	mg/L		1.00		2.00	1.04	1.00	0.80	1.55	1.00	0.76
ORGANIC PARAMETERS											
Diesel range organics (DRO) C_{10} - C_{28}	µg/L		n/s		n/s	81.00	6299.50	4242.80	N/A	N/A	N/A
Gasoline range organics (GRO) C_6 - C_{10}	µg/L		n/s		n/s	29.00	41.60	45.30	N/A	N/A	N/A
Total Petroleum Hydrocarbons (TPH)	µg/L	*1	50	*2	600	215.50	6349.50	4267.20	N/A	N/A	N/A
Total Dissolved Organic Carbon	mg/L		10		20	120.70	15.00	30.45	36.66	67.20	42.58
BACTERIOLOGICAL PARAMETERS											
Total Coliforms	counts per 100mL		10		100	440.00	2100.00	2840.00	50.00	1200.00	1600.00
Faecal Coliforms	counts per 100mL		1		10	50.00	360.00	50.00	50.00	460.00	170.40
E. Coli	counts per 100mL				1	50.00	50.00	50.00	50.00	50.00	50.00
Total Bacteria	counts per 100mL		1 000		10 000	5460.00	19000.00	20000.00	1140.00	8510.00	4000.00
CG – Confluent Growth											
n/s – No Standard											
*** - Dutch Guideline Levels (*1 – Optimum Level, *2 – Action Level)**											

8.4 KEY ISSUES

The following key issues that may impact the groundwater quality are listed below:

- Potential impact of manganese ore spills (due to manganese ore handling, conveyors, rail cars etc.) and dust fall-out from manganese ore stockpiles on groundwater.
- Potential impact of leachate from manganese ore stockpiles on groundwater.
- Potential impact of stormwater run-off from the various areas of the proposed terminal on groundwater.
- Potential groundwater pollution from diesel spills or oil (from trains and refuelling at the compilation yard) and from ancillary activities
- Potential implications for groundwater usage in the locally affected area.

The groundwater within the upper formations is saline (i.e. in terms of domestic supplies, it is classified as “dangerous water quality”) and groundwater is not used in the area. No impacts associated with the proposed project on groundwater users in the area are therefore anticipated.

8.5 APPLICABLE LEGISLATION AND PERMIT REQUIREMENTS

If a more detailed study concludes that groundwater abstraction from the deeper Coega Ridge Aquifer can be pursued and successful boreholes are drilled, a groundwater use licence will be required from the Department of Water Affairs as per Section 21 of the NWA (Act 36 of 1998). However if no groundwater abstraction is planned, no approval is required.

8.6 GROUNDWATER IMPACT ASSESSMENT

The following impacts of the proposed project on groundwater are predicted and assessed below.

8.6.1 Impact of dust fall out on groundwater

Impact assessment

Dust will be generated during construction activities, mainly from vehicle dust entrainment, demolition, excavation, ground levelling etc. Particulates emitted to the atmosphere will eventually be deposited on the ground and other surfaces. In a rainfall event, these particles may percolate into the ground and reach the groundwater.

During the operational phase, manganese ore dust from the various activities associated with the proposed Manganese Ore Export Facility (e.g. transport of the ore in uncovered wagons, stockpiling process (both stacking and reclaiming), conveyor transfers, ship loading, manganese ore spillages etc.) can accumulate on the ground and other surfaces. During a rainfall event, the dust can be washed off and percolate into the ground and possibly reach the saturated zone. The air emissions specialist study (Chapter 5) revealed the following:

The main emissions to air from operations at the proposed Manganese Ore Export Terminal result from wind-entrained dust, materials handling and fuel combustion from diesel locomotives at the compilation yard. These emissions are estimated using emission factors combined with site-

specific information such as the silt and moisture content of the material being handled and the proposed dust control technologies. With regard to dust control, the Manganese Ore Export Terminal design includes accepted best practice at all stages of the ore handling process. Estimates for the Manganese Ore Export Terminal compare the emission from the different activities with installed dust control equipment and with the addition of dust management using water and chemical surfactants. The added controls show a marked reduction in the estimated emission for dust. In both cases the stockyard is the biggest emitter of dust, with the stockpiles the largest source followed by stacking and reclaiming. A summary of emissions is shown in Table 8.4.

Table 8.4 Summary of emissions from the proposed Manganese Ore Export Facility (tons per annum)

Pollutants	Compilation Yard	Manganese Ore Export Facility	
		Standard mitigation	Full mitigation
Benzene	0.337	0.00	0.00
Toluene	0.073	0.00	0.00
Ethyl benzene	0.003	0.00	0.00
Xylene	0.013	0.00	0.00
Oxides of nitrogen (NO_x)	90.190	0.00	0.00
TSP (dust)	0.00	25 852.7	1 058.5
PM_{10}	1.27	4 252.6	172.5
$PM_{2.5}$	1.27	10.0	1.3

The risk of groundwater contamination from manganese ore dust fall out will be very low. Groundwater recharge rates for the area are low and the dust will be significantly diluted by rainfall. As the overland flow component is greater than the recharge rate, it is highly improbable that dust will contaminate groundwater. The low permeability of the vadose zone will also result in the groundwater recharge volume being less than 5% of precipitation. In addition the main aquifer of concern (i.e. the Coega Ridge Aquifer) is well protected by a thick impermeable clay layer. The anticipated dust outfall poses a negligible risk with regard to the shallow groundwater. Given the above, the significance rating of the impact of dust fall out on groundwater is predicted to be **low** even without mitigation. This statement is applicable to all areas of the manganese ore process (i.e. transportation areas, compilation yard, stockpiles etc.).

Management actions/mitigation measures

From a groundwater perspective, a precautionary approach is suggested and dust suppression is recommended. Details on dust suppression measures proposed by the proponent are described in Chapter 2 (Project Description) and Chapter 5 (Air Emissions Specialist Study). This activity will not negatively impact the shallow or deep groundwater, even if chemicals are added to the water used for dust suppression. The use of dust suppression additives is advantageous over water-only dust suppression systems by requiring much less water to be just as effective. The dust suppression additives consist of surfactants and binding agents that overcome the natural hydrophobic characteristics inherent in dust particles, resulting in fuller wetting and dramatic levels of dust reduction. If stockpiles are to be watered during stacking and reclaiming, some leachate may be generated and this is discussed in section 8.6.2. Wetting of unsurfaced roads is also encouraged (if possible fresh water should be used).

With effective implementation of these mitigation actions, the impact of dust fallout as a result of the proposed development on groundwater is predicted to be of **very low** significance.

8.6.2 Impact of Stockpile leachate on groundwater

Impact assessment

The leachate from the stockpile is a potential threat to groundwater due to the high concentration of metal ore. Relatively high leachate volumes can be generated during high rainfall events. However, under normal conditions, if the dust suppression measures are managed correctly, leachate should not be generated. To try and quantify the leachate concentrations, a water leaching test was carried out (a ratio of 1:5 (ore sample to water)). Most parameters were found to be below detection limits and the results of the remaining parameters are listed in **Table 8.5** (in order of decreasing concentration).

Table 8.5 Leachate test results (all parameters below detection limits have been excluded).

Parameter	Value (ppm)	Parameter	Value (ppm)
Ca	31.4	Mn	0.54
Mg	13.5	B	0.18
Na	12.9	Sr	0.10
Si	8.45	Fe	0.08
K	2.55	Al	0.01

As mentioned previously the hydrochemistry of the shallow groundwater is dominated by sodium and chloride with naturally occurring concentrations of calcium, magnesium, potassium, phosphorous, manganese, iron and aluminium. From the leachate test, it can been seen that Ca, Mg, Na, Si and K concentrations may increase in the vicinity of the stockpiles however these parameters already occur naturally and will not have a significant negative impact.

Without mitigation, the impact of the proposed stockyard leachate on the shallow groundwater is predicted to be of **medium** significance.

Management actions/mitigation measures
The stockpiling of the manganese ore is the most significant activity that can impact groundwater. During significant rain events, ore dust and particles could reach the water table. For this reason the stockpiles must be placed on an impermeable barrier (e.g. PVC layer). In addition, any leachate from the stockpile must be collected and treated appropriately. The stockpile leachate must not be discharged into the ground. If the above two measures are put in place the risk of groundwater contamination is low. The above mitigation measures are already proposed by the proponent.

As an additional precautionary measure, it is recommended that monitoring boreholes be installed in the vicinity of the stockpiles so that baseline data in that area can be collected. The monitoring boreholes will also detect any contamination in the unlikely event that it occurs. Five groundwater monitoring sites have been selected. **Map 8.9** indicates optimal positions for the monitoring boreholes and their approximate positions have been listed in **Table 8.6.** The boreholes must be drilled to the top of the aquiclude and fully screened. Prior to the installation of the additional monitoring boreholes, design specifications and a sampling protocol must be developed.

Table 8.6 Proposed stockyard groundwater monitoring sites.

Site_ID	Latitude	Longitude	Purpose
SY_MW1	-33.762061°	25.663294°	Up-gradient groundwater monitoring site
SY_MW2	-33.763884°	25.668976°	Groundwater monitoring between the stock yard and the Coega River
SY_MW3	-33.767181°	25.670530°	Groundwater monitoring between the stock yard and the Coega River
SY_MW4	-33.770078°	25.669024°	For monitoring groundwater within the southern portion stock yard. This site will have to be optimally sited so that is it not damaged during the stock piling operation.
SY_MW5	-33.767042°	25.665349°	For monitoring groundwater within the central portion of the stock yard. This site will have to be optimally sited so that is it not damaged during the stock piling operation.

With effective implementation of these mitigation actions, the impact of the proposed development on groundwater as a consequence of the leachate generated at the stockpiles is predicted to be of **low** significance.

8.6.3 Impact of stormwater outflows on groundwater

Impact assessment

Transnet (2012) have sub-divided the water supply and water services into three categories, namely:

- Stormwater drainage
  - Stockyard
  - Tippler
  - Quay
- Polluted Water Systems
  - Silt traps
  - Control dam
- Service water
  - Raw service water
    - Dust suppression system
    - Wash down area
  - Potable water
    - Facilities
    - Dust suppression system
  - Fire water.

It must be noted that there are three management approaches regarding the stormwater:

- The "clean stormwater" will be directly released to the environment.
- The "potentially polluted stormwater" at the stockyard and quay is sent to the proposed stormwater control dams, and
- The "potentially polluted stormwater" at the compilation yard (stormwater from the railway mainly, open areas) is sent to the stormwater attenuation ponds located at the compilation yard.
- Stormwater from workshop areas/working areas/washbays etc. will be directed to the oil/water separator and then to the sewerage.

Infiltration of the “clean stormwater” is encouraged. Elevated groundwater levels will result in increased groundwater contribution to river base flow and it is quite likely that the quality of the “clean water stormwater” will be better than that of the ambient groundwater resulting in a beneficial improvement in groundwater quality.

It is strongly supported that the "potentially polluted stormwater" be stored in stormwater control dams and stormwater attenuation ponds.

Infiltration of the "clean stormwater" poses a **low to very low** significance risk. Without mitigation, the "potentially polluted stormwater" outflows pose a **medium**significance risk with regard to the shallow groundwater.

Management actions/mitigation measures
Although it is assumed that the "clean stormwater" will be of good quality it is important to confirm and monitor this. A water sample of the "clean stormwater" should be collected after the first rainfall event of the rain season (statistically this is in August) and then every three months of the year (November, February and May). The rainfall season in the area is not clearly defined, but the higher rainfall months seem to be August, September and October. These samples must be collected at a site just before the point at which the stormwater enters the environment. Good quality stormwater will improve the quality of groundwater and also improve the quality of the groundwater contribution to river base flow.

With effective implementation of these mitigation actions, the impact of the proposed development on groundwater due to stormwater outflows is predicted to be of **low to very low** significance. In addition the impact associated with "clean stormwater infiltration" into the ground constitutes a **positive** impact.

8.6.4 Impact of accidental oil spillage/fuel leakages on groundwater

Impact Assessment
During the construction and the operational phases, there is the potential for accidental oil spills or fuel leakages associated with the proposed development. In the event of such a spill, the low permeability of the vadose zone will provide some attenuation capacity. Without mitigation, the significance of an oil spillage/fuel leakage on groundwater is therefore predicted to be of **medium** significance.

Management actions/mitigation measures
A precautionary approach should be taken and all measures taken to prevent oil spillages and fuel leakages from occurring. During the construction phase, vehicles must be regularly serviced to check and ensure there are no leakages. Any engine that stands in one place must have drip trays. Fuel storage tanks should be above ground, bunded and on an impermeable surface. Finally, vehicles should also be filled on an impermeable surface and within a secondarily contained area. During the operational phase adherence to these same precautions should be practiced.

With effective implementation of the above mitigation actions, the impact of accidental oil spillages and fuel leakages on groundwater is predicted to be of **low** significance.

8.6.5 Impact of proposed ancillary activities at the compilation yard (excluding impact of manganese ore dust) on groundwater

Impact assessment
A number of aspects associated with the proposed compilation yard (e.g. storage of diesel in 2 x 150 m^3 ASTs, wash bay, stormwater attenuation ponds, sanding facilities rolling stock workshops etc) have the potential to affect the groundwater if they are not constructed and managed correctly.

Given that the groundwater is saline and not utilised, the impacts of the various activities associated with the proposed compilation yard on groundwater is anticipated to be of **medium** significance without mitigation.

Management actions/mitigation measures
It is recommended that all measures be put in place to prevent soil and groundwater contamination. The storage tanks must be installed on an impermeable surface with a correctly designed bund. The run-off from the wash bays must not infiltrate the ground and must be stored and pumped to an appropriate facility. Any standing engines must be parked over a drip tray with absorbent material nearby.

Due to the high number of diverse activities that are proposed at the compilation yard, it is also recommended that three additional groundwater monitoring boreholes be carefully placed within the compilation yard (**Table 8.7**). Prior to the installation of these boreholes they need to be carefully positioned, designed and constructed and a groundwater monitoring protocol also needs to be developed.

Table 8.7 Proposed compilation yard groundwater monitoring sites.

Site_ID	Latitude	Longitude	Purpose
CY_MW1	-33.700721°	25.690464°	Up gradient of the compilation yard
CY_MW2	-33.720897°	25.676970°	Down-gradient southern portion of the compilation yard
CY_MW3	-33.705855°	25.699874°	Down-gradient eastern portion of the compilation yard

With effective implementation of these mitigation actions, the impact of the proposed development on groundwater as a consequence of ancillary activities at the compilation yard is predicted to be of **low** significance.

8.6.6 Comparison of the preferred and alternative options for the conveyor route and compilation yard

The impact assessment of the proposed development on groundwater would remain the same if different positions are selected for the conveyor route and compilation yard (i.e. alternative options). The reason for this is that the groundwater importance essentially remains the same across the Coega IDZ.

8.6.7 Cumulative impacts

With regard to the potential impact on groundwater, the main cumulative effect is expected to be mainly from the presence of the manganese ore stockpiles. During rainfall events (and to a far lesser degree when wetting the stockpile) manganese ore particles can be carried into the soil zone and then the saturated zone. Thus the ore is to be placed on an impermeable surface and any leachate from the stockpiles must be correctly managed. The manganese ore dust on site can also have a potentially cumulative impact and with time, rainfall events could result in an elevated manganese content of the water that recharges groundwater. Also permanently positioned machinery can have a cumulative impact if it is not serviced regularly and there are oil leaks from such equipment.

Overall the cumulative impact of the proposed manganese ore export facilities on the IDZ is considered to be very low. Nonetheless all measures need to be put in place to prevent soil and groundwater contamination and a groundwater monitoring network needs to be designed, installed and a groundwater monitoring protocol developed and implemented. The reason for this is that even though the shallow groundwater is saline and not utilised and there is an impermeable layer beneath the shallow aquifer, it does overly a good quality and high yielding fractured aquifer

It is very difficult to comment extensively on the current cumulative impact on groundwater associated with existing industries within the IDZ, supplemented by the proposed Manganese Ore Export Facility and any other proposed industries (that are currently undergoing an EIA) within the area and which would also have a potential impact on groundwater, however it is evident from the groundwater monitoring that is taking place (SRK, 2011) that negative impacts on the groundwater quality have taken place already.

However the addition of the Manganese Ore Export Facility and the planned mitigation measures (if implemented) will not worsen the condition of the groundwater of the area.

Table 8.8 Significance rating of groundwater impacts

Impact description	Mitigation	Spatial Extent	Intensity	Duration	Reversibility	Irreplaceability	Probability	Significance		Confidence
								Without mitigation	*With mitigation*	
Construction Phase										
Increased dust and other pollutants reaching groundwater.	Dust suppression required (even if chemicals are added to the dust suppressant)	Local	Low	Temporary	High	Moderate	Improbable	Low	Very low	**High**
Impact of accidental oil spillage / fuel leakage on groundwater	Disaster response plan in place. Drip trays beneath standing machinery.	Site Specific	Medium	Temporary	High	Low	Improbable	Medium	Low	**High**
Impact of ancillary activities carried out at the compilation Yard on groundwater	The fuel storage tanks must be installed on an impermeable surface with a correctly designed bund. The run-off from the wash bays must not infiltrate the ground and must be stored and pumped to an appropriate facility. Any standing engines must be parked over a drip tray with absorbent material nearby.	Site Specific	Medium	Temporary	High	Low	Improbable	Medium	Low	**Medium**

Impact description	Mitigation	Spatial Extent	Intensity	Duration	Reversibility	Irreplaceability	Probability	Significance		Confidence
								Without mitigation	*With mitigation*	
Operational Phase										
Dust from the stockpile reaching groundwater	Dust suppression required (even if chemicals are added to the dust suppressant)	Site Specific	Low	Long Term	High	Moderate	Improbable	Low	Very low	**High**
General dust from the operation (PM10 and PM25)	Dust suppression required (even if chemicals are added to the dust suppressant)	Local	Low	Long Term	High	Moderate	Improbable	Low	Very low	**High**
Leachate from the stockpile reaching groundwater	The stockpile must be on an impermeable barrier	Site Specific	Low	Long Term	Moderate	High	Improbable	Medium	Low	**Medium**
Impact of "clean stormwater" outflow on groundwater	Ensure that clean stormwater and potentially contaminated stormwater are separated	Site Specific	Medium	Temporary	High	Low	Probable	Low	Very low	**High**
Impact of potentially polluted stormwater outflow on groundwater	Ensure that clean stormwater and potentially contaminated stormwater are separated Ensure potentially contaminated stormwater does not infiltrate into the ground.	Site Specific	Medium	Temporary	High	Low	Probable	Medium	Low	**High**
Impact of accidental oil spillage / fuel leakage on groundwater.	Disaster response plan in place. Drip trays beneath standing machinery.	Site Specific	Medium	Temporary	High	Low	Improbable	Medium	Low	**High**

Impact description	Mitigation	Spatial Extent	Intensity	Duration	Reversibility	Irreplaceability	Probability	Significance		Confidence
								Without mitigation	***With mitigation***	
Impact of ancillary activities at the compilation yard on groundwater.	The fuel storage tanks must be installed on an impermeable surface with a correctly designed bund. The run-off from the wash bays must not infiltrate the ground and must be stored and pumped to an appropriate facility. Any standing engines must be parked over a drip tray with absorbent material nearby.	Site Specific	Medium	Temporary	High	Low	Improbable	Medium	Low	**High**
Decommissioning										
Impact of accidental oil spillage / fuel leakage on groundwater.	Disaster response plan In place. Drip trays beneath standing machinery.	Site Specific	Low	Temporary	High	Low	Probable	Medium	Low	**Medium**

8.7 BEST MANAGEMENT PRACTICES

Measures need to be put in place to ensure the groundwater is not contaminated. The aspects listed below are considered important and have already been taken into account by Transnet in planning the manganese ore export facility. However to ensure the measures are addressed they are listed below:

- All material that is to be stockpiled must be done so on properly constructed and protected areas.
- Stormwater quality needs to be carefully managed and the quality of the stormwater must be equivalent or better than the ambient groundwater quality prior to it being recharged.
- All vehicles and other equipment (generators etc.) must be regularly serviced to ensure they do not spill oil. Vehicles should be filled and parked on paved areas. If liquid product is being transported it must be ensured this does not spill during transit.
- Emergency measures and plans must be put in place and rehearsed in case of accidental spillage.
- Fuel storage tanks must be above ground in a bunded area.
- Vehicle and washing areas must also be on paved surfaces and the by-products removed to a hazardous waste disposal site.
- A comprehensive groundwater monitoring network needs to be established and regularly monitored. The groundwater monitoring needs to be guided by a groundwater monitoring protocol

8.8 CONCLUSION

The shallow groundwater of the area is saline and not used for socio-economic purposes. There is a deeper good quality aquifer beneath the site, however this is protected by a thick impermeable clay layer. The role the shallow groundwater does play is that of providing baseflow to the Coega River and this function must not be negatively impacted (both in terms of groundwater levels, gradients and quality).

With the effective implementation of the recommended key mitigation measures, the proposed activities are predicted to have **low** to **very low** significance impacts with respect to groundwater. The impact assessment of the proposed development on groundwater would remain the same if different positions are selected for the conveyor route and compilation yard (i.e. alternative options). The reason for this is that the groundwater importance essentially remains the same across the Coega IDZ.

The following recommendations are made:

- With respect to <u>shallow aquifer groundwater levels</u>, it is likely that the groundwater contributes to the Coega River baseflow, especially in periods of low rainfall, as the groundwater level is very shallow in places. It is not possible to calculate the baseflow contribution as flow records do not exist for the Coega River in the area. As the groundwater is anticipated to contribute to baseflow, abstraction should not occur from the upper aquifer as groundwater flow gradients may be reversed and the flow of the ephemeral Coega River reduced even further.

- <u>If</u> groundwater is required on site for processing, offices, ablutions, dust suppression etc., the only aquifer to be considered is the <u>deeper confined Coega Ridge Aquifer</u> (Peninsula Formation of the Table Mountain Group). An additional investigation will be required into the feasibility of abstracting groundwater from the deeper aquifer. Existing lawful users of this aquifer will need to be considered, detailed geohydrological work will be required to identify optimal borehole positions and associated hydrogeological conditions. Even though permission is not required for the drilling of a borehole being within the Uitenhage Subterranean Groundwater Central Area (USGWCA) it is recommended that wide consultation occurs prior to drilling of a deep borehole targeting the Coega Ridge Aquifer. Consultation with the Department of Water Affairs, Council for Geoscience, Port Elizabeth City Council and associated relevant consultants will be necessary. The borehole design will also be a crucial element to ensure management of artesian conditions which can occur. The use of the groundwater will also require licensing from the Department of Water Affairs.

- The shallow aquifer is saline and the groundwater monitoring shows clear signs of impact. All monitoring boreholes have bacteriological contamination, including E.coli and Faecal Coliforms. Three of the six monitoring boreholes have hydrocarbons present, including diesel and gasoline. In all boreholes nutrient levels are high and many chemical, including metal, parameters are elevated significantly. Nonetheless effort needs to be made to improve this shallow aquifer water quality and a precautionary approach is required in that all potentially contamination activities from the proposed manganese ore activities have high levels of protection in place to ensure minimal impact.

  The reason for this is the shallow aquifer overlies a very important deeper aquifer and although there is a significant aquiclude between the two aquifers, it is still deemed necessary that the deeper aquifer must be protected using all measures.
    - Stockpiles must be placed on an impermeable barrier
    - Any leachate from the stockpile must be collected and treated appropriately
    - A precautionary approach should be taken and all measures taken to prevent oil spillages and fuel leakages from occurring. During the construction phase, vehicles must be regularly serviced to check and ensure there are no leakages.
    - Any engine that stands in one place must have drip trays. Fuel storage tanks should be above ground, bunded and on an impermeable surface. Finally, vehicles should also be filled on an impermeable surface and within a secondarily contained area. During the operational phase adherence to these same precautions should be practiced.
    - The fuel storage tanks must be installed on an impermeable surface with a correctly designed bund. The run-off from the wash bays must not infiltrate the ground and must be stored and pumped to an appropriate facility. Any standing engines must be parked over a drip tray with absorbent material nearby.
    - Any drilling in the upper aquifer (i.e. for monitoring purposes) must be undertaken very carefully and not go into the clay layer (or even worse through it).

The following monitoring actions are recommended:

- A water sample of the "clean stormwater" should be collected after the first rainfall event of the rain season (statistically this is in August) and then every three months of the year (November, February and May).
- There is a good and regularly monitored network of boreholes in the area (SRK, 2011), and this monitoring must continue, however the monitoring network will need to be expanded to monitor the stockpile area and compilation yard. An additional eight boreholes are proposed (**Table 8.9**). These must be correctly designed and wide enough for proper sampling. The boreholes must be drilled to the top of the impermeable clay layer (and no deeper). They need to be fully screened and have an appropriately designed gravel pack installed. The boreholes must be fully developed prior to use and proper sampling techniques must be followed. A groundwater monitoring protocol needs to be established. Monitoring on a quarterly basis should suffice.

Table 8.9 Additional proposed groundwater monitoring sites (SY = Stockyard and CY = Compilation Yard)

Site_ID	Latitude	Longitude	Purpose
SY_MW1	-33.762061°	25.663294°	Up-gradient groundwater monitoring site
SY_MW2	-33.763884°	25.668976°	Groundwater monitoring between the stock yard and the Coega River
SY_MW3	-33.767181°	25.670530°	Groundwater monitoring between the stock yard and the Coega River
SY_MW4	-33.770078°	25.669024°	For monitoring groundwater within the southern portion stock yard. This site will have to be optimally sited so that is it not damaged during the stock piling operation.
SY_MW5	-33.767042°	25.665349°	For monitoring groundwater within the central portion of the stock yard. This site will have to be optimally sited so that is it not damaged during the stock piling operation.
CY_MW1	-33.700721°	25.690464°	Up gradient of the compilation yard
CY_MW2	-33.720897°	25.676970°	Down-gradient southern portion of the compilation yard
CY_MW3	-33.705855°	25.699874°	Down-gradient eastern portion of the compilation yard

Thus the proposed manganese ore activities can proceed, from a geohydrological perspective, however measures must be put in place to ensure that the shallow groundwater levels and gradients are not negatively impacted. In addition, measures must be put in place to ensure the shallow groundwater is not contaminated further.

8.9 REFERENCES

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SRK, 2006. Proposed charge in land use of the remaining area within the Coega Industrial Development Zone. Report prepared for Coega Development Corporation. Report prepared by SRK Consulting. September 2006 SRK Report Number 344230/5.

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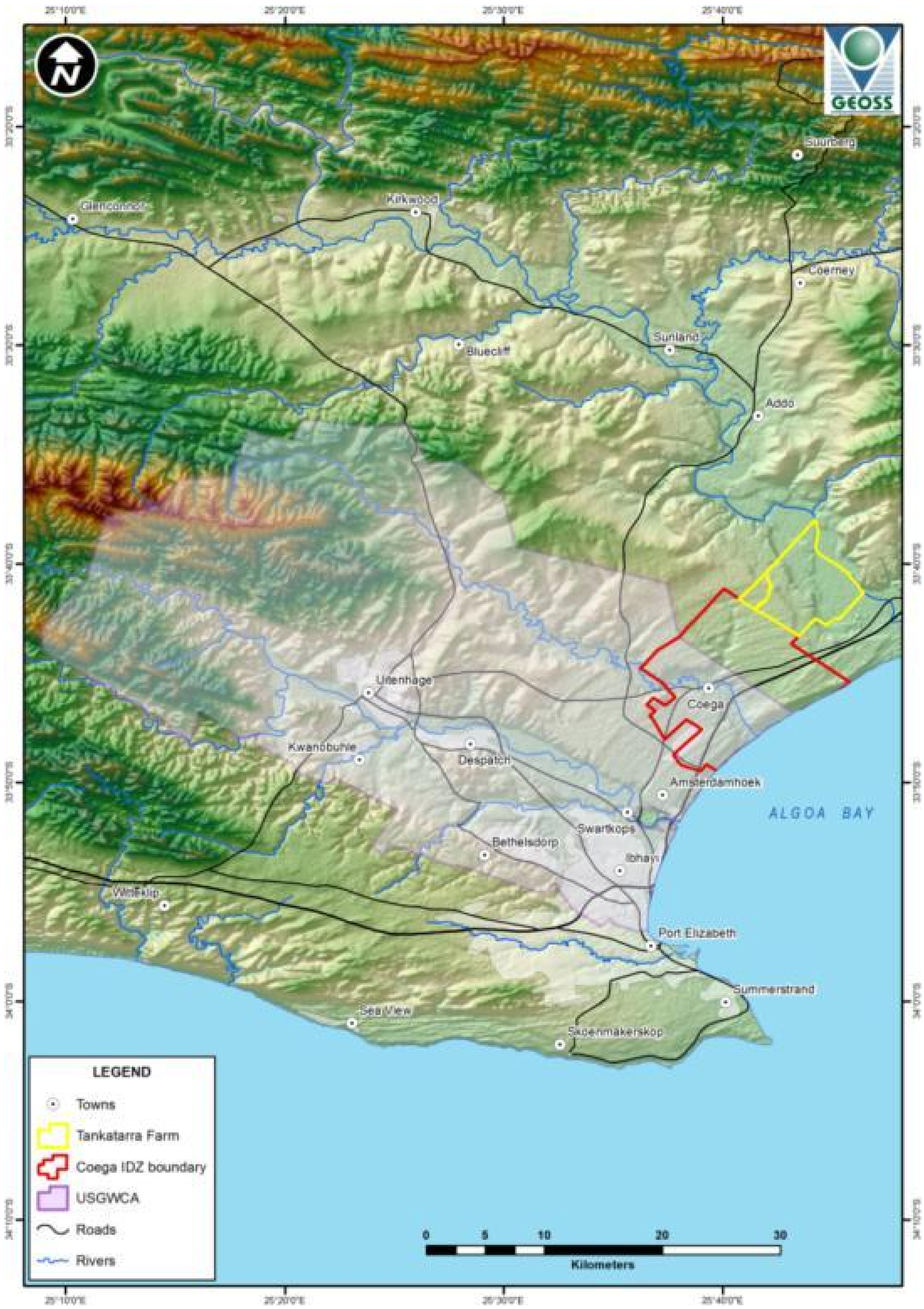
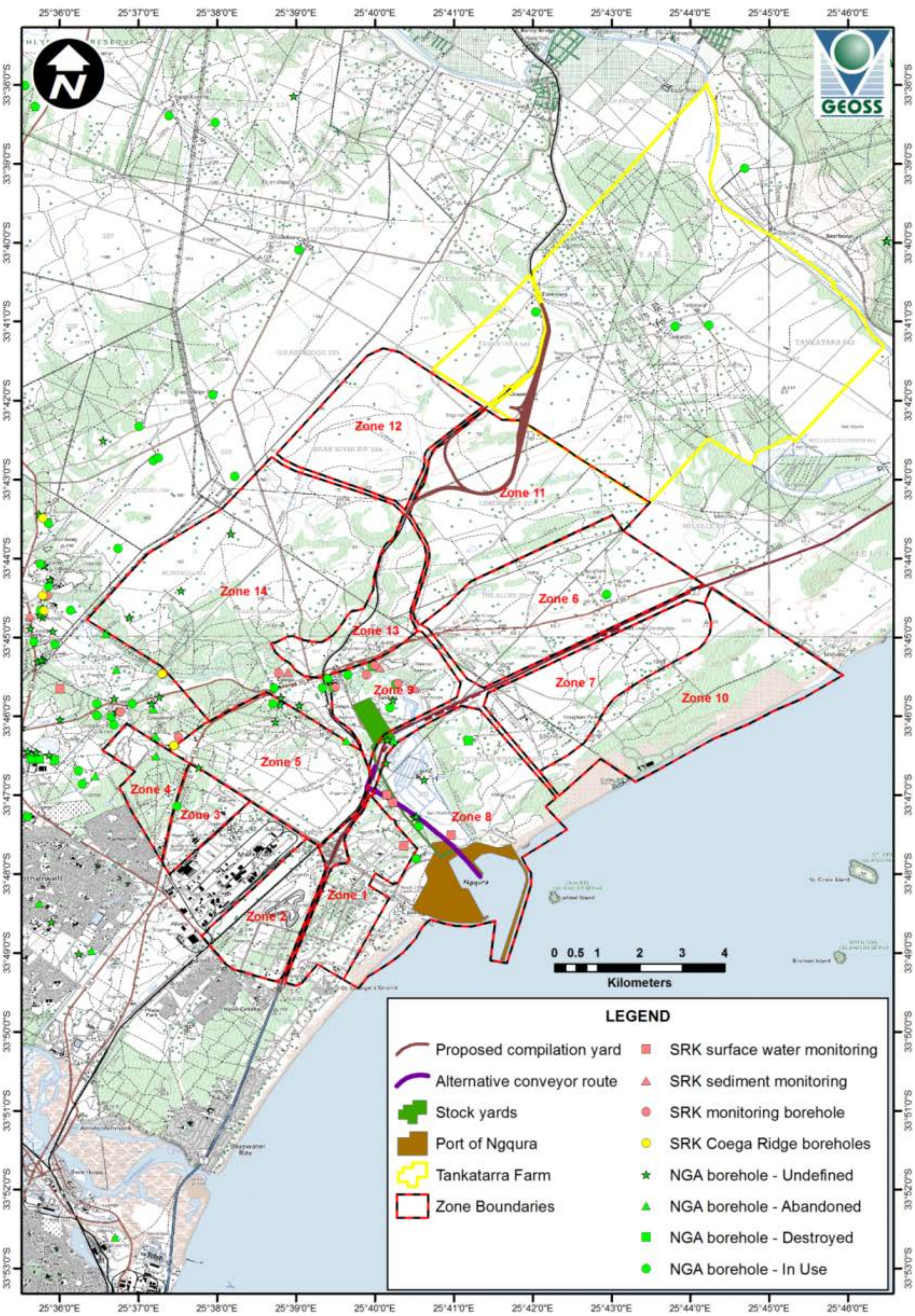
Transnet, 2012. Transnet Capital Projects – Ngqura 16 Mtpa Manganese FEL-2 Port Study. Water Supply Report. Prepared by N. Masinga on 10 February 2012.

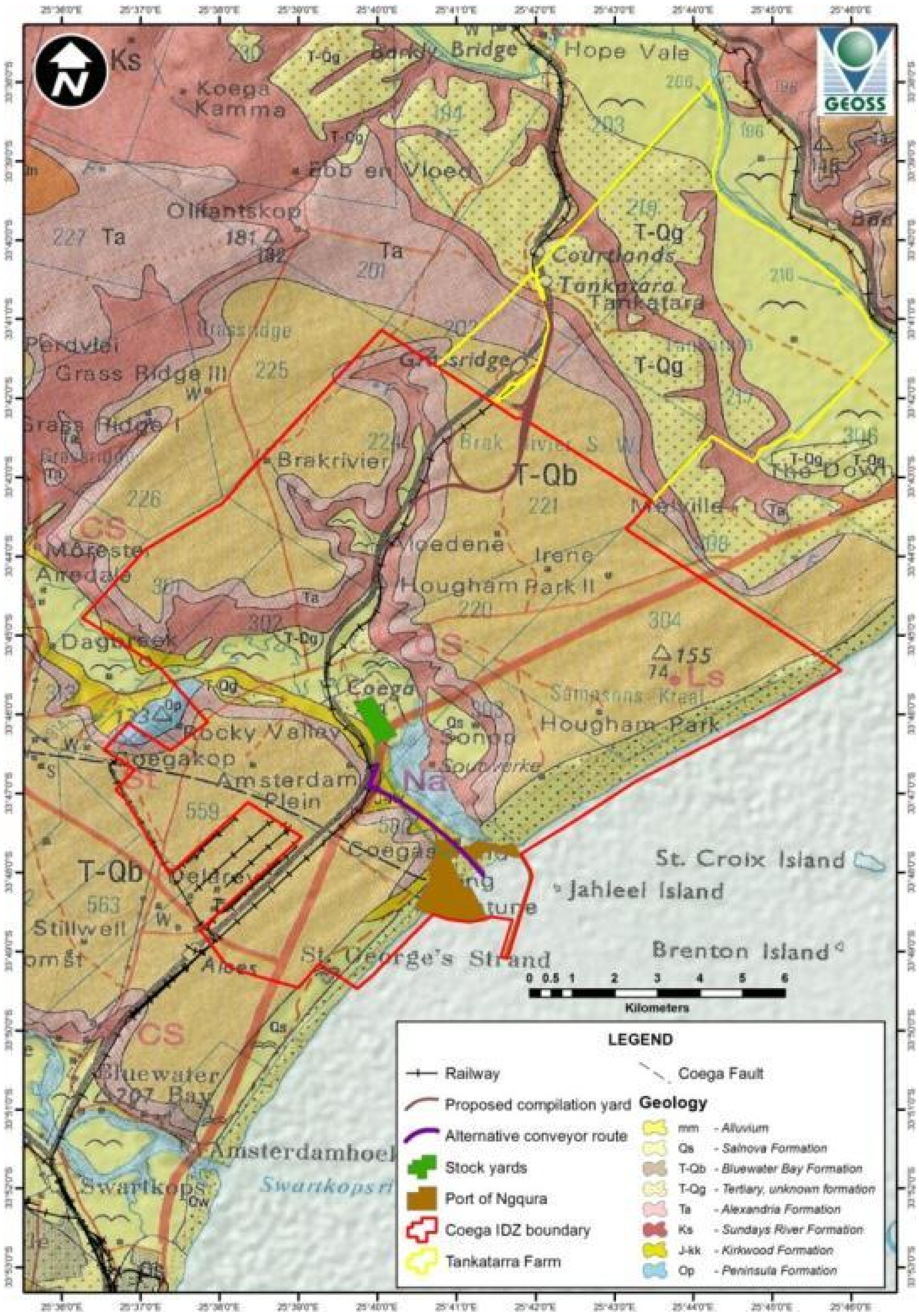
8.10 APPENDICES



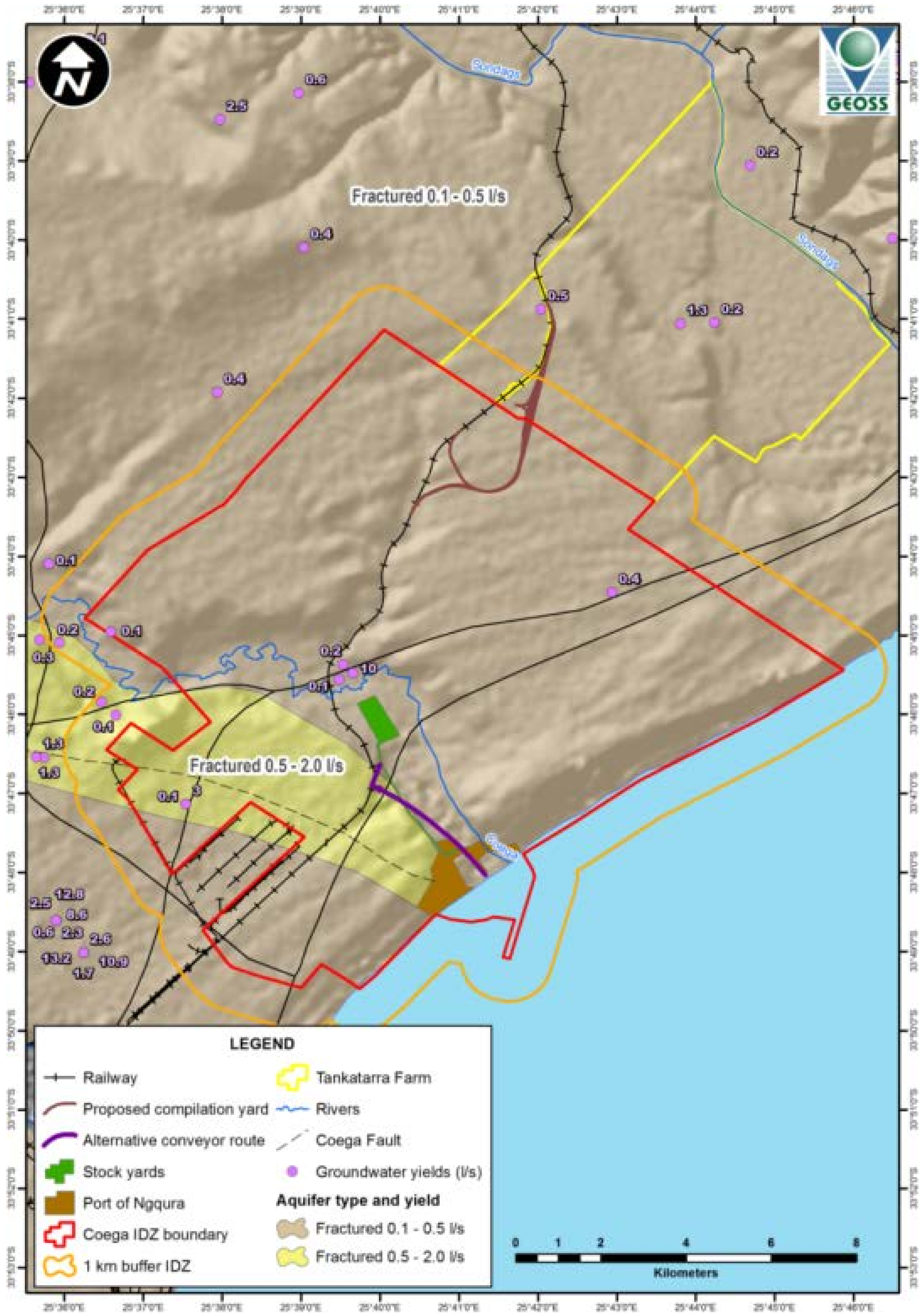
Map 8.1: Locality map of the study area and the Uitenhage Subterranean Groundwater Control Area (USGWCA)



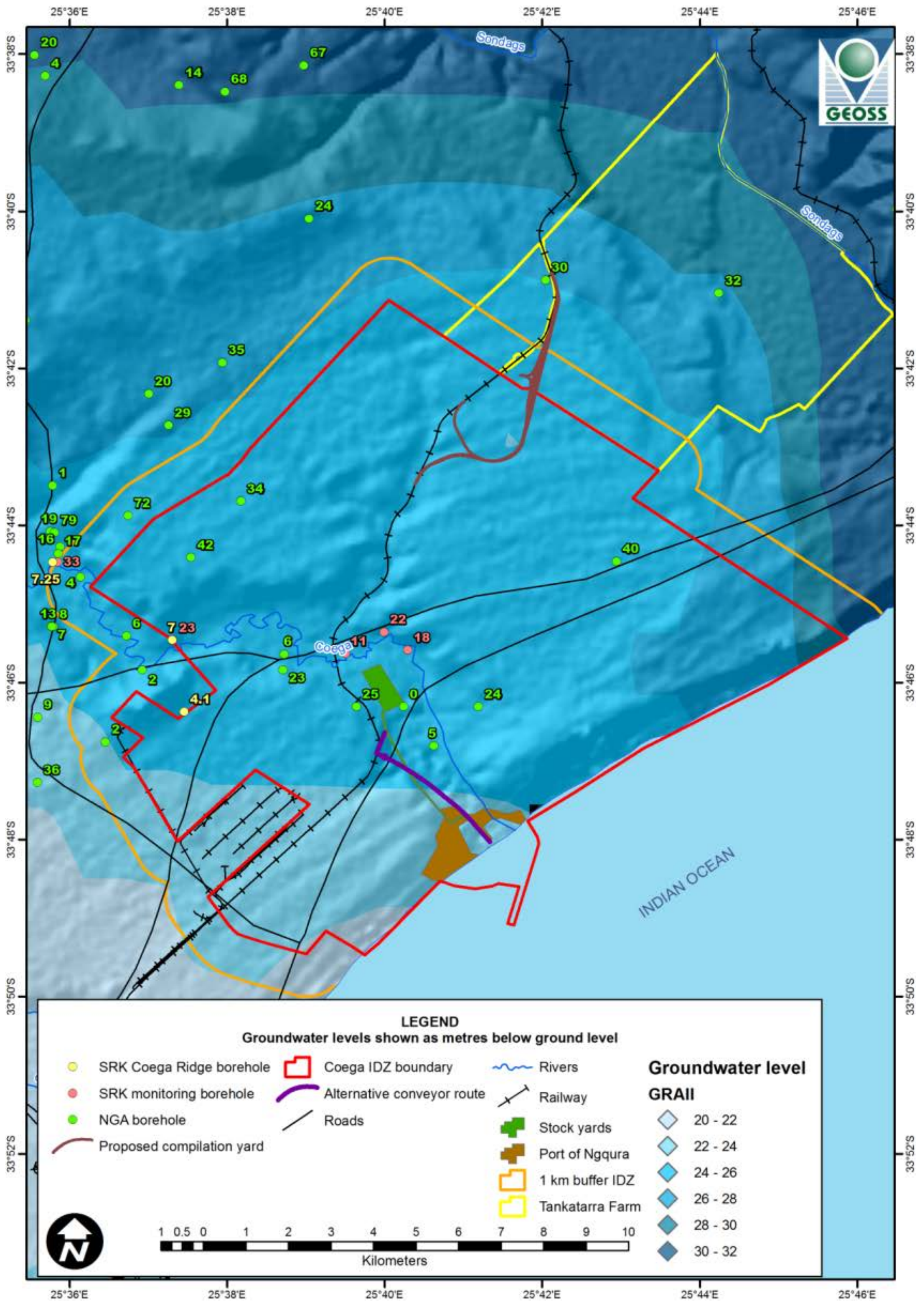
Map 8.2: ***Topocadastral setting of the study area (Maps: 3325DC&DD 3425BA-Port Elizabeth, 3325DA-Addo, 3325DB-Colchester)***



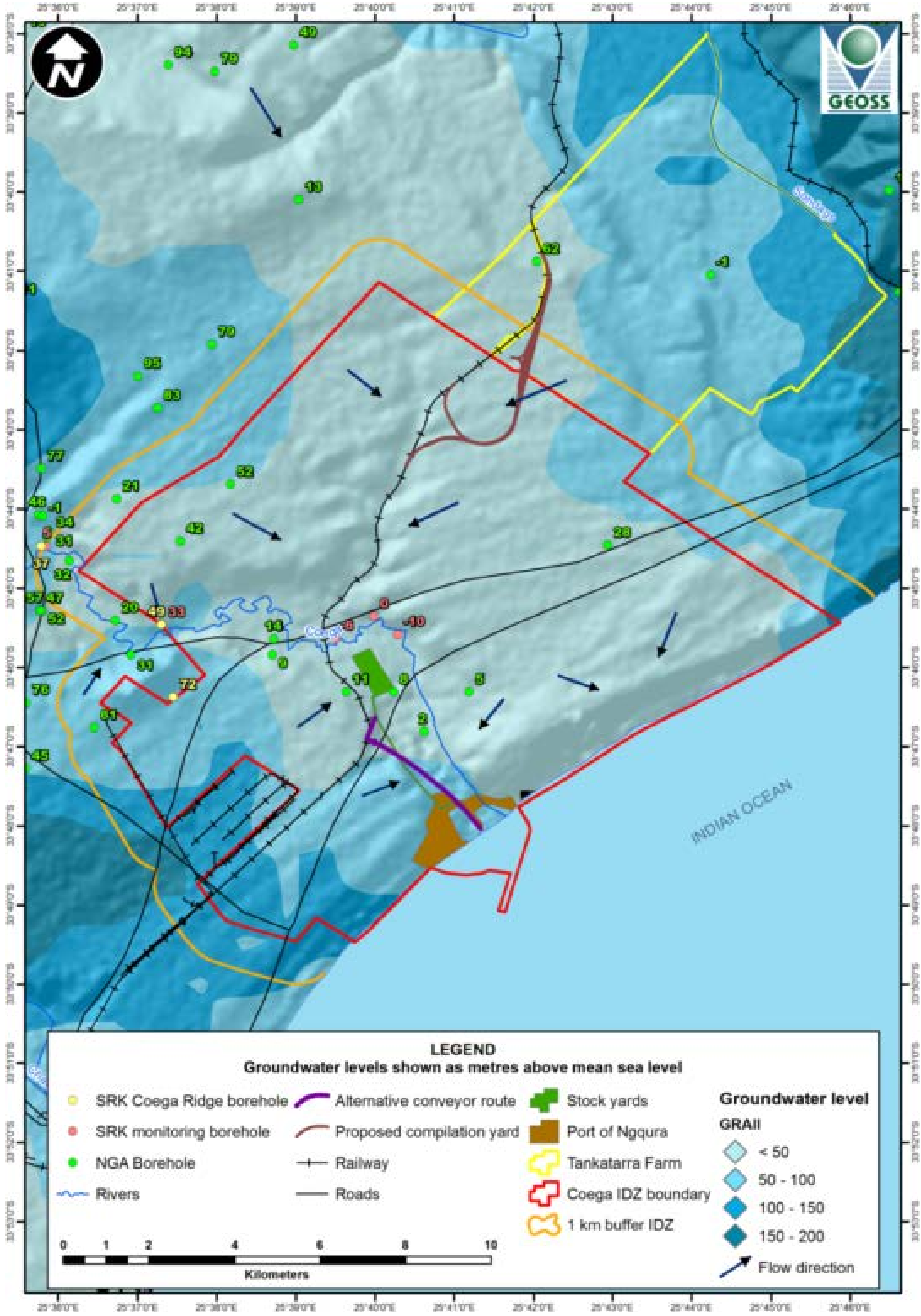
Map 8.3: ***Geological setting of the study area (Map sheet 1:250 000: 3324-Port Elizabeth)***



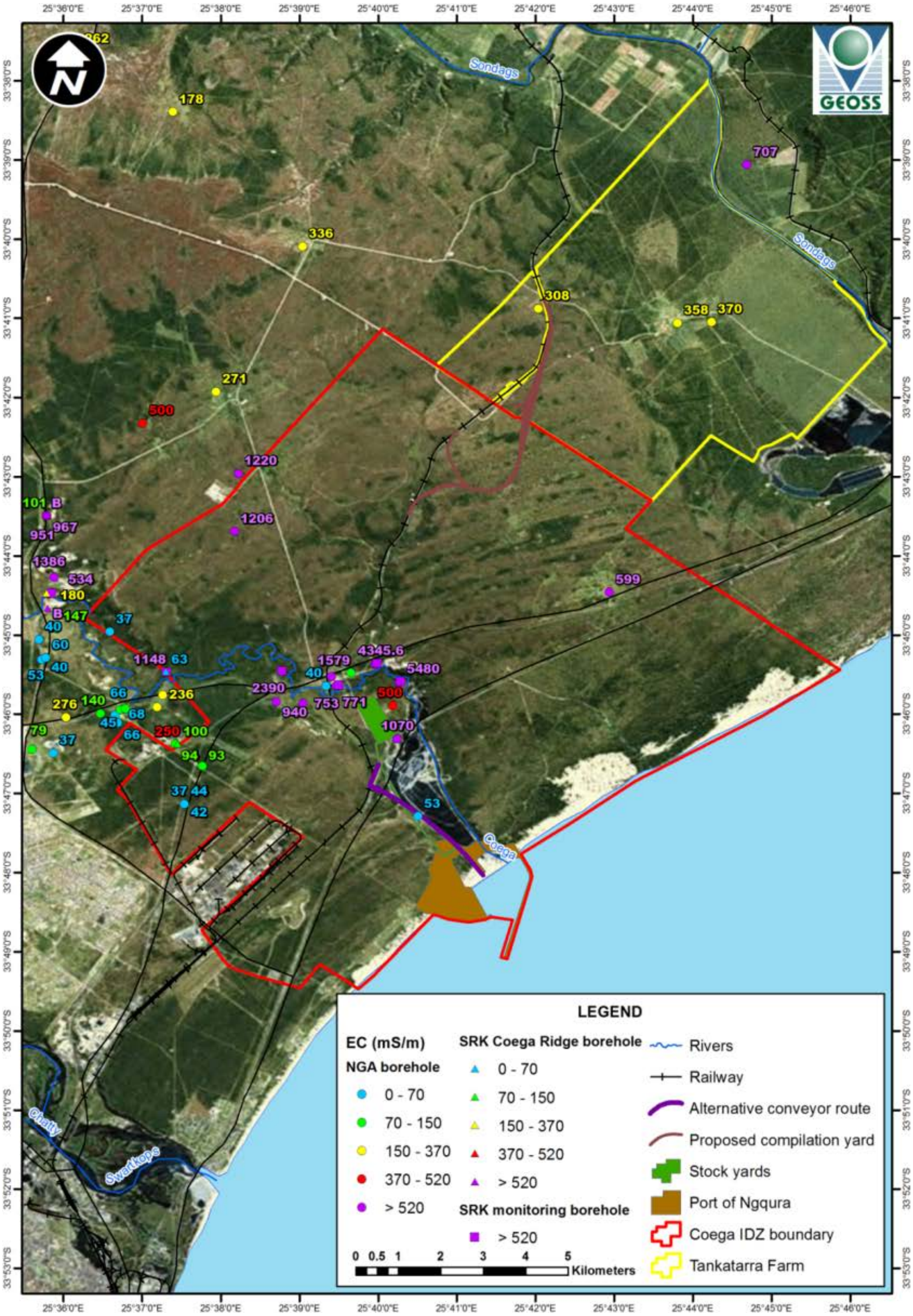
Map 8.4: ***Aquifer type and yield for the study area (Map 1: 500 000: 3324-Port Elizabeth)***



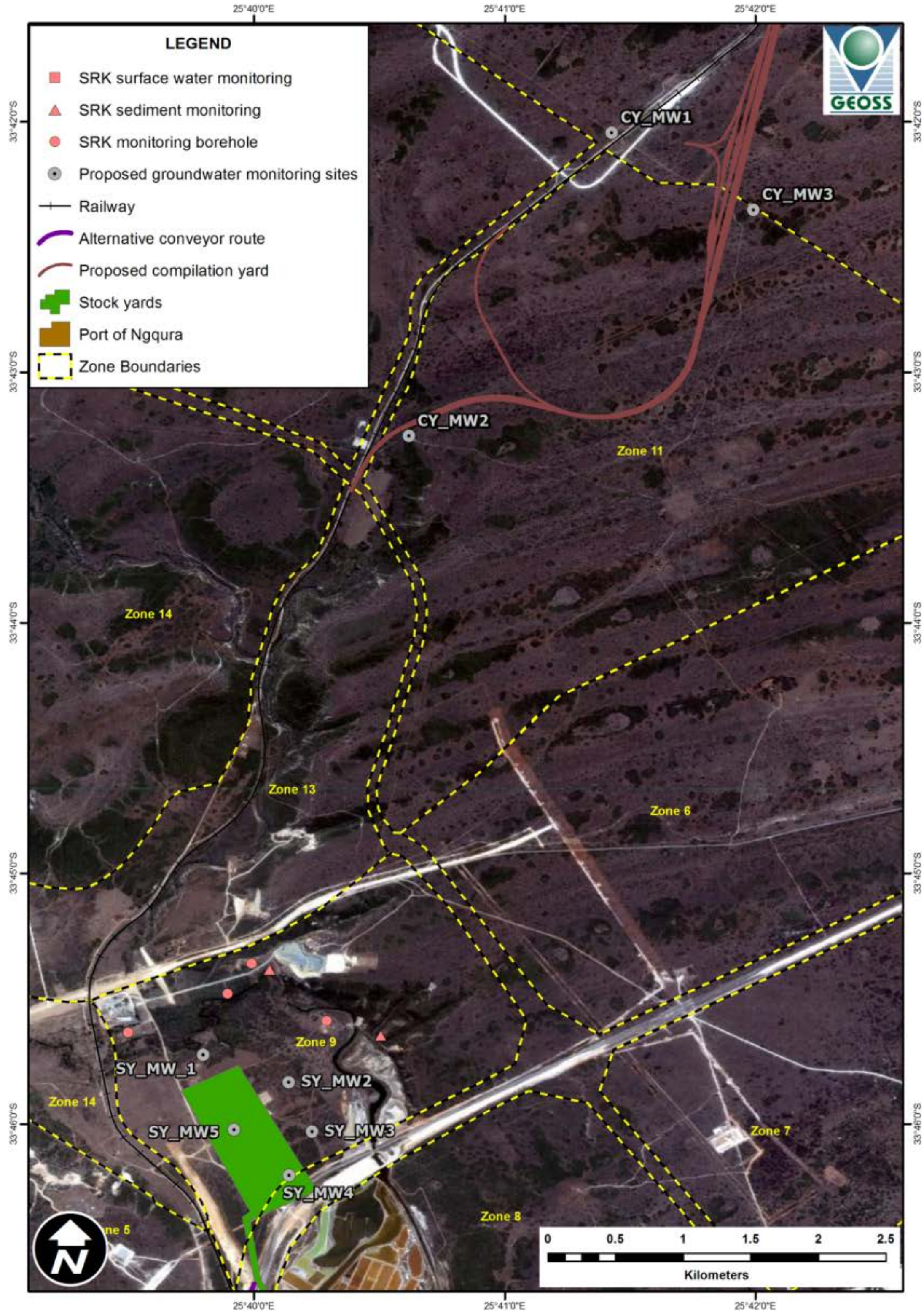
Map 8.5: ***Groundwater level for the study area (metres below ground level)***



Map 8.6: ***Groundwater level (MAMSL) and flow direction for the study area***



Map 8.7: ***Groundwater quality for the study area (as indicated by Electrical Conductivity – SABS 241 Acceptable Limit 150 mS/m and Maximum Limit 370 mS/m)***



Map 8.8: Proposed additional groundwater monitoring sites