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

FINAL EIA REPORT

CHAPTER 14B:

PALAEONTOLOGICAL IMPACT ASSESSMENT

EXECUTIVE SUMMARY

Transnet Capital Projects (Pty) Ltd (TCP) is proposing to develop a Manganese Ore Export Facility in the Coega Industrial Development Zone (Coega IDZ) and adjacent Tankatara area, located approximately 15 km north-east of Port Elizabeth, Nelson Mandela Bay Municipality, Eastern Cape Province. The facility would consist of a manganese ore stockyard and handling facility in Zones 8 and 9 of the IDZ, which includes the Port of Ngqura, as well as a compilation yard in Zone 11 of the IDZ and the adjacent Tankatara property. The site allocated to the manganese ore stockyard is located within the Coega River Valley to the north of the N2 national freeway and the Coega Salt Pans and will be situated on undeveloped land. Portions of the existing railway line through IDZ Zone 13 linking the new compilation yard and the existing marshalling yard in IDZ Zone 9 will be doubled.

The Manganese Ore Export Facility study area is underlain by a range of terrestrial, coastal and marine sedimentary rocks that extend from modern times back to the Early Cretaceous Period, some 140 or so million years ago. These sediments are assigned to two major geological successions: (1) the Mesozoic *Uitenhage Group* that was deposited within the Algoa Basin in a range of fluvial, estuarine and shallow marine settings during the Late Jurassic to Early Cretaceous Periods (*c.* 150-130 Ma), and (3) the Late Caenozoic *Algoa Group* that accumulated along the coast of Algoa Bay over the last seven million years in estuaries, lagoons, rocky and sandy shores, and aeolian dune fields.

A previous review of palaeontological heritage within the Coega IDZ (excluding Zone 8) by Almond (2010a) recorded rich shelly marine fossil assemblages (*e.g.* ammonites, bivalves, corals) within the Early Cretaceous *Sundays River Formation* here. Fossils within the slightly older terrestrial sediments of the *Kirkwood Formation* are apparently very sparse, however. Important fossil remains of dinosaurs and land plant, including petrified wood, are known from this succession elsewhere in the Eastern Cape. Diverse and abundant marine invertebrates (*e.g.* oyster beds) occur locally within the Miocene / Pliocene *Alexandria Formation* but over large areas of the Coega Plateau these coastal limestones and conglomerates are highly calcretised and largely unfossiliferous. Overlying *superficial deposits* such as downwasted surface gravels, aeolian sands and clay-rich doline (solution-hollow) infills are at most sparsely fossiliferous. Within the Coega River estuary abundant and often very rich assemblages of Pleistocene to Recent estuarine invertebrates – predominantly molluscs, but also barnacles, crustaceans, echinoids and polychaete worm tubes – occur within the *Salnova Formation* whose type area occurs here.

Anticipated fossil heritage impacts associated with this development mainly involve the destruction, disturbance or sealing-in of fossil remains exposed on the ground or buried beneath the surface during excavations and other construction work. These impacts are generally direct, negative and permanent, and they are usually confined to the development footprint during the construction phase. Significant further impacts during the operational and decommissioning phases of the Manganese Ore Export Facility are not anticipated.

Many infrastructure components of the proposed Manganese Ore Export Facility overlie sedimentary rocks that are of low palaeontological sensitivity and / or do not entail sizeable

bedrock excavations during the construction phase. In these cases, general monitoring (at least daily) of all excavations for newly exposed fossil material by a suitably qualified appointed person is recommended.

The footprints of the proposed **Compilation yard** on the Coega Plateau (IDZ Zone 11 and adjacent portion of Tankatara Farm, Zone 13) largely overlie Alexandria Formation coastal limestones that are generally of low palaeontological sensitivity here. Significant negative impacts on buried fossil heritage are only likely where Sundays River Formation bedrocks are intersected, notably at the edge of the Brak River Valley and the Sundays River Valley (near Tankatara siding – this would also include the second stormwater attenuation pond). One of the proposed attenuation ponds in Zone 13 (southern section of the compilation yard) is underlain by the Alexandria Formation and is unlikely to have a significant impact unless underlying Sundays River Formation mudrocks are intersected here. The alternative compilation yard layout is anticipated to have a slightly lower impact than the preferred option because it overlies a smaller area of Sundays River bedrocks, but in both cases the overall impact significance is assessed as **low to very low** after mitigation.

Doubling of the existing railway line linking the proposed compilation yard and the existing marshalling yard may entail significant negative impacts on fossils within the Sundays River Formation along the Brak River Valley and Coega Valley (IDZ Zones 9 and 13) if substantial new cuttings into fresh bedrock are entailed. The impact significance of this doubling on palaeontological heritage is predicted to be **medium** before mitigation and **low** after mitigation.

Excavations for the **Manganese Ore Export Terminal** (including the manganese ore stockyard, stormwater control pond and ancillary infrastructures) in IDZ Zone 9 may well intersect highly fossiliferous beds of the Pleistocene Salnova Formation. The impact on this formation is predicted to be of **low** significance, provided the prescribed mitigation is implemented effectively. The proposed stormwater retention dam at the quay in Zone 8 lies within an already highly disturbed area and so significant impacts on fossil heritage are also not anticipated here.

Most of the proposed bulk terminal infrastructure in IDZ Zone 8 (Ngqura Port area) and Zone 9 would overlie areas that are already highly disturbed where the bedrock is sealed-in, or do not involve substantial new excavations into bedrock. New cuttings for the **conveyor** belt between the tippler and ship loader along the western edge of the Coega River Valley might have significant negative impacts on Cretaceous fossils within the Kirkwood and Sundays River Formations. In this respect the preferred conveyor route is likely to have a higher impact than the alternative route since longer cuttings through Kirkwood Formation bedrocks are required in the former case. However, for all route options the impact significance is rated as **low** after mitigation since the Kirkwood Formation rocks that will be mainly concerned are only sparsely fossiliferous in the Coega area.

Given the scarcity of fossil remains within the majority of the underlying sedimentary rocks, as well as the extensive outcrop areas of the formations concerned, the impact significance of the proposed Manganese Ore Export Facility as far as palaeontological heritage resources are concerned is assessed as **LOW** after mitigation.

Given the very limited outcrop area of the Pleistocene Salnova Formation, and the current or anticipated levels of development within the Coega River Valley area, the future cumulative

negative impacts from other possible projects in the area (*e.g.* possible expansion of the Port of Ngqura up the Coega River) might well be of moderate to high significance.

General monitoring of fresh excavations for newly exposed fossil material is recommended here. If any substantial fossil remains are found these should be safeguarded, preferably *in situ*. The Eastern Cape Provincial Heritage Resources Authority (ECPHRA. Contact details: Mr Sello Mokhanya, 74 Alexander Road, King Williams Town 5600; smokhanya@ecphra.org.za) should be informed as soon as possible. A qualified palaeontologist should then be commissioned to record and sample the fossil occurrences, and also to advice on any specialist mitigation actions or further studies required.Professional palaeontological monitoring is only recommended for this project in the case of sizeable new excavations into the potentially fossiliferous Kirkwood Formation, Sundays River Formation and Salnova Formation. In particular, professional monitoring is recommended in the case of:

- Deeper (>3m) excavations within the compilation yard and associated access road footprints (IDZ Zones 11 and adjacent portion of Tankatara Farm, and Zone 13, should these intersect the underlying Sundays River Formation (see especially areas highlighted in map Figure 14B.3).
- Any new cuttings into the Sundays River Formation along the doubled-up railway line between the compilation and marshalling yards (IDZ Zones 13 and 9; green dashed line in Figures 14B.3 and 14B.4).
- Excavations into Salnova Formation estuarine deposits within the footprints of the stockyard, storm water retention pond and attenuation dam (IDZ Zone 9; small black polygons in map Figure 14B.4).
- New excavations into Kirkwood and Sundays River Formation rocks along the conveyor line route in IDZ Zone 8 (map Figure 14B.4 and satellite image Figure 14B.16).

Professional palaeontological mitigation should result in *positive* impacts in so far as it should result in a better understanding of fossil heritage resources within the Coega region of the Eastern Cape.

To carry out monitoring and mitigation of areas of high palaeontological sensitivity, which would normally involve the judicious sampling of newly exposed fossil material together with pertinent geological data, the professional palaeontologist involved would need to apply beforehand for a palaeontological collection permit from the relevant heritage management authority. In this case this is the Eastern Cape Provincial Heritage Resources Authority, ECPHRA (Contact details: Mr Sello Mokhanya, 74 Alexander Road, King Williams Town 5600; smokhanya@ecphra.org.za).

Fossil material collected must be recorded according to best academic practice and properly curated in an accredited fossil collection, such as the Albany Museum, Grahamstown.

These recommendations should be incorporated into the Environmental Management Plan for the Coega Manganese Ore Export Facility.

Contents

TABLES AND FIGURES

CHAPTER 14B: PALAEONTOLOGICAL HERITAGE ASSESSMENT

This chapter presents the Palaeontological Heritage Specialist Study undertaken Dr John E. Almond from *Natura Viva* cc, under appointment to CSIR, as part of the Environmental Impact Assessment for the proposed Manganese Ore Export Facility and associated infrastructure in the Coega Industrial Development Zone, Port of Ngqura and Tankatara area.

14B.1 INTRODUCTION AND METHODOLOGY

14B.1.1 Scope and Objectives

The present palaeontological heritage assessment report has been commissioned by the CSIR (Contact details: Ms Annick Walsdorff, CSIR Consulting and Analytical Services, Jan Cilliers Street, Stellenbosch 7600, RSA; tel. 021-888 2589; fax. 021-888 2693; email. awalsdorff@csir.co.za). It forms part of the EIA for the proposed Coega Manganese Ore Export Facility, falling under Section 38 (Heritage Resources Management) of the South African Heritage Resources Act, and it will also inform the Environmental Management Plan for this project.

The overall project description is provided in Chapter 2, and this chapter will therefore only include additional project information that is required specifically to understand and assess the impacts for this particular specialist study. A map outlining the major components of the proposed Manganese Ore Export Facility is available in Chapter 2 (Figure 2.2).

14B.1.2 Terms of References

The terms of reference for the present palaeontological specialist study, as defined by the CSIR, are briefly as follows:

- Prepare and undertake a desktop study on the fossil heritage of the proposed project areas, based on:
  - a review of all relevant palaeontological and geological literature, including geological maps and previous reports,
  - location and examination of fossil collections from the study area (*e.g.* museums),
  - data on the proposed development (*e.g.* location of footprint, depth and volume of bedrock excavation envisaged)
- Undertake a detailed field examination of representative natural and artificial exposures of potentially fossil-bearing sediments (rock outcrops, quarries, roadcuts *etc*) within or in the region of the development area. The primary focus of fieldwork would be to cover those areas of the project that were not covered by previous field-based study of the Coega IDZ, *i.e.* the TNPA port area where potentially fossiliferous Kirkwood Formation beds occur as well as the private land (Tankatara Farm) to the NE of the IDZ.
- Record observed fossils and associated sedimentological features of palaeontological relevance (photos, maps, aerial or satellite images, GPS co-ordinates, and stratigraphic columns).

- Undertake photography and provisional identification of fossils .
- Analyse the stratigraphy, age and depositional setting of fossil-bearing units.
- Specify the potential impacts, as well as cumulative impacts, of the construction, operational and decommissioning phases of the development on the palaeontological heritage within the study area.
- Identify and rate potential direct, indirect and cumulative impacts of the proposed project on the palaeontological heritage during the construction, operational and decommissioning phases of the project.
- Compile an illustrated, fully-referenced review of palaeontological heritage within study area based on desktop study and new data from fieldwork and analysis.
- Identify and rank the highlights and sensitivities to development of fossil heritage within study area.
- Provide specific recommendations for further palaeontological mitigation (if any).
- Provide recommendations and suggestions regarding fossil heritage management on site, including conservation measures, as well as promotion of local fossil heritage (*e.g.* for public education, schools) to ensure that the impacts are limited.

14B.1.3 Approach and Methodology

This PIA report provides a short assessment of the observed or inferred palaeontological heritage within the Coega Manganese Ore Export Facility study area, with recommendations for specialist palaeontological mitigation where this is considered necessary.

In preparing a palaeontological desktop study the potentially fossiliferous rock units (groups, formations etc) represented within the study area are determined from geological maps. The known fossil heritage within each rock unit is inventoried from the published scientific literature, previous palaeontological impact studies in the same region, and the author's field experience (Consultation with professional colleagues as well as examination of institutional fossil collections may play a role here, or later following field assessment during the compilation of the final report). This data is then used to assess the palaeontological sensitivity of each rock unit to development (Provisional tabulations of palaeontological sensitivity of all formations in the Western, Eastern and Northern Cape have already been compiled by J. Almond and colleagues; Almond *et al.* 2008). The likely impact of the proposed development on local fossil heritage is then determined on the basis of (1) the palaeontological sensitivity of the rock units concerned and (2) the nature and scale of the development itself, most significantly the extent of fresh bedrock excavation envisaged. When rock units of moderate to high palaeontological sensitivity are present within the development footprint, a Phase 1 field assessment study by a professional palaeontologist is usually warranted to identify any palaeontological hotspots and make specific recommendations for any mitigation required before or during the construction phase of the development.

On the basis of the desktop and Phase 1 field assessment studies, the likely impact of the proposed development on local fossil heritage and any need for specialist mitigation are then determined. Adverse palaeontological impacts normally occur during the construction rather than the operational or decommissioning phase. Phase 2 mitigation by a professional palaeontologist – normally involving the recording and sampling of fossil material and associated geological information (*e.g.* sedimentological data) may be required (a) in the pre-construction phase where important fossils are already exposed at or near the land surface and / or (b) during the construction phase when fresh fossiliferous bedrock has been exposed by excavations. It should be emphasized that, providing appropriate mitigation is carried out, the majority of developments involving bedrock excavation can make a positive contribution to our understanding of local palaeontological heritage.

14B.1.4 Assumptions and Limitations

In inferring the palaeontological sensitivity of rock units underlying a development from field and other data obtained outside the study area it is assumed that fossil heritage is fairly uniformly distributed throughout the outcrop area of a given formation. Experience shows that this assumption does not always hold. This is because the original depositional setting across a formation that may extend over hundreds of kilometres may vary significantly, with palaeoecological implications (*e.g.* from a shallow to deeper water environment), while fossils are often patchy in their occurrence. Furthermore, the levels of tectonic deformation (folding, cleavage development *etc.*), as well as the intensity and nature of metamorphism and weathering experienced by a given formation may change markedly across its outcrop area. These factors may seriously compromise the preservation of fossil remains present within the original sedimentary rock.

In the case of the Coega Manganese Ore Export Facility project study area a major limitation is the generally low level of bedrock exposure within the relevant zones of the Coega IDZ and Transnet Port Authority area. However, in the author's opinion field study of the available exposures within and along the margins of the study area as well as elsewhere within the Coega IDZ (*c.f.* Almond 2010a) has allowed an adequate assessment of palaeontological heritage resources relevant to the proposed development.

14B.1.5 Sources of Information

The report is based on (1) a review of the relevant scientific literature, and in particular the comprehensive fossil heritage assessment for the Coega IDZ by the author (Almond 2010a; *N.B.* Coega IDZ Zone 8 was specifically excluded from this earlier study) and a recent specialist palaeontological study in IDZ Zone 8 (Almond 2012); (2) published geological maps and accompanying sheet explanations (*e.g.* Toerien & Hill 1989, Le Roux 2000); (3) a one-day palaeontological field assessment (18-19 May 2012) carried out by the author; and (4) the author's extensive field experience with the formations concerned and their palaeontological heritage.

14B.1.6 Declaration of Independence

The declaration of independence by the palaeontological heritage specialist is provided in Box 14.1 below:

BOX 14.1: DECLARATION OF INDEPENDENCE FOR PALAEONTOLOGICAL HERITAGE IMPACT ASSESSMENT

I, John Almond, 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
Dr John E. Almond (PhD, Cantab.), Member of the Palaeontological Society of Southern Africa and the Association of Professional Heritage Practitioners (Western Cape).

14B.2 APPLICABLE LEGISLATION AND PERMITTING REQUIREMENTS

The proposed Coega Manganese Ore Export Facility and associated infrastructure will involve substantial excavations into potentially fossiliferous bedrocks of Mesozoic and Caenozoic age (Section 14.3). All fossil heritages in the RSA are protected by the South African Heritage Resources Act (Act No. 25 of 1999) which triggers a palaeontological heritage assessment for the proposed development. Minimum standards for the palaeontological component of heritage impact assessment reports are currently being developed by SAHRA.

The various categories of heritage resources recognised as part of the National Estate in Section 3 of the National Heritage Resources Act (1999) include, among others:

- geological sites of scientific or cultural importance
- palaeontological sites
- palaeontological objects and material, meteorites and rare geological specimens.

To carry out any necessary Phase 2 mitigation, the palaeontologist involved will need to apply for a palaeontological collection permit from the relevant heritage management authority (*i.e.* The Eastern Cape Provincial Heritage Resources Authority, ECPHRA. Contact details: Mr Sello Mokhanya, 74 Alexander Road, King Williams Town 5600; smokhanya@ecphra.org.za).

14B.3 DESCRIPTION OF PROJECT ASPECTS RELEVANT TO PALAEONTOLOGICAL HERITAGE IMPACTS

A general description of the proposed development is provided in Chapter 2 of this EIA Report.

The proposed Coega Manganese Ore Export Facility will include the following key components that are relevant to fossil heritage conservation and management within the development footprint (Chapter 2 Figure 2.2):

- The construction in IDZ Zones 8 and 9 of a **Manganese Ore Export Terminal** for handling manganese ore, including a stockyard, conveyor systems linking the stockyard to the tippler and ship loader as well as the associated infrastructure such as a tippler, stackers, reclaimers, ship loaders on the existing berths C100 and C101, surge bins, office buildings, bulk services infrastructure and additional rail infrastructure from the existing marshalling yard linking into the tippler.

- The construction and operation in IDZ Zones 11 and 13 of a **Compilation yard** comprising five yard lines, a rail loop and an additional rail link line. Ancillary facilities would include a wagon and locomotive maintenance facility, a diesel refuelling facility with a total capacity of approximately 150 m³, a locomotive sanding facility, security building, two shunters cabins, three signalling relay rooms and a main TFR operations building.

- A portion of the **railway line** between the new Coega compilation yard and the existing marshalling yard in IDZ Zones 9 and 13 will also be doubled to allow for transport of manganese ore to the port terminal.

- The construction of a **storm water control dam** in IDZ Zone 9, as well as a **stormwater control dam** at the quay in Zone 8 and an **attenuation pond** in Zone 13 (compilation yard).

- The construction of bulk service **access roads** within Zone 8, 9 and 11 as well as a road and rail bridge over the compilation yard.

The proposed project components listed above will be serviced by general infrastructure related to electricity, water, stormwater and sewage to accommodate offices and working areas.

Significant impacts during the operational and decommissioning phases of the Manganese Ore Export Facility are not anticipated since bedrock disturbance will be confined to the footprint established in the construction phase of the development and these will therefore not be assessed further in this study.

14B.4 DESCRIPTION OF THE AFFECTED ENVIRONMENT

14B.4.1 Geological context of the study area

This general account of the geology of the broader study region has been abstracted from the recent palaeontological heritage assessment of the Coega IDZ by Almond (2010a) to which the interested reader is referred for further details, illustrations of relevant rocks and fossils, and comprehensive references. Please note that the Transnet Port Authority (TNPA) area in IDZ Zone 8 was specifically excluded from the 2010 study. Key references for the present study are listed in Section 14.7 of this report.

The Coega IDZ is situated on the coastal plain inland of Algoa Bay some 15 to 25km to the northeast of Port Elizabeth, Eastern Cape Province. The area comprises a low-relief coastal plateau mantled by sand dunes along the coast and traversed by the shallow NW-SE valley of the Coega River and its tributaries (*e.g.* dry valley of the Brakrivier). The only prominent topographic feature is the rugged quartzitic hill of Coega Kop (146 m asl).

Apart from the modern (i.e. geologically Recent) coastal sand dunes, most of the Coega IDZ landscape is mantled by dense vegetation – primarily mesic succulent Sundays Thicket along the valley slopes and drier Coega Bontveld on the calcareous plateau. Natural exposures of bedrock are therefore confined to occasional erosional dongas and low limestone cliffs along the steeper Coega Valley sides, small craggy outcrops on Coega Kop, as well as narrow rocky benches, low calcareous sandy cliffs and dunes in the coastal zone. Fresh exposures of the older geological units are for the most part only found in roadcuts, borrow pits, limestone quarries and clay-pits, as well as an extensive network of storm water channels and reservoirs. Most of these excavations have been made in recent years following the establishment of the Coega IDZ and port facilities. Older excavations such as clay pits and limestone quarries, several of which have yielded important fossil material in the past, are in many cases already overgrown and difficult to access. Ongoing rehabilitation involving infilling of many of these excavations with rock waste, rubble and cleared vegetation further restricts opportunities to study the bedrock and to record fossils.

The geology of the Coega IDZ has been mapped at 1: 250 000 scale (sheet 3324 Port Elizabeth) and, more recently, at 1: 50 000 scale (sheets 3325DA Addo, 3325DC & DD, 3425 BA Port Elizabeth). Geological explanations to these maps, including brief palaeontological data, are provided by Toerien and Hill (1989) and Le Roux (2000) respectively. Older sheet explanations by Haughton (1928) and Engelbrecht *et al.* (1962) are also relevant, as is the excellent unpublished report on the geology of the Coega IDZ by Goedhart and Hattingh (1997). Several desktop and field-based palaeontological heritage studies within the Coega IDZ have been completed by the author (See references in Section 14.7).

The Coega IDZ is underlain by a range of terrestrial, coastal and marine sedimentary rocks that extend from modern times back to the Early Ordovician Period, some 470 or so million years ago (Figure 14B.1). These sediments are assigned to three major geological successions: (1) the Early Palaeozoic **Table Mountain Group** comprising Ordovician (*c.* 450 Ma) fluvial sandstones and quartzites of the Peninsula Formation that are only seen at Coega Kop; (2) the Mesozoic **Uitenhage Group** that was deposited within the Algoa Basin in a range of fluvial, estuarine and shallow marine settings during the Late Jurassic to Early Cretaceous Periods (*c.* 150-130 Ma), and (3) the Late Caenozoic **Algoa Group** that accumulated along the coast of Algoa Bay over the last seven million years in estuaries, lagoons, rocky and sandy shores, and aeolian dune fields. A rich fossil record has been found in several of the marine sedimentary formations found here, notably the Early Cretaceous Sundays River Formation, the Late Tertiary Alexandria Formation, and the Pleistocene Salnova Formation. The terrestrial formations tend to be far less fossil rich on the whole, but important fossil material – notably dinosaurs and plants in the Early Cretaceous Kirkwood Formation – may potentially be found here as well.

The distribution of outcrops of these various sedimentary formations are outlined in the published 1: 250 000 geological map sheet 3324 (Toerien & Hill 1989). Please note that modifications to this map are shown in the more recent and detailed 1: 50 000 scale geological maps listed above, relevant extracts from which are provided later on in this report (Figures 14B.2 and 14B.3).

A brief review of the major rock units represented within the Coega Manganese Ore Export Facility study area follows, based largely on the recent palaeontological heritage review by Almond (2010a).

14B.4.1.1 Kirkwood Formation (J-Kk)

The **Kirkwood Formation** comprises readily-weathered, multi-hued, silty overbank mudrocks and subordinate channel sandstones and pebbly conglomerates of fluvial origin and Early Cretaceous (Berriasian / Valanginian) age, *i.e.* around 140 Ma. Key geological accounts of the Kirkwood Formation include those by Rigassi & Dixon (1972), McLachlan & McMillan (1976), Tankard *et al.* (1982), Dingle *et al.,* (1983) and Shone (2006).

14B.4.1.2 Sundays River Formation (Ks)

The Sundays River Formation is of Early Cretaceous (Valanginian-Hauterivian) age, *i.e* .around 136 Ma (million years old). It comprises a thick (up to 2km) succession of thin-bedded grey sandstones, siltstones and finer-grained mudrocks that are often highly fossiliferous (Shone 2006). Depositional settings range from estuarine through littoral (shoreline) to marine outer shelf (McMillan 2003). These beds are differentiated from the older Kirkwood Formation of the Uitenhage group by (a) the absence of reddish-hued mudrocks, (b) the presence of prominent-weathering calcareous sandstones, and (c) the frequent occurrence of fossil marine shells. These last are commonly, but not invariably, associated with the thin, calcareous sandstone beds, many of which are tempestites (*i.e.* storm deposits). Key geological accounts of the Sundays River Formation include those by Du Toit

(1954), Rigassi & Dixon (1972), Winter (1973), McLachlan & McMillan (1976), Tankard *et al.* (1982), Dingle *et al.,* (1983), McMillan (2003) and Shone (1976, 2006). For the study area the geological sheet explanations by Haughton (1928), Engelbrecht *et al.* (1962), Toerien and Hill (1989) and Le Roux (2000) are most relevant.

14B.4.1.3 Alexandria Formation (Ta)

This estuarine to coastal marine formation consists of a basal conglomerate rich in oyster shells overlain by calcareous sandstones, shelly coquinas and thin conglomerates. It represents a composite product of several marine transgressions (marine invasions) and regressions (marine retreats) across the Algoa coastal plain in Late Miocene-Pliocene times, *ie* roughly around 7-5 Ma ago (Maud & Botha 2000, Roberts *et al.* 2006). The Alexandria Formation overlies a series of marine terraces incised into older (mainly Cretaceous) rocks in the hinterland of the Algoa Basin - the lower seawards Coega Plateau and the higher, landwards Grassridge Plateau (Ruddock 1968, Goedhart and Hattingh 1997). The Alexandria Bay Formation ranges from three to 13m in thickness, with an average of 9 to 10m (Le Roux 1987b, Goedhart and Hattingh, 1997). It reaches its greatest thickness between the Swartkops and Sundays Rivers. Maud & Botha (2000) record a maximum thickness of 18m.

Geologically recent karstic (*i.e.* solution) weathering of the lime-rich Alexandria Formation has led to the development of pebbly, reddish-brown residual soils over much of the inland outcrop area of the Alexandria Formation (Maud & Botha 2000). These were formerly identified as a separate, bipartite *fluvial* unit of Plio-Pleistocene age with calcrete horizons that was named the Bluewater Bay Formation (Le Roux 1987c, 1989). This unit is mapped as such (T-Qb) on the 1: 250 000 Port Elizabeth geology sheet but not on the later 1:50 000 scale geological maps where it is indicated as pedogenic gravels overlying the Alexandria Formation (circular symbols). Incised "channels" cutting into the Alexandria Formation and infilled with cross-bedded coarse "Bluewater Bay" gravels are illustrated by Le Roux (1989). Maud and Botha (2000) suggest that these surface deposits comprise a composite of *in situ* karstic weathering products (including coarse solution-hollow infills) as well as fluvial sediments of late Neogene age. Goedhart and Hattingh (1997) have developed an explanatory scheme showing how residual pebbly and sandy weathering products of the Alexandria Formation infill solution cavities within the calcretised limestones following periods of humid climate leaching. The superficial "Bluewater Bay" deposits average 1.2m in thickness, but this varies greatly due to the presence of numerous incised channel-fill and solution pipe structures up to 7m deep (Le Roux 1987c, 1989, 2000, Hattingh 2001).

The most prominent and widely occurring solution structures in the Alexandria Formation outcrop area are *dolines*. They stand out clearly on aerial and satellite images as rounded or oval grassy patches within darker zones of thicket. These shallow but large depressions are caused by karstic solution of the underlying limestone and may reach diameters of 100m or more. Centripetal drainage causes the build-up of fine-grained sediment and pebbles within the doline. The surface depression often develops into a pan where rainwater may accumulate unless the doline is drained by a subsurface outlet (*i.e.* swallow hole). The distribution of dolines in the Coega area has been mapped in detail by Goedhart and Hattingh (1997) who note that they generally occur in well-defined NE-SW zones that correspond to furrows between fossil beach ridges developed in the underlying shallow marine Alexandria Formation. These arcuate beach ridges are clearly seen, picked out by contracting vegetation, in satellite images of the Coega Plateau area where the proposed compilation yard is to be constructed.

14B.4.1.4 Nanaga Formation (T-Qn)

Coastal aeolianites (ancient, wind-blown dune sands) of the Nanaga Formation of Pliocene to Early Pleistocene age crop out extensively to the west and east of Port Elizabeth (Le Roux 1992). They have recently been mapped along the coast of the Coega region (not shown in earlier 1: 250 000 maps). The Nanaga beds comprise calcareous sandstones and sandy limestones that often display large scale aeolian cross-bedding - well seen, for example, in deep N2 roadcuts between Colchester and Grahamstown. They may reach thicknesses of 150m or more (Maud & Botha 2000). The Nanaga aeolianites are normally partially to well-consolidated, although unconsolidated sands also occur west of Port Elizabeth (Le Roux 2000). The upper surface of the aeolianites weathers to calcrete and red, clay-rich soil, and the dune sands themselves may be profoundly reddened. The age of the palaeodunes decreases towards the modern coastline, reflecting marine regression (relative sea level fall) during the period of deposition. The oldest outcrops located furthest from the modern coast are the most elevated, having experienced some 30m of uplift in the Pliocene, and may even be Miocene in age (Roberts *et al*. 2006). Typically the ancient dunes are preserved as undulating ridges of rounded hills trending parallel to the modern shoreline (Le Roux 1992).

The Nanga Formation is not mapped at 1: 50 000 scale in the present study area on the Coega Plateau (Figure 14B.2). However, sizeable relict patches are mapped on the higher-lying Grassridge Plateau to the northwest (see also Almond 2011) while smaller areas of reddish, semi-consolidated aeolianites observed on the Coega Plateau may be assigned to this formation (Almond 2010a) (Figure 14B.6).

14B.4.1.5 Salnova Formation (Qs)

The **Salnova Formation** (**Qs**) in the Coega IDZ study area comprises a spectrum of poorly consolidated to well-indurated intertidal deposits, including beach sands, coquinites (= shell hash), shell-rich gravels and pebbly to bouldery conglomerates. These marine rocks typically crop out along the modern coast at low elevations - less than 18m amsl according to Le Roux (1991). Intraformational clasts of older Algoa Group coquinite and conglomerate are much commoner than in the older Alexandria Formation. Finer-grained estuarine and lagoonal sediments are also found, such as the stratotype D locality designated by Le Roux (1991) near Salnova saltworks in the Coega estuary area (TNPA land, Coega Zone 8) (Almond 2012). The Salnova sediments were formed during a series of several Mid to Late Pleistocene transgressions. Some authors now extend the scope of this formation to include estuarine and shoreline sediments of post-Pleistocene (Holocene) age. These include shell-rich cobbly and bouldery beds up to 2-3m amsl that may reflect the Mid Holocene highstand (= sea level peak) of 4000 to 3000 BP. Along the Coega IDZ coast the Salnova beds overlie the Uitenhage Group and are generally overlain by aeolianites of the Nahoon and / or Schelm Hoek Formations.

Recent field observations show that Salnova sediments containing rich estuarine shelly faunas extend into Coega IDZ Zone 9 to the north of the N2 (these are currently mapped on 1: 50 000 scale as T-Qk; Figure 14B.3).

A brief outline of the known fossil record of each major geological unit that is mapped within the study area, as listed in the preceding section of this report, is provided in Table 14B.1 below. The table is abstracted from the recent general review of Coega IDZ palaeontology by Almond (2010a) where further information, illustrations of typical fossils and extensive references to the relevant palaeontological literature can be found. Brief, illustrated overviews of Eastern Cape fossil heritage are provided by Rust *et al.* (1998), MacRae (1999) and Almond *et al.* (2008). Provisional identifications of Late Caenozoic marine molluscs encountered in the study area were made using

the well-illustrated account of South African sea shells by Kilburn and Rippey (1982). Only a small selection of the rich variety of shelly taxa present in these beds is mentioned by name in this report.

An indication of the overall sensitivity to development of each stratigraphic unit as well as recommended mitigation in each case is given in Table 14B.1. Note that, despite its rich recorded fossil heritage in the Eastern Cape, specialist palaeontological mitigation of excavations into the Alexandria Formation is not regarded as invariably necessary unless the beds concerned prove to be fossiliferous. This is because most shallow excavations into Alexandria Formation limestones in the Coega IDZ are likely to encounter highly calcretised sediments whose original fossil content has been largely destroyed by diagenesis (Almond 2010a).

14B.4.2 Geology and fossils within the Manganese Ore Export Facility development footprint

The study area for the proposed compilation yard and associated developments in Coega IDZ Zones 11 and 12 as well as the adjacent portion of Tankatara Farm is situated on a low-lying, stepped coastal plateau that is incised by the Coega River to the southwest and the Sundays River to the northeast (Figure 14B.4). The lower, seaward portion of this stepped surface is termed the Coega Plateau and the higher, landward portion is called the Grassridge Plateau (Goedhart & Hattingh 1997). The compilation yard development at *c*. 60 to 90m amsl largely overlies the gently sloping Coega Plateau except for the western and eastern extremities where the development intersects shallow scarps (the edges of the Brak River and Sundays River Valleys) incised into the plateau edge.

The coastal plateau as a whole is largely built of fine-grained fluvial, estuarine and marine shelf sediments of the Early Cretaceous **Uitenhage Group** and is capped by a thin veneer (usually *c*. 10 m or less) of lime-rich Neogene to Recent sediments of the **Algoa Group**. The flatter plateau areas are largely covered by scrubby vegetation with isolated thicket patches (Coega Bontveld) while the valley slopes as well as the slope break between the Grassridge and Coega Plateaux are clothed in dense Sundays Thicket (Mucina & Rutherford 2006). Bedrock exposure is mainly limited to the artificial excavations associated with roads, storm water drainage and sewage systems, active and abandoned quarries and electricity substations. However, steeper scarps along river valleys feature numerous small donga exposures into the softer Uitenhage Group sediments while the tougher "coastal limestone" Alexandria Formation often forms a thin *krans* or cliff at the plateau edge.

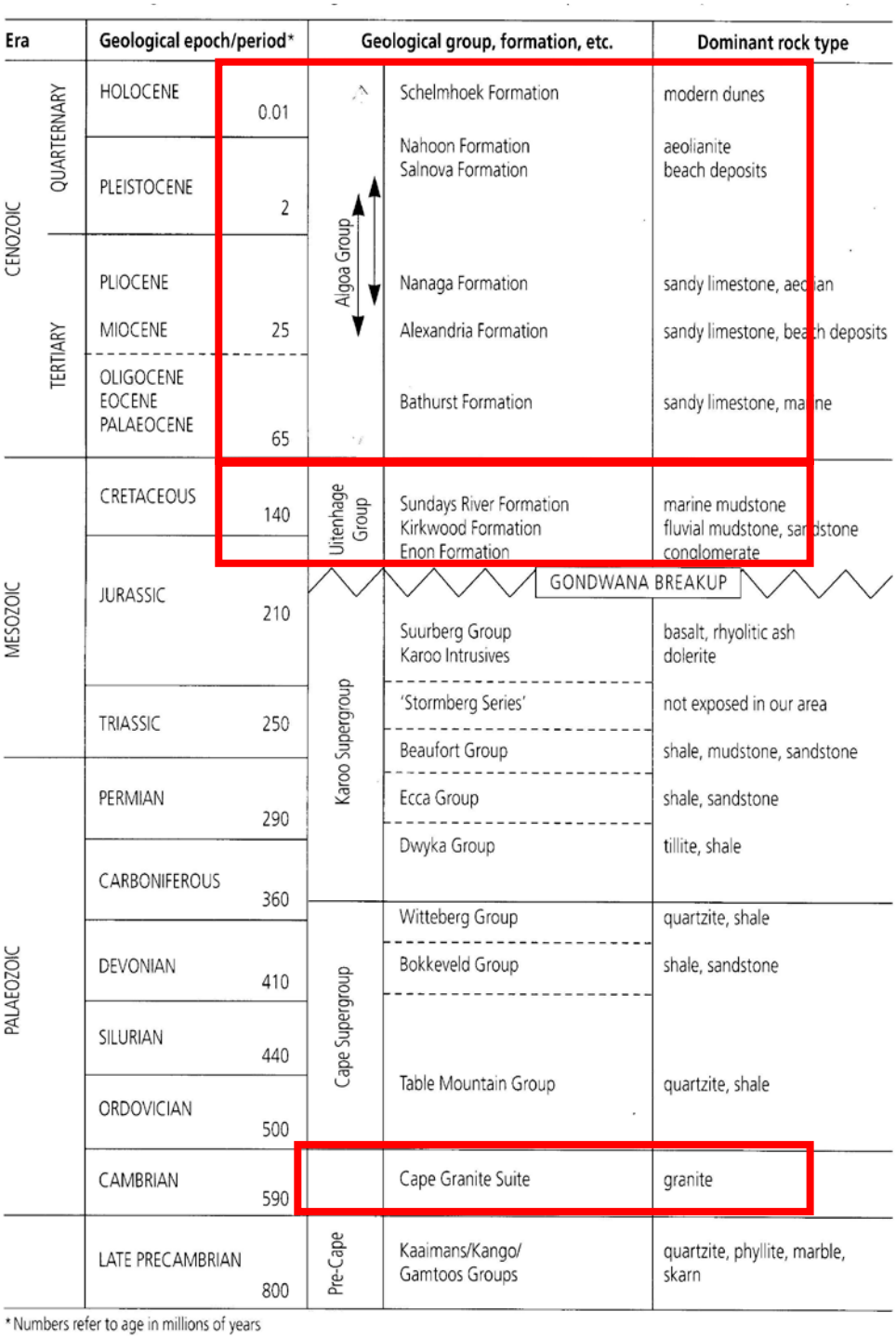

Figure 14B.1: Stratigraphic table of geological units represented on the South Coast of the Eastern Cape (modified from Rust 1998). The three main sedimentary successions that occur within the Coega IDZ – the Table Mountain, Uitenhage and Algoa Groups - are outlined in red. Of these, only the Uitenhage and Algoa Groups underlie the Manganese Ore Export Facility study area. Note that these rock successions are separated by significant time gaps of tens to hundreds of millions of years.

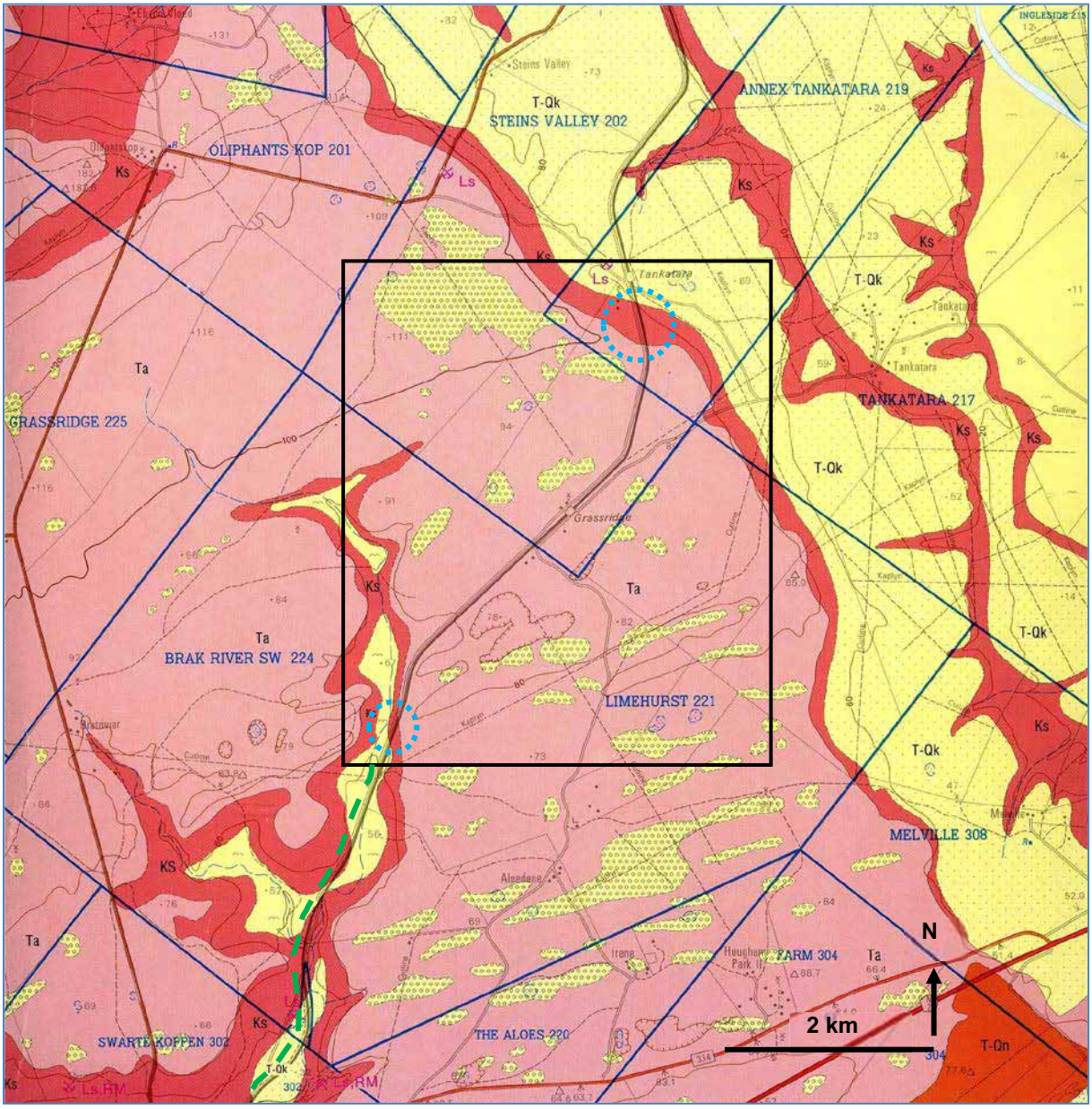

Figure 14B.2: Extract from 1: 50 000 geological map 3325DA Addo showing the distribution of the main sedimentary rock units within the broader development footprint of the proposed compilation yard within Zones 11 and 12 of the Coega IDZ as well as the adjacent portions of Farm Tankatara (This area is approximately indicated by the black rectangle). The main geological units represented here include the Sundays River Formation (pinkish red, Ks), the Alexandria Formation (pink, Ta), residual soils overlying the latter, previously known as the Bluewater Bay Formation (medium yellow with large dots), Tertiary to Quaternary fluvial deposits of the Brak and Sundays Rivers (pale yellow with dots, T-Qk), and the Nahoon Formation (orange, T-Qn). Areas of high palaeontological sensitivity along the eastern margin of the Coega limestone plateau and the edge of the Brak River Valley where the proposed developments transect fossiliferous marine beds of the Sundays River Formation are encircled by blue dotted lines. Doubling of the railway line between the compilation yard and the existing marshalling yard in IDZ Zones 9 and 13 (green dashed line) may also entail significant impacts on Sundays River fossil heritage along the Brak River Valley.

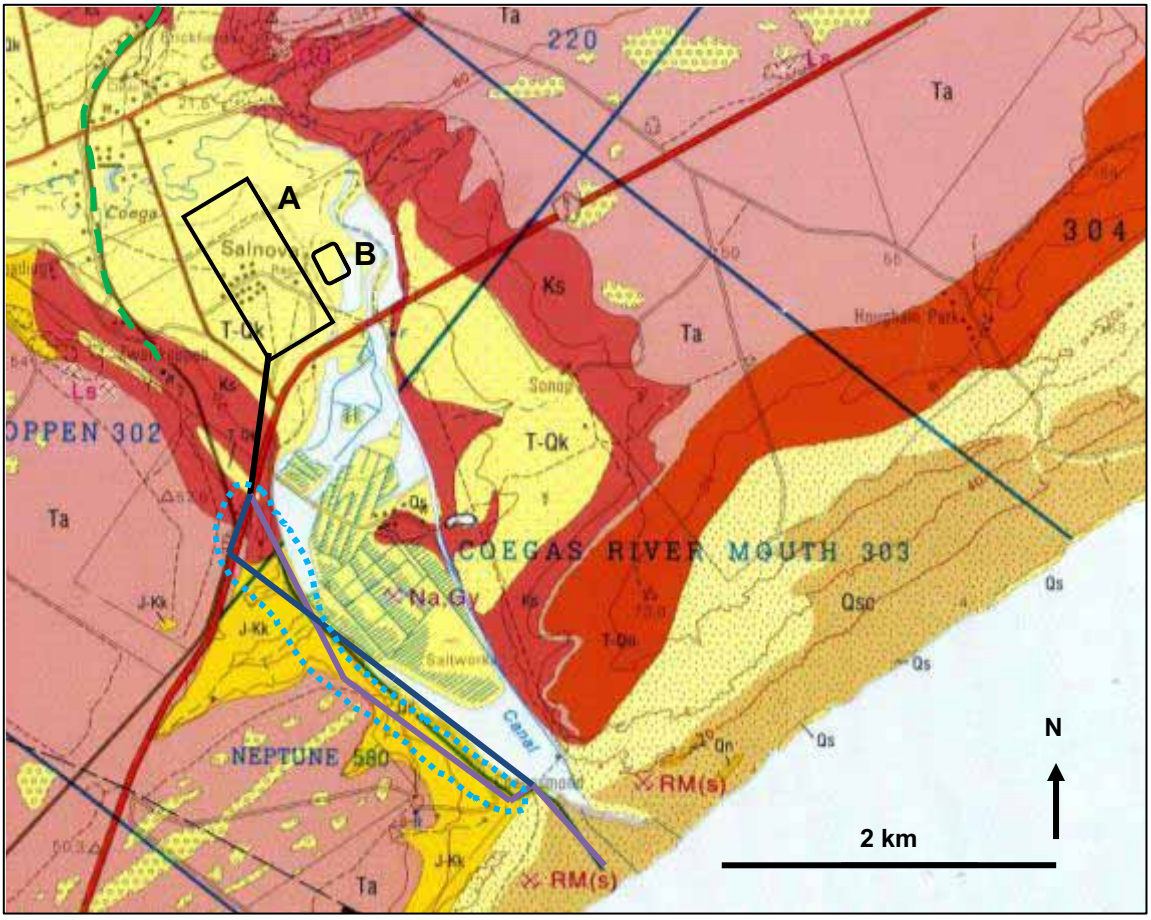

Figure 14B.3: Extract from 1: 50 000 geological map 3325DC & DD, 3425BA Port Elizabeth showing the distribution of the main sedimentary rock units within the broader development footprint of the proposed manganese ore bulk terminal within Zones 8 and 9 of the Coega IDZ. The approximate footprints of the stockyard (A), storm water retention dam (B) are indicated by the black polygons. The preferred route for the conveyor between tippler and ship loader is shown by the purple line. The alternative conveyor route is shown by the dark blue line (See also Figure 14B.4).

The main geological units represented here include the Kirkwood Formation (dark yellow, J-Kk), Sundays River Formation (pinkish red, Ks), the Alexandria Formation (pink, Ta), residual soils overlying the latter, previously known as the Bluewater Bay Formation (medium yellow with large dots), Tertiary to Quaternary fluvial deposits of the Brak, Coega and Sundays Rivers (pale yellow with dots, T-Qk), estuarine sediments of the Salnova Formation (Qs), and the Nahoon Formation (orange, T-Qn). Note that recent field observations show that the Salnova Formation outcrop area actually extends into Zone 9 north of the N2 highway and probably underlies at least parts of areas A and B.

Areas of high palaeontological sensitivity along the conveyor belt routes are indicated by the blue dotted line. Doubling of the railway line between the compilation yard and the existing marshalling yard in IDZ Zone 9 (green dashed line) may also entail significant impacts in the Coega River Valley where the line overlies the Sundays River Formation.

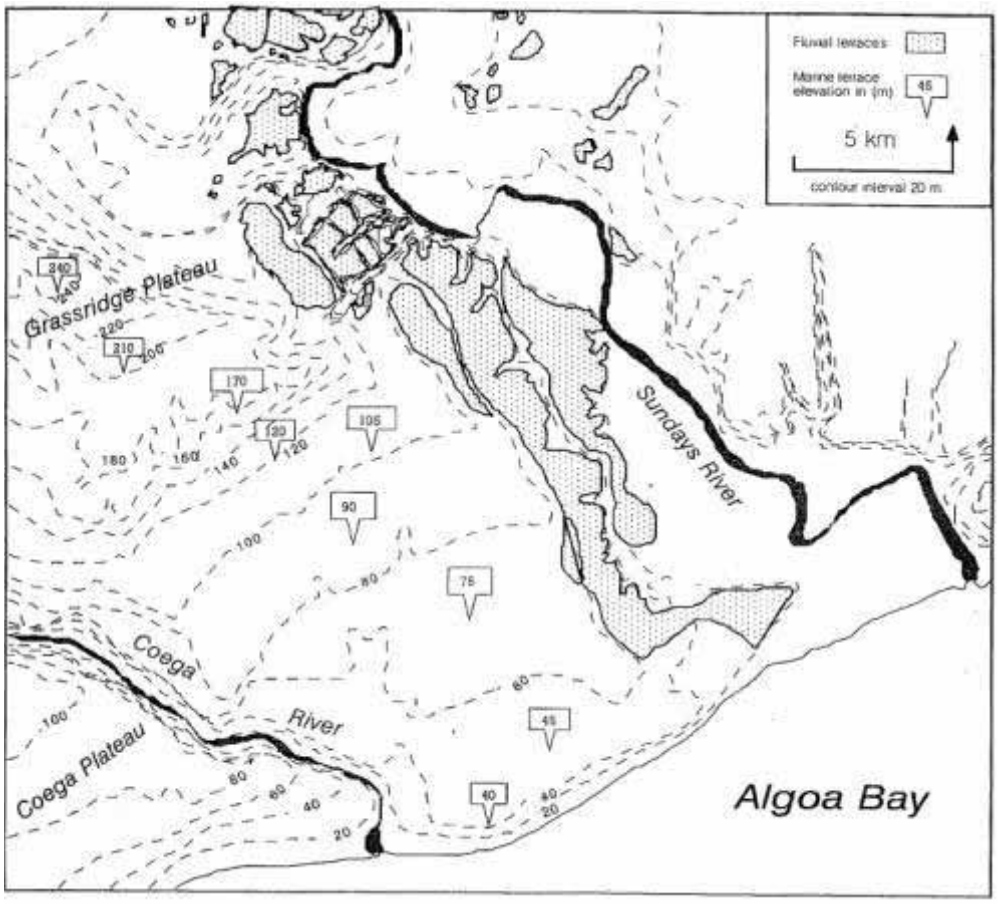

Figure 14B.4: Contour map of the coastal area between the Coega and Sundays Rivers showing the high inland Grassridge Plateau and the lower coastal Coega Plateau separated by a steeper break in slope (From Goedhart & Hattingh 1997). The stippled areas west of the Sundays River are elevated ancient fluvial terrace deposits, seen for example in the Tankatara area (Hattingh 2001).

In the Coega IDZ study area the coastal plateau is largely built of fine-grained estuarine and marine shelf sediments of the Early Cretaceous **Sundays River Formation** (**Uitenhage Group**, **Ks**). These readily-weathered rocks are capped by a thin (10m or less), limestone-dominated shallow marine to coastal succession, the **Alexandria Formation** (**Algoa Group**, **Ta**) of Neogene (Late Tertiary) age. In some areas the Alexandria Formation is extensively blanketed in pebbly, reddish-brown residual soils. These were previously (1: 250 000 map, Figure 14B.1) assigned to a separate **Blue Water Bay Formation** (**T-Qb**) but are now incorporated into the Alexandria Formation (1: 50 000 map, dotted symbols). Relict patches of Pleistocene aeolianites (dune sands) of the **Nanaga Formation** (Algoa Group) are scattered across the interior coastal plateau, especially on the higher lying Grassridge Plateau. These sands are often rubified (reddened) through weathering of metal-rich impurities.

The **Alexandria Formation** is known for its rich shelly marine fauna of Miocene – Pliocene invertebrates (Table 14B.1). However, the recent fossil heritage survey by Almond (2010a) concluded that over much of the Coega Plateau these lime-rich sediments have been heavily calcretised and otherwise modified by diagenesis so that they now often contain little or no well-preserved fossil material. Many of the original shelly remains have been dissolved and are preserved as moulds. Occasional lenses of coquinite (shell hash) and pebbly conglomerate beds with fragmentary to intact

fossil shells – mainly oysters or large, thick-shelled gastropods (*e.g.* cowries) – are occasionally seen, however, especially towards the base of the succession. A few productive fossil localities in this region – mainly surface limestone quarries or borrow pits that are no longer operational - are listed by Le Roux (1987). The residual soils of the "Bluewater Bay" facies overlying the Alexandria Formation limestones are only very sparsely fossiliferous, with occasional terrestrial snails as well as robust marine shells that have weathered out of the underlying beds (Le Roux 1989, Almond 2010a). Carbonaceous silty to clay-rich doline infills might be expected to be associated with mammalian remains (bones, teeth, horn cores) and palynomorphs but there are no records of such fossils so far (Almond 2010a).

Elevated **Late Caenozoic terrace deposits** ("High Level Gravels") of the Sundays River margin the eastern edge of the Coega Plateau (Figure 14B.4). The step-like topography here is emphasised on the geological map by narrow NNW-SSE bands of Sundays River Formation rocks cropping out along the steeper escarpment slopes separating flatter-lying, river-incised terrace surfaces (Figure 14B.2). Gravelly terrace deposits of inferred Late Pliocene age (T-Qk) are seen in the Tankatara area at the north-eastern end of the compilation yard development; this is terrace T7 of Hattingh (2001) which lies at elevations of 65 to 85m amsl. The polymict surface gravels here comprise mainly angular downwasted calcrete clasts intermingled with well-rounded pebbles and cobbles of Table Mountain Group quartzites and Uitenhage Group sandstones (Figure 14B.5). No fossil remains were recorded within the Late Caenozoic alluvial gravels during the present field assessment and although very sparse specimens of fossil or subfossil vertebrates (*e.g.* mammalian bones, teeth) might occur here, their palaeontological sensitivity is generally low (Table 14B.1).

Road cuttings in the Tankatara area locally show a substantial thickness of orange-hued sands overlying surface calcrete (Figure 14B.6). These sands may be relict aeolianites of the Nanaga Formation. They appear to be leached and no land snails or other fossils were observed within them during the present field study.

Figure 14B.5: Polymict terrace gravels of probable Pliocene age mantling the surface in the Tankatara area (Hammer = 29 cm). These are ancient alluvial deposits of the Sundays River.

Figure 14B.6: Orange-brown semi-consolidated aeolianites overlying calcrete in the Tankatara area. These may be relict patches of Pleistocene wind-blown sands of the Nanaga Formation.

A long section of the railway line between the new compilation yard and the existing marshalling yard runs along the dry valley of the Brakrivier, a small, intermittent north bank tributary of the Coega River (IDZ Zone 13). The floor of the river valley is mantled by **Late Caenozoic fluvial deposits** (T-Qk) while its banks are incised into Early Cretaceous marine sediments of the Sundays River Formation (Ks, Figure 14B.2). However, the latter are rarely exposed due to dense thicket vegetation on steeper slopes. Several important shelly fossil sites within the Sundays River Formation, including various defunct brick clay quarries, are reported from the escarpment zone close to the intersection of the Brak and Coega Rivers, as reviewed by Almond (2010a; see also Cooper 1981). Fresh excavations into the Sundays River beds in this area (*e.g.* new railway cuttings) are therefore likely to expose marine fossil remains.

Where the southern sector of the railway crosses the floor of the wide Coega River Valley in IDZ Zone 9 it overlies thicker alluvial and / or estuarine deposits of Late Caenozoic age (T-Qk). Estuarine sediments occurring here may be highly fossiliferous and are now incorporated into the **Salnova Formation** (Qs) whose definition has been expanded to incorporate post-Pleistocene marine-influenced deposits below 18m amsl. These are underlain in turn by Sundays River beds, as shown for example by river bank exposures near Coega siding (*e.g.* Chetty River section, Almond 2010a, fig. 30 therein). Several other components of the proposed Coega Manganese Ore Export Facility within IDZ Zone 9 – including the stockyard, storm water retention pond and evaporation dam– are also underlain by Late Caenozoic estuarine and / or alluvial deposits on the floor of the Coega River estuary to the north of the N2 trunk road (Figures 14B.3 and 14B.7). The underlying Sundays River Formation beds are unlikely to be intersected here except by excavations of more than several meters depth.

Orange-brown silty deposits of probable alluvial or estuarine origin are exposed in road cuttings in IDZ Zone 9 to the northeast of the marshalling yard (Figure 14B.8). The upper part of the deposits contain calcretised root structures (rhizoliths) while sparse dispersed pebbles, ostrich egg shell fragments, subfossil land snails (*e.g. Tropidophora*), millipede exoskeletal remains, occasional white mussel valves (*Donax*) and flaked quartzite occur lower down. These superficial deposits are probably Pleistocene in age or younger. The orange-brown silts overlie lenticular to sheet-like cobble and boulder conglomerates composed largely of well-rounded Table Mountain quartzite, clearly representing ancient alluvial deposits of the Coega River.

Figure 14B.7: View towards the northwest across the southern part of the Zone 9 study area, close to the N2. This part of the Coega River Valley is floored at depth by the Sundays River Formation mantled by Late Caenozoic fluvial and estuarine deposits of the Coega River.

Much of the surface sediments to the east of the marshalling yard have been disturbed, sealed-in by building rubble (*e.g.* large exotic blocks of Alexandria Formation shelly conglomerates close to the previous Salnova settlement) or are densely vegetated so their palaeontological heritage potential is difficult to assess. In the development areas of the proposed stockyard and storm water retention pond on the west bank of the Coega River, close to the N2, estuarine shelly assemblages typical of the Pleistocene "Swartkops Fauna" are weathering out from buff siltstones that are exposed at the surface here and are clearly several meters thick (Figure 14B.9). Typical estuarine species of mollusc such as the knobbly tapering gastropod *Cerithium*, the smaller gastropod *Nassarius* and the bivalves *Dosinia* and *Tellina* are abundant here, so these deposits can be assigned to the **Salnova Formation** (Qs) rather than the ill-defined unit T-Qt as mapped (See also Almond 2012). Other interesting remains recorded here during the field assessment include weathered teeth of an equid (presumed subfossil, Figure 14B.10) as well as occasional quartzite flakes. The semi-consolidated shelly Salnova beds can be traced south of the N2 highway in road cuttings along the north-western edge of IDZ Zone 8 where they are overlain by a thin calcretised zone and orange-brown silty soils containing extant land snails.

Figure 14B.8: Thick reddish-brown silty alluvium overlying fluvial pebbly and cobbly conglomerates exposed in a Zone 9 road cutting to the northeast of the marshalling yard (Hammer = 29 cm). The upper alluvial sediments here are partially calcretised around plant roots.

Figure 14B.9: Pleistocene estuarine shelly fauna of the Salnova Formation weathering out at surface along the southern margin of Zone 9, close to the proposed storm water retention pond and stockyard development areas (Scale in cm and mm). Taxa seen here include the gastropod Cerithium and the bivalve Dosinia hepatica.

Figure 14B.10: Subfossil high-crowned mammalian teeth (possibly equid) weathering out from Salnova Formation estuarine deposits on the southern margin of Zone 9 (Scale in cm).

Figure 14B.11: Rich coquinas of reworked shells within dark estuarine muds along the western banks of the Coega River, southern edge of Zone 9 (scale in cm and mm).

Figure 14B.12: Detail of shelly lenticle seen in previous figure showing invetebrate taxa including bivalves (Macoma), barnacle tests and calcareous tubes of the estuarine polychaete Ficopomatus (Scale in cm and mm).

Rich shelly lenticles (coquinas) of estuarine invertebrates are exposed within dark estuarine silts and fine gravels along the eastern banks of the Coega River close by, just north of the bridges (Figures 14B.11 and 14B.12). Shells are variously intact to fragmented, with most bivalves disarticulated. Common invertebrate taxa seen here include the small but robust-shelled gastropod *Nassarius*, abundant shells of the tiny estuarine snail *Assiminea*, various bivalves (*Macoma litorialis, Tellina, Dosinia*), estuarine polychaete worm tubes (*Ficopomatus*), barnacle plates, as well as occasional reworked land snails (*Natalina, Tropidophora*) and flaked quartzite clasts. These estuarine sediments probably represent the youngest, Holocene equivalents of the Salnova Formation.

The south-western banks of the Coega River estuary in Coega IDZ Zone 9 are largely built of Early Cretaceous fluvial sediments of the **Kirkwood Formation**. Away from the banks these are capped by Tertiary Alexandria Formation limestones and associated "Bluewater Bay" downwasted gravels (Figure 14B.3). High Level terrace gravels may also occur here, but are not mapped at 1: 50 000 scale. Apart from occasional cliff, cutting and gully exposures facing the river valley, the Kirkwood beds are poorly exposed here due to thick vegetation cover. Where seen, they comprise typical reddish-brown, cream and grey-green overbank siltstones with occasional more resistant-weathering interbeds of greenish-brown sandstone, locally pebbly (Figures 14B.13 and 14B.14).

Figure 14B.13: Greenish sandstones of the Early Cretaceous Kirkwood Formation exposed on the western edge of the Coega River Valley in the TNPA area (Coega IDZ Zone 8).

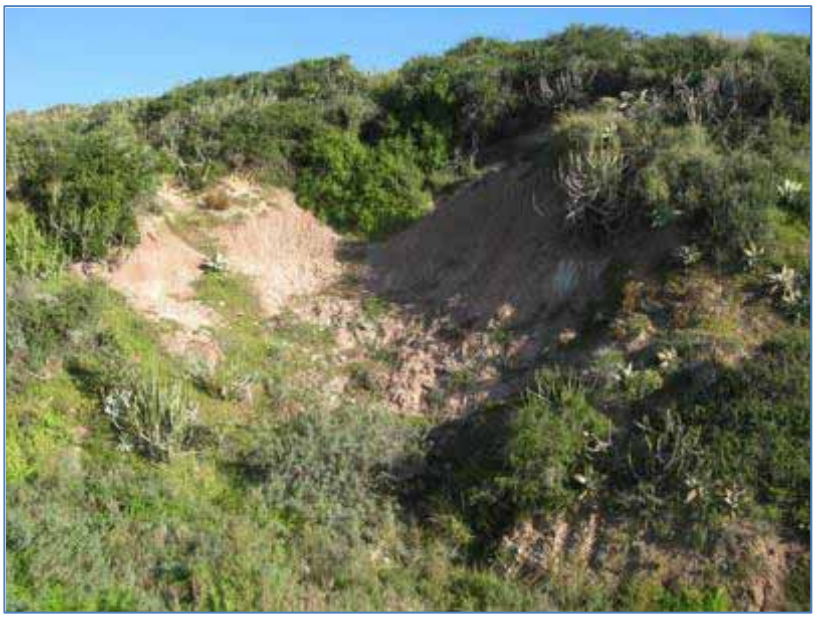

Figure 14B.14: Reddish-brown and cream overbank siltstones of the Early Cretaceous Kirkwood Formation exposed on the western edge of the Coega River Valley in the TNPA area (Coega IDZ Zone 8). Note low levels of exposure due to dense vegetation cover.

No fossil remains were noted within the Kirkwood beds in the TNPA area during the present field assessment. Fossil remains within this unit are clearly very sparse, as noted in the previous study by Almond (2010a) who only found one fragmentary bone specimen within the Coega IDZ exposures examined. An earlier brief palaeontological assessment of selected developments in the Ngqura Port area by De Klerk (2007) also yielded no fossils from the Kirkwood beds here. Buff shelly estuarine silts of the Salnova Formation, also containing sparse land snails and pebbles, are banked up against the Kirkwood cliffs in the area close to the N2 but some or all of these fossiliferous younger deposits may have been disturbed during previous construction work.

Table 14B.1: Fossil heritage of the sedimentary formations represented within the development footprint of the Manganese Ore Export Facility, Coega IDZ, Eastern Cape (Modified from Almond 2010a).

FORMATION & AGE	FOSSIL HERITAGE	PALAEONTOLOGICAL SENSITIVITY	RECOMMENDED MITIGATION FOR NEW DEVELOPMENTS
RIVER TERRACE GRAVELS (T-Qk) & ALLUVIUM Miocene to Recent river deposits	Possibly rare rolled bones, freshwater molluscs, plant remains	**LOW**	Mitigation not required - *unless* rich fossil assemblages exposed during excavation
NAHOON FORMATION (Qn) Mid to Late Pleistocene calcareous dune sands	Common land snails, calcretised root casts, peats, termitaria, sparse MSA stone tools	**LOW**	Mitigation not required - *unless* rich fossil assemblages exposed during excavation
SALNOVA FORMATION (Qs) Mid Pleistocene to Recent coastal and estuarine sediments	Very rich shelly invertebrate faunas, especially molluscs but also several other groups, such as crustaceans & echinoids, possible rare vertebrate bones	**HIGH**	Excavations (especially those into fine-grained mudrocks) to be examined and sampled by professional palaeontologist while fresh bedrock is still exposed
NANAGA FORMATION (T-Qn) Pliocene – Early Pleistocene calcareous dune sands	Common land snails, calcretised root casts, possible termitaria	**LOW**	Mitigation not required - *unless* rich fossil assemblages exposed during excavation
"BLUEWATER BAY FORMATION" residual weathering product of Alexandria Fm	Rare fossil shells weathered out from underlying limestones *plus* land snails, freshwater mussels	**LOW**	Mitigation not required - *unless* rich fossil assemblages exposed during excavation

Note: Confidence levels are moderate because these sensitivity ratings are based on inspection of representative rock exposures of the various rock units within the entire Coega IDZ and further afield.

Table 14B.1 continued: Fossil heritage of the sedimentary formations represented within the development footprint of the Manganese Ore Export Facility, Coega IDZ, Eastern Cape (Modified from Almond 2010a).

FOSSIL HERITAGE OF SEDIMENTARY FORMATIONS OCCURRING WITHIN THE COEGA IDZ, THE EASTERN CAPE *continued*			
FORMATION & AGE	**FOSSIL HERITAGE**	**PALAEONTOLOGICAL SENSITIVITY**	**RECOMMENDED MITIGATION FOR NEW DEVELOPMENTS**
ALEXANDRIA FORMATION (Ta) Miocene – Pliocene shallow marine to estuarine sediments	Very rich shelly invertebrate faunas, especially molluscs but also several other groups, sharks teeth, possible rare vertebrate bones	**LOW TO HIGH** Rich shelly faunas only found at some localities fossil shells often destroyed by deep weathering, calcrete formation, especially in near-surface sections	Mitigation not required - *unless* rich fossil assemblages exposed during excavation
SUNDAYS RIVER FORMATION (Ks) Early Cretaceous marine to estuarine / intertidal mudrocks and sandstones	Rrich variety of marine molluscs (bivalves, ammonites *etc*) and other invertebrates v. rare marine reptiles (plesiosaurs)	**MODERATE TO HIGH** Most shelly fossils associated with thin sandstones	Substantial (high volume) excavations to be examined and sampled by professional palaeontologist while fresh bedrock is still exposed
KIRKWOOD FORMATION (J-Kk) Early Cretaceous fluvial to estuarine mudrocks and sandstones	Rare dinosaurs, petrified wood, plants (esp. gymnosperms), charcoal, freshwater crustaceans & molluscs	**MODERATE TO HIGH** Fossils generally sparse but may be concentrated at certain horizons (*eg* ancient soils, flood deposits)	Substantial (high volume) excavations to be examined and sampled by professional palaeontologist while fresh bedrock is still exposed

14B.5 IDENTIFICATION OF KEY ISSUES

The proposed Coega Manganese Ore Export Facility is located in an area of the Eastern Cape that is underlain by potentially fossil-rich sedimentary rocks of Mesozoic and younger, Tertiary or Quaternary age (Section 14.3). The construction phase of the development will entail substantial excavations into the superficial sediment cover as well as the underlying bedrocks. In addition, large areas of bedrock will be sealed-in or sterilized by new infrastructure. Construction may therefore adversely affect scientifically valuable fossil heritage within the study area by destroying, damaging, disturbing or permanently sealing-in fossils - either already exposed on the land surface or buried beneath it - that are then no longer available for scientific research or other public good. Once constructed, the operational and decommissioning phases of the facility will not involve further adverse impacts on palaeontological heritage, however.

14B.6 IMPACT ASSESSMENT

In this section of the report the potential impacts of the various major components of the Coega Manganese Ore Export Facility on palaeontological heritage are discussed and the significance of these impacts is then assessed in tabular form.

14B.6.1 Proposed Manganese Ore Export Terminal

Most of the seaward components of the bulk Manganese Ore Export Terminal will be located within areas of the Coega IDZ Zone 8 (TNPA area) that are already developed and sealed-over, and therefore will not entail significant additional impacts on local fossil heritage. A large area (c. 40 ha) of fossiliferous estuarine sediments of the Salnova Formation in the Coega Estuary will be sealed-in by the proposed stockyard in IDZ Zone 9.

Any new bedrock excavations associated with construction of the conveyor system between the tippler and the ship loader might have significant impacts on buried palaeontological heritage within the Uitenhage Group (Kirkwood and Sundays River Formations) here. The preferred alignment of the ground level conveyor belt route will entail substantial cuttings into the potentially-fossiliferous Kirkwood Formation beds to the west of the Coega Estuary in Zone 9 (Figures 14B.3 and 14B.15). The alternative conveyor belt route largely follows an existing corridor that runs along the south-western edge of the salt flats, close to sea level, and that is already highly disturbed and sealed-in, so significant impacts are not anticipated in this case unless substantial new cuttings are made at the landward end of the route.

Substantial excavations for the proposed stormwater control dam in Zone 9 (Figure 14B.3, B) may entail significant impacts on richly fossiliferous estuarine sediments of the Salnova Formation within the development footprint. The full extent of the Salnova Formation outcrop area in Zone 9 is currently unclear because of extensive cover by unfossiliferous alluvial sediments, soils and vegetation. The proposed stormwater control dam at the quay in Zone 8 lies within an already highly disturbed area and so significant impacts on fossil heritage are not anticipated here.

The significance of the potential impact of the proposed Manganese Ore Export Terminal on palaeontological heritage is therefore predicted to be **medium to low** before mitigation and **low** after mitigation.

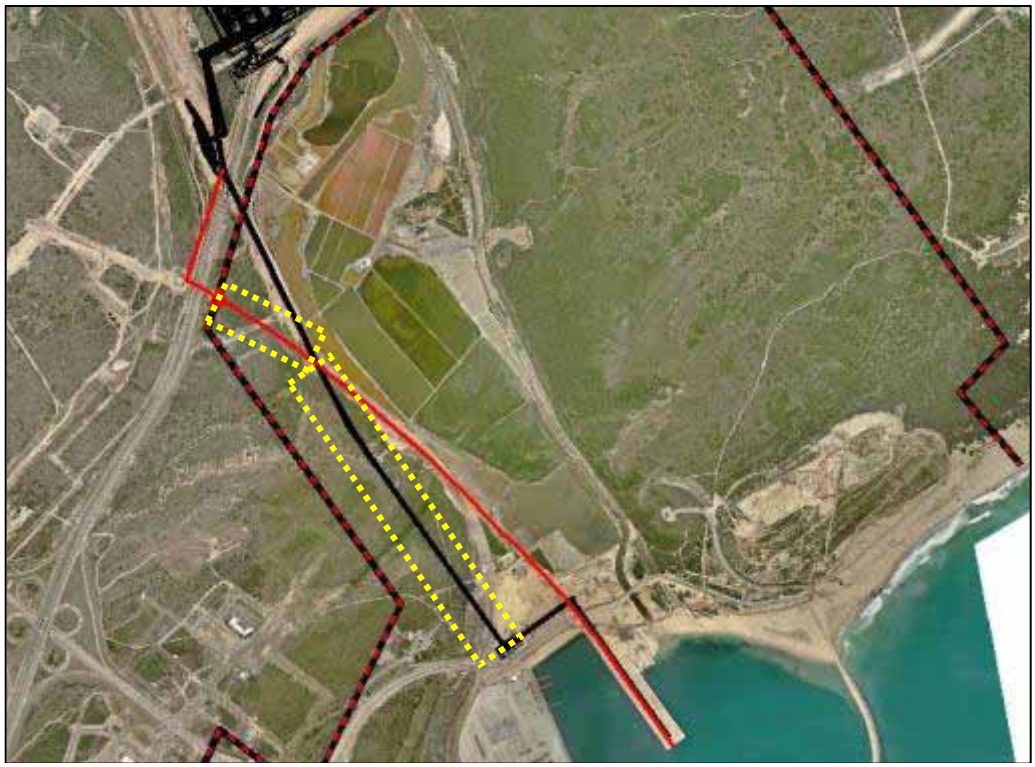

Figure 14B.15: Google earth© satellite image of the IDZ Zone 8 area (Ngqura Port) showing the preferred conveyor belt route (black line) and the alternative route (red line). The preferred route would entail the excavation of cuttings through potentially fossiliferous sediments of the Kirkwood Formation on the south-western side of the Coega Estuary. The alternative route runs largely along an existing alignment that is already disturbed and sealed-in, so bedrock excavations required here are considerably less. Zones of high palaeontological sensitivity along the conveyor routes are indicated by the yellow dotted rectangles.

14B.6.2 Proposed Compilation Yard

The greater part of the proposed compilation yard development (including one of the stormwater attenuation pond), including the preferred as well as alternative layouts, overlie calcretised coastal limestones of the Alexandria Formation (Figures 14B.2 and 14B.16). These coastal marine rocks are generally poorly fossiliferous on the Coega Plateau, although shelly fossil-rich pockets may occasionally be encountered here (Almond 2010a). Superficial sediments within the compilation yard / access road footprint – including downwasted surface gravels ("Bluewater Bay Formation"), leached ancient aeoliantes (possibly Nanaga Formation) and clay-rich doline infills - are generally poorly fossiliferous. It is therefore unlikely to have a significant impact unless underlying Sundays River Formation mudrocks are intersected here.

Two small sectors of the proposed compilation yard (to the northern section of the yard where the second attenuation pond is proposed to be located and to the southern section where the railway link from the yard joins the existing main railway line–) – at the edge of the Brak River and Sundays River valleys in the west and east respectively (red dotted areas in Figure 14B.16) – overlie the outcrop area of the Sundays River Formation. Significant impacts on buried fossil heritage might occur here if major new railway cuttings are constructed. In this respect, the alternative layout of the

compilation yard is likely to have a smaller negative impact on fossil heritage than the preferred option since the former is likely to intersect a smaller volume of Sundays River Formation bedrocks.

Elsewhere in IDZ Zones 11 and 13, only deeper excavations (over ten meters) that penetrate through the surface limestones into the underlying Sundays River beds, are likely to have significant negative impacts on buried or surface fossils.

The significance of the potential impact of the proposed Compilation yard on palaeontological heritage is therefore predicted to be **medium to low** before mitigation and **low to very low** after mitigation.

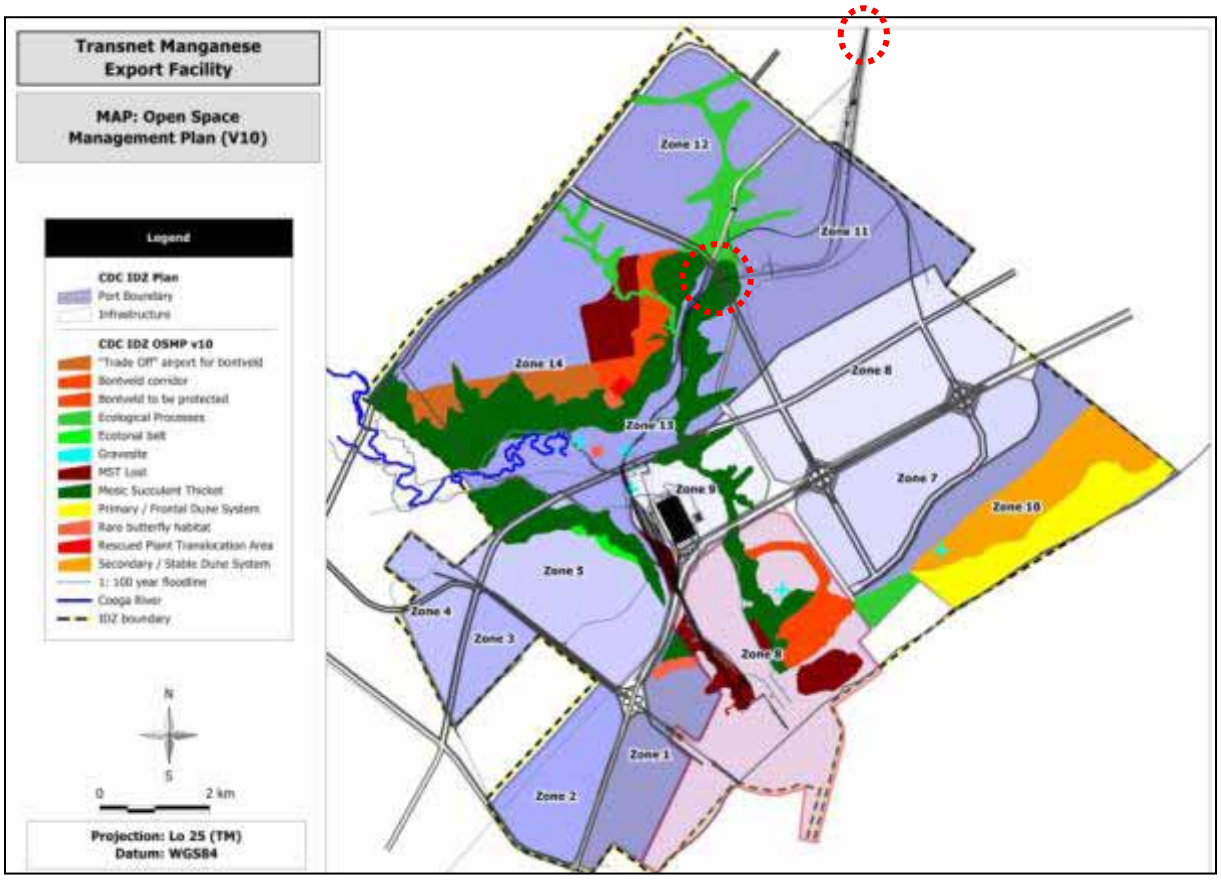

Figure 14B.16: Map showing alternative layouts for the compilation yard in Coega IDZ Zones 11 and 13. The preferred compilation yard layout (Alternative A) is shown in grey and the alternative layout in black. Areas of high palaeontological sensitivity where the proposed infrastructure overlies the outcrop area of the Sundays River Formation are outlined by red dotted lines (See also Figure 14B.3).

14B.6.3 Proposed Doubling of Railway

Doubling of the railway between the compilation yard and the existing marshalling yard in IDZ Zones 9 and 13 will mainly involve construction within the existing rail reserve which is already highly disturbed. However, any new railway cuttings through Sundays River Formation bedrocks in the Brak

River or Coega River Valleys (notably areas mapped as Ks in Figures 14B.2 and 14B.3) might have significant impacts on buried fossil heritage.

The significance of the potential impact of the proposed doubling of railway line on palaeontological heritage is therefore predicted to be **medium** before mitigation and **low** after mitigation.

14B.6.4 Summary and recommendations

The inferred impact significance of the proposed Coega Manganese Ore Export Facility for palaeontological heritage is assessed in tabular form below, according to the methodology developed by the CSIR (refer to Chapter 4). Impacts on palaeontological heritage are generally direct, confined to the development footprint and to the construction phase. Separate assessments are provided for those major components of the project that have a large footprint (*e.g.* stockyard) and / or involve substantial bedrock excavations since only these are likely to have significant impacts on buried fossil heritage.

In all cases, irrespective of its permanent nature, the palaeontological impact significance of the construction phase of the proposed development is rated as **low to very low**, given its local extent (confined to the immediate development footprint) and the generally sparse occurrence of fossils in most – but not all - of the sedimentary rocks concerned. High negative impacts on palaeontological heritage are only envisioned should rich fossil occurrences be exposed during construction and not mitigated as recommended here. On the other hand, should specialist mitigation be followed through, this could represent a significant *positive* impact (in the event of small portion of the overall heritage resource (e.g. fossiliferous formation) being affected), since our understanding of previously hidden fossil heritage will thereby be enhanced.

The operational and decommissioning phases of the proposed Manganese Ore Export Facility will not involve significant additional adverse or other impacts on palaeontological heritage.

Many infrastructure components of the proposed Manganese Ore Export Facility overlie sedimentary rocks that are of low palaeontological sensitivity and / or do not involve sizeable bedrock excavations at the construction phase. In these cases, general monitoring at least on a daily basis of all excavations for newly exposed fossil material by a suitably qualified appointed person is recommended. Professional palaeontological monitoring is only recommended for this project in the case of substantial new excavations (*e.g.* more than 200 m^3) into the potentially fossil-rich Kirkwood Formation, Sundays River Formation and Salnova Formation. In particular, professional palaeontological monitoring is recommended in the case of:

- Deeper (>3m) excavations within the compilation yard footprint (IDZ Zones 11, 12, 13), should these intersect the underlying Sundays River Formation (see areas highlighted in Figure 14B.12).
- Any new cuttings into the Sundays River Formation along the doubled-up railway line between the proposed compilation and existing marshalling yards (IDZ Zone 13 and 9; green dashed line in Figures 14B.2 and 14B.3).
- Excavations (> 200 m^3) into Salnova Formation estuarine deposits within the footprints of the stockyard, storm water retention pond and evaporation dam (IDZ Zone 9; small black polygons in map Figure 14B.3).
- New excavations into Kirkwood and Sundays River Formation rocks along the conveyor line route in IDZ Zone 8 (map Figure 14B.4 and satellite image Figure 14B.15).

These recommendations should be incorporated into the Environmental Management Plan for the proposed Manganese Ore Export Facility.

14B.6.5 Cumulative impacts

In the absence of details of other projected developments within the Coega IDZ, it is not possible to realistically assess cumulative impacts. Most of the sedimentary formations concerned are of considerable lateral extent and volume, so cumulative impacts on their fossil heritage are likely to be low. A possible exception concerns the highly fossiliferous estuarine component of the Salnova Formation that has a limited outcrop area which is largely confined to the Coega and Swartkops estuaries (Le Roux 1991) (*N.B.* The full extent of the Salnova Formation outcrop area within the Coega Estuary is unknown due to soil, alluvium and vegetation cover. Recent field observations suggest that it may be much larger than indicated on published geological maps). Cumulative impacts on the highly fossiliferous, but volumetrically limited, estuarine deposits of the Salnova Formation as a result of the Ngqura Port and associated development projects within Zones 8 and 9 of the Coega IDZ, such as the proposed Manganese Ore Export Facility, are potentially significant and negative. It is therefore imperative that all future developments involving bedrock excavation within these IDZ zones (*e.g.* cumulative impact from construction of possible new ship berths upstream in the Coega River that form part of the conceptual planning for the extension of the Port of Ngqura) be adequately assessed, and where necessary professionally monitored and mitigated, in terms of fossil heritage issues.

Table 14B.2: Paleontological impact assessment summary

Construction Phase										
Impact Description	**Mitigation**	**Spatial Extent**	**Intensity**	**Duration**	**Reversibility**	**Irreplaceability**	**Probability**	**Significance & Status**		**Confidence**
								Without Mitigation	***With Mitigation***	
Direct Impacts										
Compilation Yard (Preferred Option – Alternative 1) – Zones 11, 13 and portion of Tankatara farm										
Destruction, disturbance or sealing-in of fossils exposed on the ground or buried beneath the surface during excavations and other construction work	Specialist monitoring of new excavations into the Sundays River Formation. Monitoring of all excavations for fossil material during construction phase (at least daily).	Site specific	Medium	Permanent	Irreversible	Low	Probable	**Medium**	**Low**	Medium
Compilation Yard (Alternative 2) – Zone 11 and portion of Tankatara farm										
Destruction, disturbance or sealing-in of fossils exposed on the ground or buried beneath the surface during excavations and other	Specialist monitoring of new excavations into the Sundays River Formation.	Site specific	Low	Permanent	Irreversible	Low	Probable	**Low**	**Very low**	Medium

construction work	Monitoring of all excavations for fossil material during construction phase (at least daily).									
Conveyor system (Preferred alignment) – Zone 8										
Destruction, disturbance or sealing-in of fossils exposed on the ground or buried beneath the surface during excavations and other construction work	Specialist monitoring of new excavations (*e.g.* cuttings) into the Kirkwood (mainly) and Sundays River Formations. General monitoring of all excavations for fossil material during construction phase.	Site specific	Medium to High	Permanent	Irreversible	Low	Probable	**Medium**	**Low**	Medium
Conveyor system (Alternative alignment) – Zone 8										
Destruction, disturbance or sealing-in of fossils exposed on the ground or buried beneath the surface during excavations and other construction work	Specialist monitoring of new excavations (*e.g.* cuttings) into the Kirkwood and Sundays River Formations. General monitoring of all excavations for fossil material during construction phase.	Site specific	Low	Permanent	Irreversible	Low	Probable	**Low**	**Low**	Medium

Doubling of railway line between compilation yard and marshalling yard – Zones 9 and 13										
Destruction, disturbance or sealing-in of fossils exposed on the ground or buried beneath the surface during excavations and other construction work	Specialist monitoring of new excavations into the Sundays River Formation in the Brak River and Coega River Valleys. General monitoring of all excavations for fossil material during construction phase.	Site specific	Medium	Permanent	Irreversible	Low	Probable	**Medium**	**Low**	Medium
Stockyard, stormwater control dam and ancillary infrastructures (Zone 9)										
Destruction, disturbance or sealing-in of fossils exposed on the ground or buried beneath the surface during excavations and other construction work	Specialist monitoring of deeper excavations (especially into the shell-rich Salnova Formation). General monitoring of all excavations for fossil material during construction phase.	**Site specific**	**Medium**	**Permanent**	**Irreversible**	**Moderate**	**Probable**	Medium	Low	Medium
Operations Phase										
Not applicable										

14B.7 BEST INTERNATIONAL PRACTICE

Wherever development occurs within the Coega IDZ the responsible ECOs should be alerted to the possibility of significant buried fossil heritage, for example by familiarizing themselves with the recent palaeontological report for the Coega IDZ (Almond 2010a). In this light all major bedrock excavations should be examined at intervals for fossil material by the ECOs. If any substantial fossil remains are found these should be safeguarded, preferably *in situ*. The Eastern Cape Provincial Heritage Resources Authority (ECPHRA) should be contacted as soon as possible. A qualified palaeontologist should be commissioned to record and sample the occurrence, and also to advise on any further mitigation actions or further studies needed.

To carry out monitoring and mitigation of areas of high palaeontological sensitivity, which would normally involve the judicious sampling of newly exposed fossil material together with pertinent geological data, the professional palaeontologist involved would need to apply beforehand for a palaeontological collection permit from the relevant heritage management authority. In this case this is the Eastern Cape Provincial Heritage Resources Authority, ECPHRA (Contact details: Mr Sello Mokhanya, 74 Alexander Road, King Williams Town 5600; smokhanya@ecphra.org.za).

Fossil material collected must be recorded according to best academic practice and properly curated in an accredited fossil collection, such as the Albany Museum, Grahamstown.

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