AMC CONSULTANTS

MDL Mineral Sands Group

Grande Côte Operations SA

Grande Côte Project

Definitive Feasibility Study

ENGINEERING AND TECHNICAL

VOLUME 1 | JUNE 2010

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Project Manager

Stephen Williams	Signed	30 June 2010 Date

Peer Reviewer

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CONTENTS

MDL Mineral Sands Group

GRANDE CÔTE OPERATIONS SA | GRANDE CÔTE PROJECT | **DEFINITIVE FEASIBILITY STUDY**

Executive Summary

Copy 16

AMC CONSULTANTS

CONTENTS

EXECUTIVE SUMMARY

Project Background

In September 2004, Mineral Deposits Limited (MDL) was selected by the Government of the Republic of Senegal (GRS) to develop the Grande Côte Project (GCP). Under a Mining Convention MDL acquired the rights to explore and develop the project, which had been previously held by DuPont.

The Republic of Senegal (Senegal) is located on the western bulge of Africa. Senegal is a stable, democratic republic under multi-party democratic rule based on the French civil law system. The country gained its independence from France in 1960 after about 75 years of French rule. The capital, Dakar, is situated on the most westerly point of the coastline of Africa. The topography of the country is generally low, rolling plains rising to foothills in the south-east. The area to be mined is located on a coastal dune system. The dunes begin 25 km north-east of Dakar and extend northward for more than 140 km (Figure i).

In 2004, MDL also acquired the Sabodala Gold Project in eastern Senegal via an open tender from the GRS. The Sabodala Gold Mining Convention was signed in early 2005 and MDL moved to develop the project. In March of 2009 the Sabodala Mine was successfully commissioned and commenced operation.

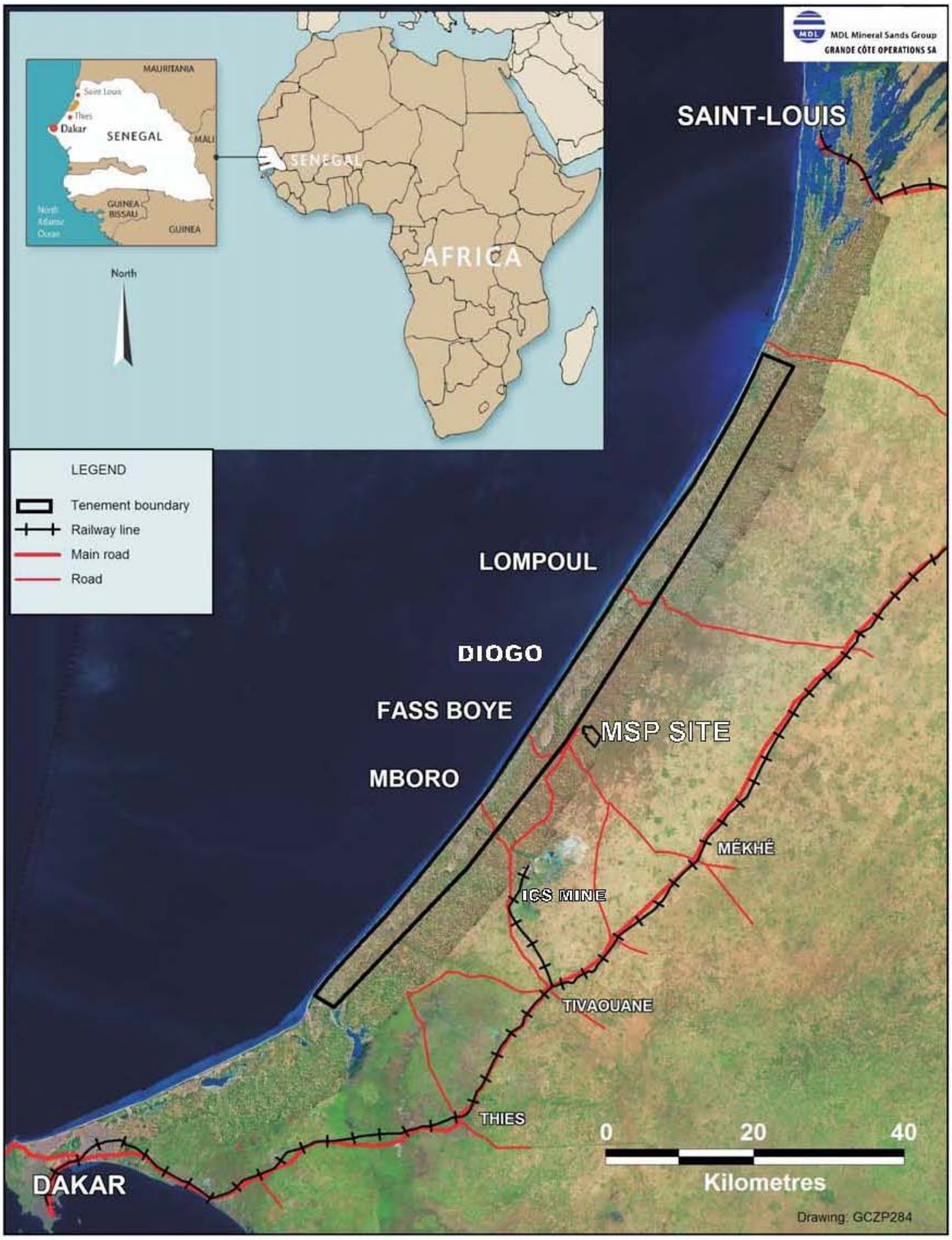
Through the development of the Sabodala Mine, MDL has gained considerable knowledge and practical expertise in the development and operation of mining projects in Senegal. This includes an excellent working relationship with the GRS, an understanding of the legal requirements, the management of construction and contracting activities, supply and logistics, human relations, environmental management and community issues. This expertise has been used in the development of the project execution and operational strategy proposed for the GCP. The recent development of the Sabodala Project also provides a valuable and current database of construction and operational costs, which gives considerable added confidence to the capital and operating costs used in the GCP Definitive Feasibility Study (DFS).

Project Ownership

MDL's interest in the GCP is held by the Senegal-based company Grande Côte Operations SA (GCO). GCO is 90% owned by a Mauritius-based company Mineral Deposits Mauritius Limited (MDM), which in turn is 100% owned by MDL. The remaining 10% of GCO is held by the GRS.

Prior to the incorporation of GCO, MDM established MDL Senegal Suarl (MDLSS) under a Mining Convention with the Senegal Government in September 2004. The purpose of the Mining Convention was to provide a contractual basis for the relationship between the Senegal Government and MDLSS over the entire period of the mining operations. The Mining Convention defines the general, legal, financial, fiscal, economic, administrative and specific corporate conditions under which MDLSS can undertake exploration and mining activities in the Grande Côte Permit Area.

Figure i Site Location Plan



As required under the Environmental Code (2001) and the Mining Convention, an Environmental and Social Impact Assessment Study (Etude d' Impact Environmental et Social, EIES) was completed in December 2005. In December 2005, MDL submitted the EIES in support of its application for a Mining Concession. The EIES was approved by the Environmental Department of the Ministry of Environment and Nature Protection of the GRS on 20 January 2006.

A Mining Concession was applied for by MDLSS and elaborated on in a series of letters from July through to October 2007, in conjunction with the submission of a feasibility study. The Mining Concession was granted to MDL on 24 September 2007 for a period of 25 years. The mining concession allows for the development, extraction, processing, transport and marketing of zircon, ilmenite, rutile, leucoxene and related minerals. The mining concession is renewable and the Senegal Government has entitlement to 10% participation in the exploitation of the project.

In accordance with the Mining Convention and Supplementary Deed No. 2, MDM and the Senegal Government created a separate Senegal-based company, GCO, and MDL transferred the mining concession to GCO. GCO is jointly owned, under a shareholders agreement, by MDM (90%) and the Senegal Government (10%) and is required to subscribe to the terms and conditions of the Mining Convention. GCO is the developer and will be the operator of the GCP. Within the Mining Concession there is potential to identify additional resources beyond the limits of present drilling.

Project Development Studies

Since the granting of the Mining Concession, GCO has progressed the development of the GCP. Additional drilling, sampling and assaying were completed between September 2005 and April 2010. A total of 150,665 m have been RC drilled, with a further 45,203 m of hand auger work carried out by GCO, and this has been added to the 39,063 m of drilling by DuPont.

Studies conducted since 2005 have considered all aspects related to the development of the project, including mining, metallurgical, marketing, environmental, legal, economic, social and governmental, based predominantly on producing saleable zircon. Further detailed work in late 2007 was also undertaken to consider the production of ilmenite concurrently with zircon.

These development studies have shown that the project can be optimised as a dredging operation, with mineralised sand being treated in a conventional floating spiral pre-concentrator, a separate wet concentrator and a dry mineral separation plant. Detailed engineering work undertaken by Ausenco Limited (Ausenco) in 2006 and 2007 was initially based on reusing a substantial portion of equipment from MDL's decommissioned Hawks Nest and Viney Creek operations in Australia. However, inspection of this equipment and the decision to substantially increase the throughput rate resulted in the decision to build a new plant for the complete process from dredging to final product separation and grading.

Testwork on a series of bulk samples has determined that the project can yield a high-quality zircon product and an ilmenite product along with small amounts of rutile and leucoxene products. In 2007 long lead time items, including the main dredge pump, cutter gearbox and tower crane for the feed bin, were purchased. Purchased equipment is currently in storage in Scotland, Belgium and Perth, Australia awaiting shipment to Senegal.

The key project metrics are summarised in Table i.

Table i Key Project Assumptions and Metrics

Item	Assumption and Metrics
Saleable products and average annual production rates	Premium zircon – 32,000 tpa Intermediate zircon – 25,000 tpa Standard zircon – 20,000 tpa Secondary zircon – 2,500 tpa Sulphate ilmenite – 400,000 tpa Chloride ilmenite – 175,000 tpa Rutile – 6,000 tpa Leucoxene – 11,000 tpa
Mining strategy	Owner mining.
Total metres drilled (MDL)	150,665 m reverse circulation (RC) drilling. 45,203 m augur drilling.
Classified Resource	Indicated Resource - 74 Mt at 1.8% HM. Measured Resource -1,002 Mt at 1.7% HM. Total Indicated and Measured - 1,075 Mt at 1.7% HM.
Mining rate	55 Mt per year of sand. Average 7,000 tonnes per hour.
Mining method	Floating cutter-suction dredging operation.
Classified Reserve	Probable Reserve - 5 Mt at 1.7% HM. Proved Reserve - 746 Mt at 1.8% HM. Total Probable and Proved - 751 Mt at 1.8% HM.
Processing method	Floating concentrator featuring banks of gravity-fed high capacity spirals, followed by a land-based mineral separation plant (MSP), which includes a wet high-intensity magnetic separation plant (WHIMS), a zircon wet and dry plant and an ilmenite plant.
Processing rate	140 tph to a maximum of 200 tph.
Tailings disposal method	Cyclone and discharge with tailings stacker.
Product transport method	Road transport in containers to Port of Dakar for zircon, rutile and leucoxene. Combination of road and rail transport in bulk to Port of Dakar for ilmenite.
Project execution methodology	Engineering, procurement, and construction management (EPCM) contractor.
Construction start date	Beginning of second quarter 2011.
Production start date	End of second quarter 2013.
Defined mining path	14 years.

Geology and Mineral Resources

The GCP is located on a coastal mobile dune system starting about 80 km north-east of Dakar and extending northward for more than 100 km. The mineralised dune system averages 4 km in width. The project area is 445.7 km^2 and the main heavy mineral (HM) deposits identified to date are Diogo, Mboro, Fass Boye, Diogo Extension and Lompoul. Other deposits have been partially explored within the Mining Concession and there is potential to identify additional deposits beyond the limits of present drilling.

Both the dunes and the underlying marine sands contain HMs, principally ilmenite, with accessory zircon, rutile and leucoxene. Zircon and ilmenite are the main commodities of interest.

Exploration has been conducted with two types of drilling: air core RC and hand auger. All holes are vertical. Samples were collected at 1 m intervals from both RC and hand auger drilling. To the end of May 2010, GCO has drilled 8,285 RC holes for 150,665 m and 12,462 hand auger holes for 45,203 m, which, combined with 39,063 m of DuPont drilling, give a combined total of 234,931 m, drilled and assayed.

Geological and mining consulting company AMC Consultants Pty Ltd (AMC) has estimated a mineral resource for the Diogo, Mboro, Fass Boye, Diogo Extension and Lompoul areas of the deposit. The combined GCO and DuPont RC and auger drilling were used in the estimate, see Table ii.

Table ii Resource Estimate at 1.25% HM Cut Off

Resource Category	Tonnage (M)	HM (%)
Measured	980	1.7
Indicated	50	1.7
Measured + Indicated	1,030	1.7

Based on a surface that is 6 m below the natural water

A block model was used to define the resource volume and HM grades were estimated into each parent block using ordinary kriging. The resource estimate has been reported assuming the deposit will be mined by dredging where the total thickness of the sand mined is based on the dredge operating at the natural water table and its cutter operating up to 6 m below the water table. For reporting, the total sand accumulated to 6 m below the natural water table, above a nominated cut off has been classified as Measured, Indicated and Inferred based on the drill hole spacing and available information on the water table level. Decreasing the cut-off has a significant effect on the resource estimate, see Table iii.

Table iii Resource Estimate by HM Cut off (Measured + Indicated)

Cut-Off (% HM)	Tonnage (Bt)	HM (%)
0.25	4.37	1.0
0.50	4.14	1.1
0.75	2.90	1.2
1.00	1.72	1.5
1.25	1.03	1.7

Marketing

The GCP will produce three main zircon products plus rutile, leucoxene and ilmenite. The key characteristics of each of the GCP products is summarised in Table iv.

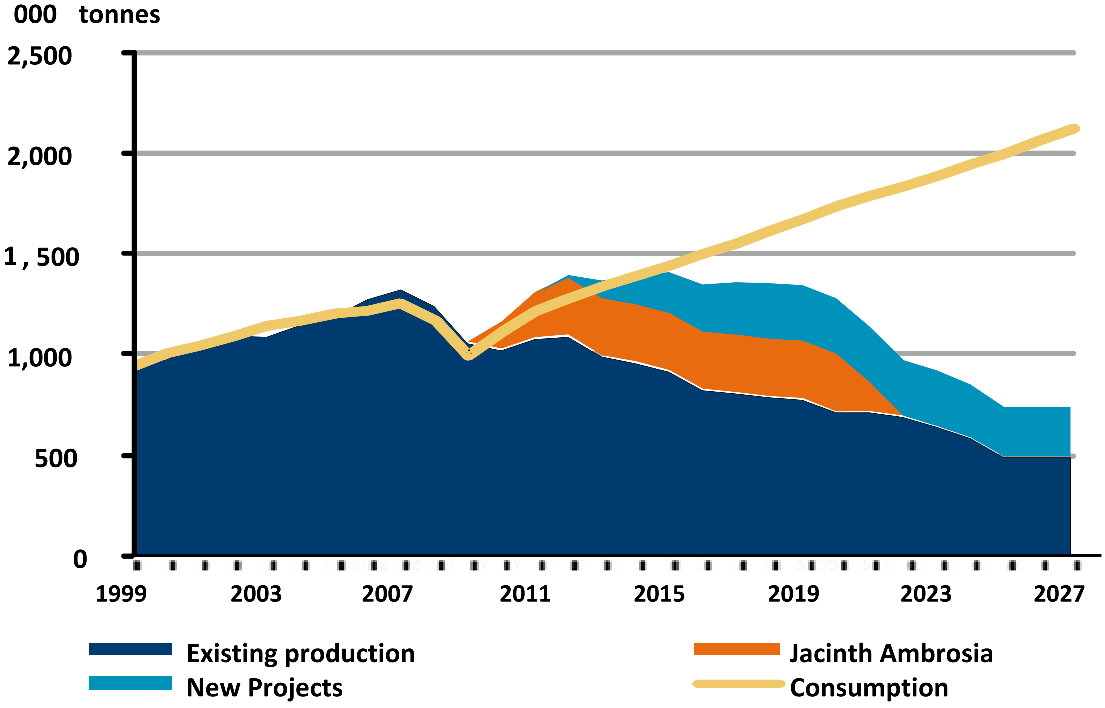
Table iv Key Characteristics of GCP Products

Product	Average tpa	Chemical Characteristics (Versus Competition)	Markets
Primary zircon	32,000	Has very low levels of Fe_2O_3, TiO_2 and Al_2O_3, which is favourable. Has among the lowest U and Th levels for commercial zircon sand at 280 ppm.	The main potential customers for the premium zircon would be the dominant zircon sand millers based in Europe, with milling operations located around the world.
Intermediate zircon	25,000	The Fe_2O_3 levels (at 0.09%) is are just above the levels required for a premium zircon classification. Very low levels of TiO_2 at 0.07% and a favourable Al_2O_3 content. U+Th at 333 ppm is low compared to competitors.	For the intermediate and standard-grade products, there is a wide array of potential end-use applications and consumers across a number of regions, for which the product specifications would be suited. MDL is planning to undertake niche marketing initiatives for these products to achieve prices that exceed those for the premium grade product
Standard zircon	20,000	Impurity levels are a little higher than Intermediate Grade but 0.09% TiO_2 and 389 ppm is very low.	Highly competitive against existing commercially available standard grade products for use in non-ceramic applications.
Secondary zircon	2,500	> 500 ppm U+Th	Likely market will be in the chemicals or foundry sectors.
Sulphate ilmenite	400,000	Fairly high TiO_2 at 53%. Acceptable FeO and Fe_2O_3 content .	Suitable for sulphate pigment manufacture.
Chloride ilmenite	175,000	TiO_2 content of 58.6%. Cr_2O_3 levels not an issue for chloride route ilmenite. V_2O_5 higher than other products.	Acceptable for slag and for synthetic rutile production. It is also acceptable for direct chlorination.
Rutile	6,000	Meets the industry standard of a ‘premium’ grade rutile with TiO_2 above 95% at 95.7%. SiO_2 content slightly elevated. U+Th levels favorably low. Levels of the other impurities are all acceptable. SnO_2 analysis was not available.	The relatively fine grain size of the Grand Côte Rutile and the low volume suggests the flux core wire segment of the welding electrode sector is the preferential target as this would attract a premium price for its quality and particle size.
Leucoxene	11,000	Lower TiO_2 level, 90%, than the main competing commercial products. ZrO_2 and V_2O_5, lower than the main competing commercial products. The levels of other impurities are acceptable.	The lower TiO_2 level does not impact on end use. The finer particle size than competing products would impact on its competitiveness as a chloride pigment feedstock, but is a positive for use in welding electrode applications.

Customer benefits are enhanced by the close proximity of the Port of Dakar to the important European and North American markets. Container shipments of zircon will allow just-in-time inventories to be serviced and new export business to Senegal, filling containers that are currently returned after import, empty. This is also expected to enable negotiation of attractive freight rates. The large market size for zircon and ilmenite enables the GCP to attract long-term contracts and large customers seeking bulk volumes. Contract packaging of rutile and leucoxene to the welding industry enables the product specifications to be tailored to the consumer, opening up niche markets.

Independent mineral sands technical and commercial specialist TZMI forecasts that the supply/demand balance for zircon is for a short-term supply surplus attributed to high inventory levels due to reduced demand. Increase in demand as a result of urbanisation in developing economies such as China and India will gradually be met by an increase in supply and some new projects will enter the market. Beyond 2015, a widening supply deficit is expected due to resource depletion (see Figure ii).

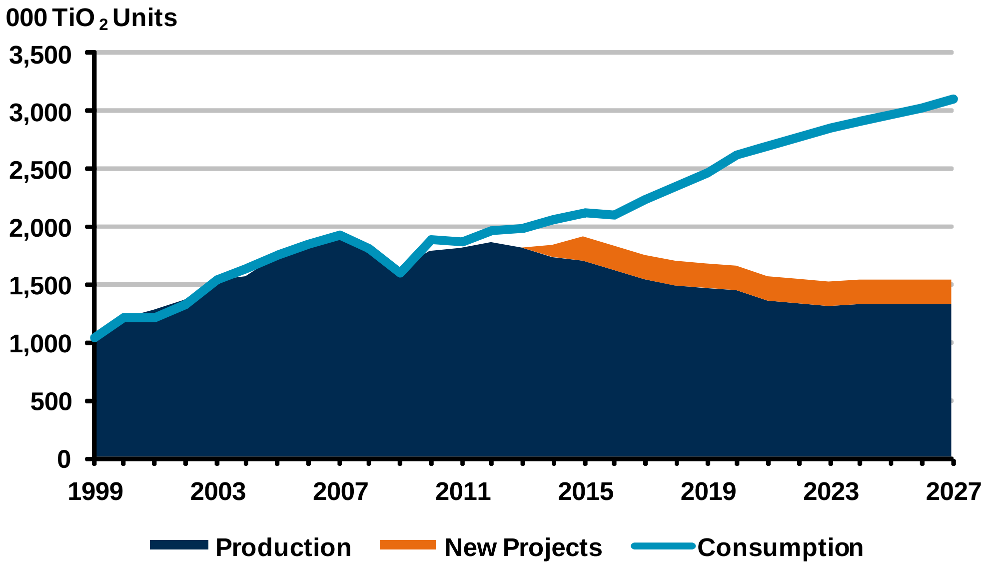
Figure ii TZMI Global Zircon Supply/Demand to 2027 Showing New Projects, Including Grande Côte



Source: TZMI 2009

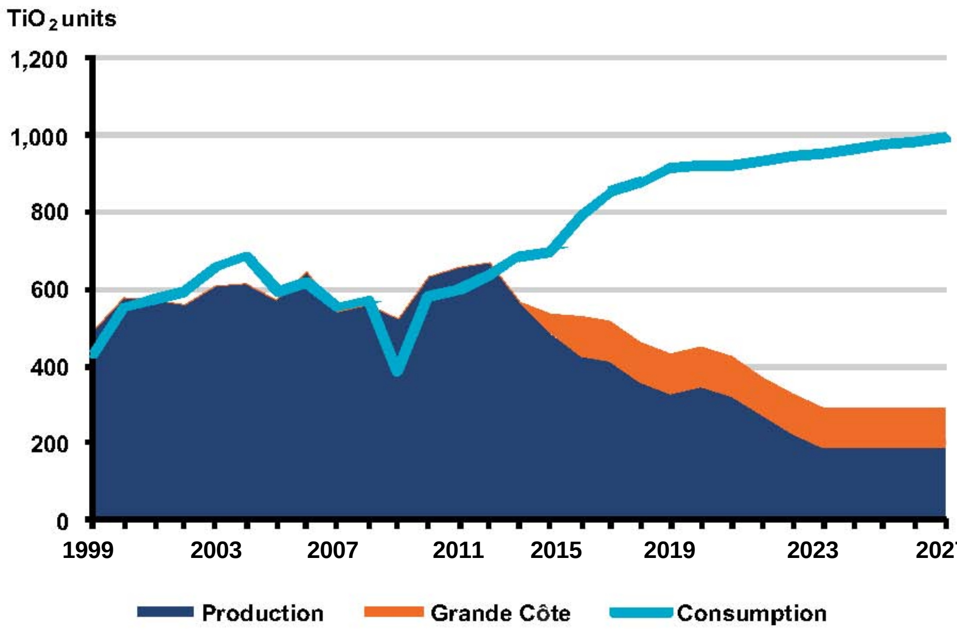
TZMI anticipates significant supply gaps for sulphate and chloride ilmenite (see Figure iii and Figure iv), rutile and leucoxene to 2027. Long-term strong demand growth due to urbanisation in developing economies such as China and India will be faced with progressive decrease in supply due to the economic rationalisation of the Global Economic Crisis and resource depletion. These supply deficits can only be met by the discovery and development of new resources such as the GCP.

Figure iii Forecast Supply/Demand for Sulphate Ilmenite to 2027, Including Grande Côte



Source: TZMI 2009

Figure iv Forecast Supply/Demand for Chloride Ilmenite to 2027, Including Grande Côte



Source: TZMI 2009

MDL's marketing objective is to optimise the sales mix, thereby improving the overall sales price for GCP products. This will be achieved by having a wide customer base and a sales mix for zircon, rutile and leucoxene based on small lot sales by container shipments, enabling sale into a range of niche markets and establishing price competition. In addition, MDL expects to achieve premium prices through targeted product differentiation for selected end use markets, leveraging off a number of product and project benefits. For ilmenite, long-term contracts will be developed to secure the position of this high-volume bulk shipment product.

TZMI average bulk pricing forecasts for zircon and for titanium feedstock and the forecast prices for GCP products based on TZMI's assessment of a number of product quality and project benefits are shown in Table v.

Table v TZMI Pricing Forecasts for Zircon and for Titanium Feedstock

Product	**US$ Real 2009 Prices (FOB/t)**			
TZMI bulk average $ FOB	2013f	2014f	2015f	Post 2015
TZMI bulk premium zircon	928	1,023	1,088	1,150
Sulfate ilmenite	114	113	113	125
Chloride ilmenite	114	120	131	145
Bulk rutile	605	614	619	635
GCP project evaluation $ FOB				
GCP zircon (average for all products)*	1,130	1,225	1,300	1,350
GCP average ilmenite	105	110	120	125
GCP average rutile*	805	815	820	835
GCP average leucoxene*	705	715	720	735

* Includes GCP specific premium of US$ 200 per tonne.

MDL (on behalf of GCO) has negotiated sales arrangements with a number of customers covering all of the currently envisaged zircon production. The terms of these arrangements include a pricing mechanism that is renewed on a rolling basis and is subject to final product quality. The agreements will be formalised after completion of further product quality trials and customer evaluations. These trials are well advanced and have demonstrated that the GCP zircon product will have a competitive edge in terms of product quality against other suppliers. Ilmenite marketing is also being progressed with a number of customers having expressed interest in receiving samples.

Mining and Ore Reserves

Mining will be carried out by dredging a continuous canal (dredge path) through the dunal orebody. The dredge will float in an artificial pond accompanied by a floating spiral concentrator (WCP). To the rear of the WCP a tailings stacker will deposit the tailings to fill the mined canal and achieve a final landform. Tailings represents approximately 98% of all material mined by the dredge. Once the dredge is fully commissioned and operational, the tailings disposal system will be required to place 55 Mt of sand per annum. Vegetation will be cleared in advance of the dredge pond and rehabilitation will be completed on the final landform.

The heavy mineral concentrate (HMC) from the WCP will be pumped to the mineral separation plant (MSP), where it will be dewatered and stockpiled for batch processing in the MSP. The dredge, WCP and MSP design and engineering have been undertaken by Ausenco.

Based on the drilling to date a mine dredge path for the first fourteen years of the operation has been developed and the Ore Reserve Estimate is shown in Table vi.

Table vi Ore Reserves

Item	Units	Probable and Proved Classification
Tonnage	(Mt)	751
HM	(Mt)	13.3
	(%)	1.8

The deposit continues to the north and south on the Lease beyond these Reserves. Additional mine life will depend on the economics of the project, including the mineral distribution, geometry and access. While the current Mineral Resource has not been defined sufficiently to extend to these areas and additional drilling is required, it could be anticipated that an additional 10 or more years of mine life beyond the current reserves is feasible.

A dredge production schedule for the first 14 years of the mine life is shown in Table vii.

Table vii Mining Schedule

Year	Tonnage (Mt)	Grade (HM %)	Mineral (HM Mt)
1	41	1.8	0.76
2	52	2.0	1.04
3	55	1.8	1.01
4	55	1.8	0.99
5	55	1.8	0.99
6	55	1.8	0.97
7	55	1.8	0.96
8	55	1.8	1.01
9	55	1.7	0.94
10	55	1.8	0.99
11	55	1.7	0.92
12	55	1.9	1.04
13	55	1.6	0.89
14	55	1.5	0.77
Total	748	1.8	13.3

Note: Mining tonnes in years 1 and 2 reflect ramp-up allowances.

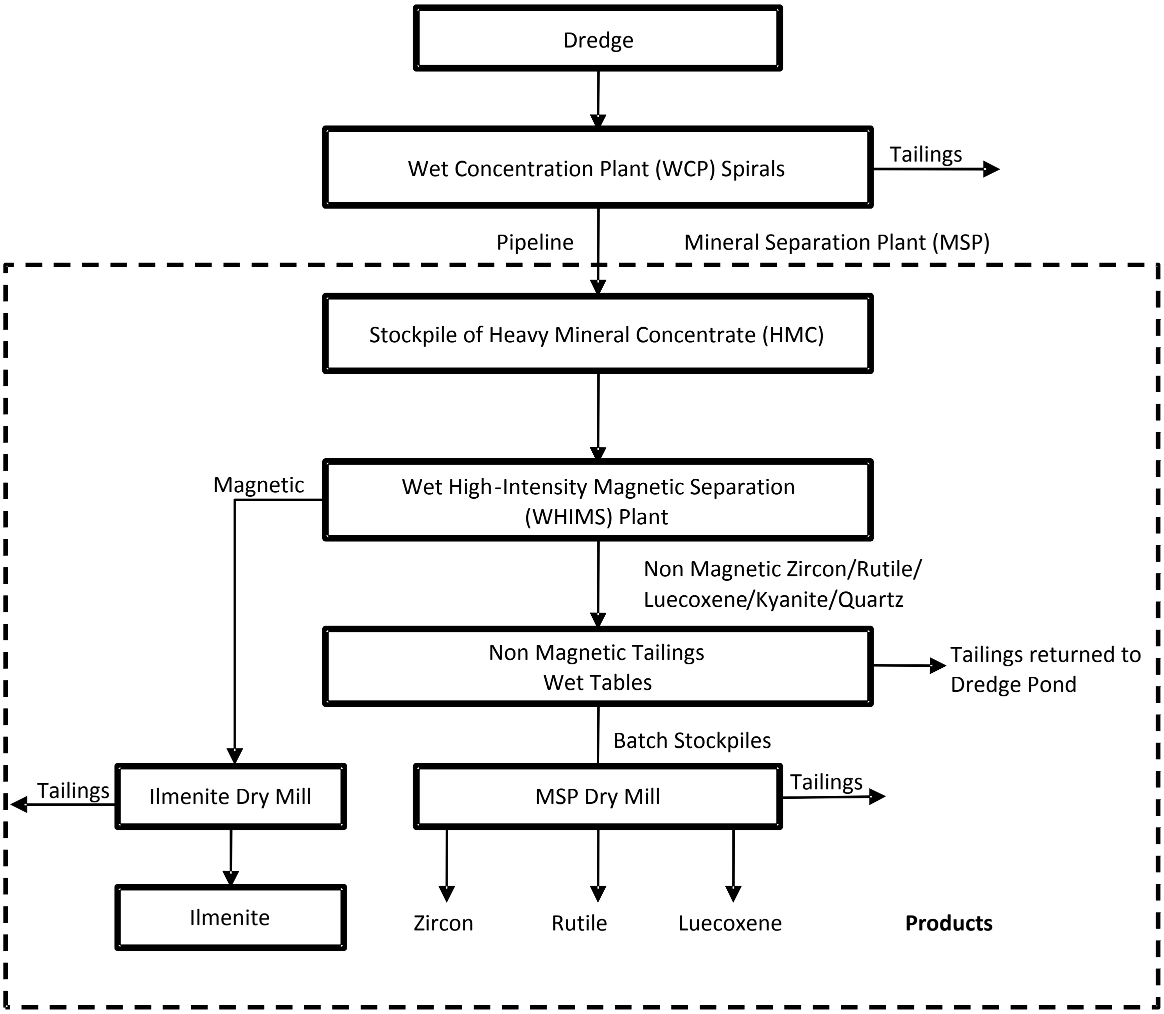
Processing and Engineering

An extensive testwork program has been completed with the primary aim being to maximise recovery and product quality. The testwork commenced in 2004 and continued to early 2010. The most recent testwork was completed by Downer EDI in 2010 using a 1,037 kg bulk sample collected from a trial pit located in the Diogo portion of the deposit.

Testwork results indicate a product mix of three to four zircon products, two ilmenite products and rutile and leucoxene products is feasible. Overall recovery for HM was 82.6% using a combination of spiral concentrators, wet high-intensity magnetic separation, wet tables, high-tension roll separators, rare earth roll magnetic separators, electrostatic plate separators and induced roll magnetic separators. Upgrading of the ilmenite to synthetic rutile was also considered but not included in the final treatment flow sheet.

Detailed flow sheets, plant layouts and the plant design basis have been developed by Ausenco. A high-level flow sheet is shown in Figure v. The flow sheets for the mine and WCP present mass balances using the nominal feed tonnage (7,000 tph) from the dredge and a plant feed heavy mineral (HM) grade of 2.0%. The mineral separation plant (MSP) consists of three separate circuits: wet circuit, zircon dry circuit and ilmenite dry circuit.

Figure v High-level Process Flow Sheet



Infrastructure

Infrastructure and services required includes:

- Buildings and storage facilities.
- Power station and liquid fuel storage.
- Communications and information technology.
- Road and rail infrastructure.
- Port and harbour facilities.

Mill buildings, the power station and fuel storage, administration offices, warehouses and lay-down areas will be located at the MSP site.

The maximum power demand for the GCP is 22 MW with a connected load of 27 MW. Annual power consumption is calculated as 141,000 MWh. MDL's power supply strategy is similar to that used in the Sabodala operation, whereby GCP will own and operate a 28 MW dual-fuel (Heavy Fuel Oil (HFO)/Natural gas) fired power station. Given the long life of the operation, GCO considers this a more economic option than other power supply options investigated. The installation of a natural gas compatible power station will also provide opportunity for utilisation of a local energy source with the added benefit of potential carbon credits under the clean development mechanism.

The liquid fuel farm will have a HFO storage capacity of 1 M litres, which is sufficient for two weeks supply if straight HFO is burnt in the power station. If required during the wet season, additional storage capacity of 2M litres is available at the Port of Dakar. Gasoil (diesel) is also required to fuel pilot burners on the dry mill and the ilmenite plant heating equipment. The fuel farm incorporates a gasoil storage tank (100,000 litres).

The existing communications and information technology (IT) infrastructure at the Exploration Camp and in GCO's Dakar offices will be upgraded during development of the GCP. The key elements will be similar to those of the Sabodala operation and include voice and data communications, wide and local area infrastructure, PCs and specialist software.

The MSP is located near Diogo village, approximately midway along the mining lease to enable access to nearby infrastructure, including major highways, roads, railways and the Port of Dakar. The nearby town of Mboro, 25 km south, is adjacent to the Industrie Chemique Senegal (ICS) phosphate mine, which has a railhead and loading facilities. The main highway between Dakar and Saint Louis to the north is located 20 km east of the MSP site.

Ilmenite will be transported in bulk by road to the ICS loading facilities and then by rail to the Port of Dakar, while zircon, rutile and leucoxene will be transported in shipping containers by road to the port. Of the approximate 125 km of road from the MSP to the Port of Dakar, 25 km is unsealed. However, government funding is in place and work is currently well advanced to repair and seal the entire road during 2010.

Wagons will be purchased and running rights have been negotiated for their operation on tracks held as concessions by ICS and Transrail. A new mobile loading facility will be required for loading trains at the ICS rail head and new unloading; storage and ship loading facilities for bulk ilmenite will be constructed at the Port of Dakar.

Plant construction materials and equipment for the mine, MSP and the power station, liquid fuel (if required) for the power station, operating supplies and maintenance components will be transported to site by road from Dakar. Dakar is the main West African base for well-equipped, international freight logistics companies. MDL successfully used a number of the Dakar based international freight logistics companies during the construction of the Sabodala Project. The EPCM Contractor will conduct a detailed transport and logistics study for project construction items, to ensure the timely low-cost delivery of equipment and materials to site.

Water management is one of the key issues affecting the success of the GCP. It is important for the operation of the mine, the transfer of concentrates to the MSP, the mineral separation processes and the needs of the local community, which depends on it for their survival. There are three predominant uses of water:

- Flotation of the mining dredge, surge bin and wet concentrator modules and slurrying of dunal orebody for processing.
- Pumping mineral concentrates as slurries from the mine to the MSP and waste return to the mine.
- Processing of mineral streams in the MSP.

Extensive modelling of existing water resources and the effects of mining on the water table has been completed by PSM Australia Pty Ltd. This modelling incorporates regional data such as rainfall, irrigation practices and project-based weather station data. Based on this work, the project water requirements are able to be met and the effect on regional water resources is understood.

Environmental and Social

GCO is committed to developing and maintaining an integrated environmental and social management system (ESMS), which incorporates the requirements of the following standards:

- International Finance Corporation (IFC) Performance Standards.
- Equator Principles.
- AS/NZS ISO 14001 (2004) Environmental management systems – Specification with guidance for use.
- AS/NZS 4801 (2001) Occupational health and safety management systems – Specification with guidance for use.
- AS/NZS 4360 (2004) Risk Management.

The Environmental and Social Management and Monitoring Plan (ESMMP) describes the monitoring, mitigation and management measures required during the construction, operation, decommissioning and rehabilitation phases of the GCP. It is based on commitments made in the Environmental and Social Impact Assessment (EIES) and on requirements of the GRS and financial institutions involved in the project. The ESMMP provides a framework for ongoing environmental and social management and sets guidelines for development of management plans and standard operating procedures that will be developed as part of the ESMS. The ESMMP is a dynamic document subject to updating and adjustment following biennial review. The ESMMP will address the following key environmental and social issues:

- Water.
- Rehabilitation.
- Avoidance of settlements and appropriate compensation if temporary or permanent resettlement is required.

It is estimated that the project will employ directly up to 800 people during construction with a GCO workforce of approximately 280 people plus 130 outsourced roles during operation. It is anticipated that 30% to 40% of the total workforce will be recruited from local communities. In comparison, some 45% of MDL's Sabodala's workforce was recruited from regional communities.

Capital Cost Estimate

The capital estimate was prepared by Ausenco and is an update to the capital cost estimate prepared in August 2006. The primary changes to the 2006 estimate have been that the previously tendered equipment prices were revalidated and Sabodala Project experience was used for estimating owner's costs, subcontract and material rates, productivity factors and EPCM manning requirements. Additional scope changes resulting from the recent testwork have also been incorporated into the plant design and the capital estimate.

A summary of the capital costs is shown in Table viii. The capital estimate is based on a single contract for EPCM.

Table viii Capital Cost Estimate

Item	Total Capital US$M
Mining – dredge and services	37.9
Wet concentrator plant	84.7
Mineral separation plant	54.1
Mining – infrastructure	8.4
Mineral separation plant – infrastructure	5.8
Power station	45.3
Rail/port facilities and rolling stock	18.6
Temporary construction facilities	21.5
Indirects – EPCM, commissioning and project fee	52.1
Owner's costs	47.0
Estimation/design allowance	16.8
Contingency	13.8
Total	**406.0**

The exchange rates used for conversion of costs to $US are:

- 1 A$ equals 0.90 US$.
- 1 Euro equals 1.50 US$.
- 1 CFA equals 0.0022 US$.

When unit rates from the Grande Côte Zircon Project August 2006 estimate have been used they have been increased by 25% to allow for escalation. This is consistent with the average for equipment price increases from the tender price validation.

For construction activities craft base wages are based on current gang rates applying to other project estimates within the region. Where unit rates from the Sabodala Project have been used, they have been increased by 15% to allow for escalation. This is based on the labour index increasing by 25% over the period, while bulk commodity prices have remained flat.

A 2.5% duty is payable on ex-works value of all goods entering Senegal.

Costs for construction accommodation are based on 400 persons for year one and 800 persons for year two of construction. Provisions have been included for spare parts and first-fill consumables.

An EPCM fee of 3% of direct costs under management by the EPCM contractor has been included in the estimate. Owner's costs include the GCO's representatives during construction, accommodation, transport, IT and communications, social and environmental programs, studies and costs associated with local and statutory requirements.

The capital cost estimate excludes demurrage for capital freight, working capital (which is included in the overall project financial model) withholding taxes and other similar Senegalese taxes, and corporate costs. Sustaining or deferred capital costs are included in the financial model.

The base date for the capital costs is 30 November 2009. A provision for escalation beyond the estimate base date (30 November) has not been included in the estimate. A contingency allowance of $13.8M has been included by GCO in the capital estimate. In addition to the owner contingency a further $16.68M is included by way of a design allowance. The level of accuracy of the estimate is ±15%.

Operating Costs

Operating costs have been prepared for the mining, wet concentrator, mineral separation processing operations, transportation and the supporting services required for the operations at Grande Côte. A summary of the operating costs is shown in Table ix.

Table ix Annual Operating Costs

Description	Annual Operating Cost $M
Power and fuel	23.1
Employee costs	7.9
Maintenance	13.8
Transportation/shipping	22.4
Other	8.1
Total	**75.3**

Fuel is required for power generation and gasoil for drying and mobile equipment. For power generation the unit rate cost estimation was based on the Sabodala power station fuel/lubricant consumption rates, downtime and performance. The inputs for the fuel cost estimation are based on the Senegal Government fuel pricing schedule and an offer of natural gas, which is linked to this pricing via like-for-like energy content.

The human resources strategy and costs for the GCP draw on the considerable expertise built up over the past five years by MDL in Senegal. Expatriate and national salaries are based on the current operation at Sabodala. Average salaries are used for expatriate employees while the national labour rates are as regulated by the government and gazetted by Decree 2006-1262 dated 15 November 2006. All employee costs include on-costs.

Maintenance labour is included in the labour rates. Maintenance unit rate costs are based on benchmarks for similar operations and include the dredge and wet plant, MSP and the ilmenite plant.

Transport of GCP zircon, rutile and leucoxene final products will be via sealed road in 20” containers to the port of Dakar for dispatch by sea. Ilmenite in bulk will be trucked to the nearby ICS rail head and then transported to a bulk load-out facility at the Dakar Port for shipments to customers. All costs are on a Free On Board (FOB) basis.

The base date for operating costs is April 2010. No contingency has been included on operating costs. Operating costs estimated by GCO have an accuracy of ±15% and include a significant portion of real in-country costs.

Implementation Schedule

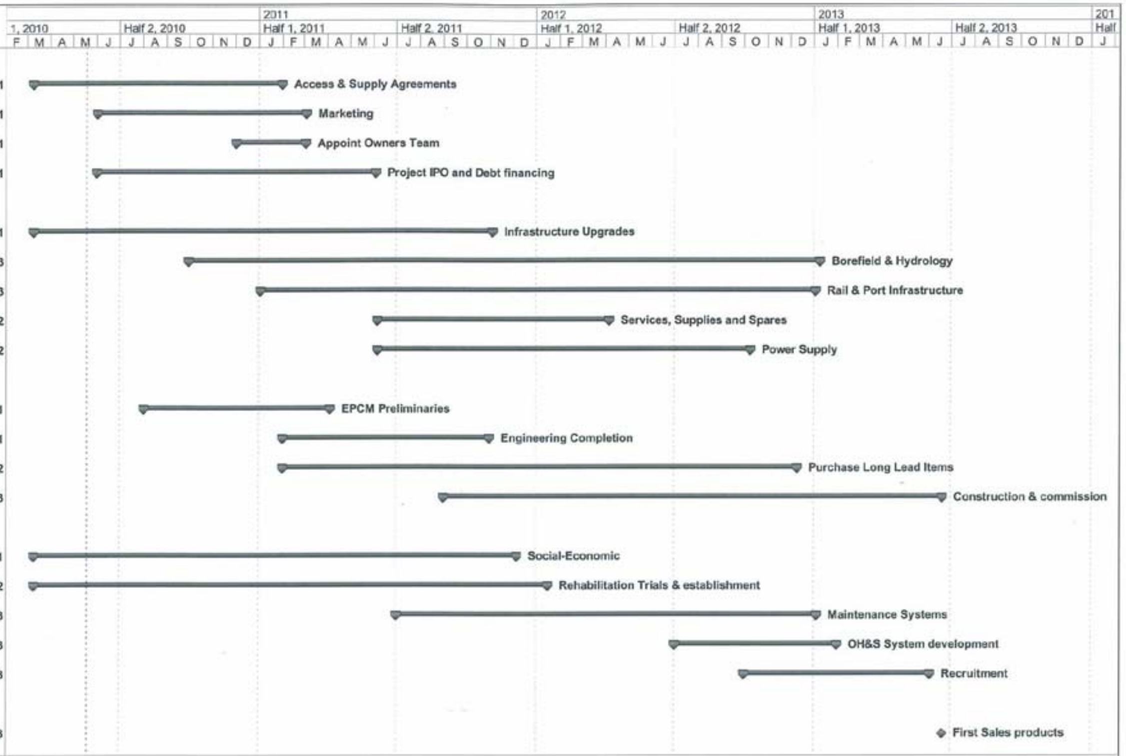
GCO proposes to construct the project using a single contract for EPCM with an internationally recognised and experienced engineering company. High-quality local and European-sourced contractors will be utilised for plant construction. This strategy was successfully employed for the construction of the Sabodala Gold Project.

A high-level project development schedule has been developed by Ausenco and GCO and is shown in Figure vi. The Project Execution Schedule assumes that financing for the Project will be completed by the 1st quarter of 2011 and that the EPCM contractor will be selected early in 2011. The schedule indicates a completion data for initial commissioning sign-off during the first quarter of 2013. The first sales products are scheduled to be produced by June 2013.

The schedule is high-level at this stage and will require further detailing as a part of the development of the Project Development Plan. The schedule does not include any float for unscheduled delays.

Figure vi High-level Project Execution Schedule

ID	Task Name	Duration	Start	Finish
1				
2	Access & Supply Agreements	10.64 mo	Wed 10/03/10	Mon 31/01/11
9	Marketing	9 mo	Wed 2/06/10	Fri 4/03/11
12	Appoint Owners Team	3 mo	Thu 2/12/10	Thu 3/03/11
14	Project IPO and Debt financing	12 mo	Tue 1/06/10	Fri 3/06/11
17				
18	Infrastructure Upgrades	19.68 mo	Wed 10/03/10	Fri 4/11/11
24	Borefield & Hydrology	27 mo	Fri 1/10/10	Wed 9/01/13
28	Rail & Port Infrastructure	23.82 mo	Mon 3/01/11	Thu 3/01/13
34	Services, Supplies and Spares	10 mo	Mon 6/06/11	Fri 6/04/12
51	Power Supply	16 mo	Mon 6/06/11	Tue 9/10/12
56				
57	EPCM Preliminaries	8 mo	Mon 2/08/10	Mon 4/04/11
64	Engineering Completion	8.86 mo	Tue 1/02/11	Mon 31/10/11
93	Purchase Long Lead Items	22.05 mo	Tue 1/02/11	Mon 10/12/12
108	Construction & commissioning	21.36 mo	Thu 1/09/11	Wed 19/06/13
147				
148	Social-Economic	20.68 mo	Wed 10/03/10	Tue 6/12/11
153	Rehabilitation Trials & establishment	22 mo	Wed 10/03/10	Mon 16/01/12
157	Maintenance Systems	18 mo	Fri 1/07/11	Fri 4/01/13
161	OH&S System development	7 mo	Mon 2/07/12	Thu 31/01/13
163	Recruitment	8 mo	Mon 1/10/12	Mon 3/06/13
166				
167	First Sales products	0 days	Wed 19/06/13	Wed 19/06/13



Project: Project execution 10-05-16-AS
Date: Tue 18/05/10

Task, Progress, Milestone, Summary, Rolled Up Task, Rolled Up Milestone, Rolled Up Progress, Split, External Tasks, Project Summary, Group By Summary, Deadline

Page 1

Financial Summary

The GCP generates revenue from the sale of the following products:

- Premium zircon.
- Intermediate zircon.
- Standard zircon.
- Secondary zircon.
- Sulphate ilmenite.
- Chloride ilmenite.
- Rutile.
- Leucoxene.

For all products TZMI price analysis and forecasts to 2027 have been used. While financing options have not been assessed in the project financial evaluation, a debt-to-equity ratio of 50/50 was used.

The GCP is exempt from Senegalese Government taxes for a period of 15 years from the start of operation, with provision also made for exemptions during investment and development.

The production ramp-up assumes 67% utilisation in the first year of plant operation, followed by 85% in the second year and nominally full capacity in subsequent years. The average HMC feed processing rates at full production capacity are approximately:

- 240,000 tpa through the wet mill.
- 105,000 tpa through the dry mill.
- 680,000 tpa through the ilmenite dry plant.

The GCP is forecast to generate total gross revenue of US$2,687M to 2027. Net annual cash flow is positive in 2014 at US$42.3M.

The total amount of saleable product over the first 15 years of mine life is 9,693,900 tonnes. Total revenue is split between the different products, with zircon sales contributing to 56.9% of total gross revenue, ilmenite 37.0%, leucoxene 3.5% and rutile 2.5%. Revenue is shown in Table x.

Total capital costs are US$406M excluding working and sustaining capital and are spread over years 2011 to 2013. Total operating costs are US$1024.6M to 2027. Operating and capital costs are shown in Table xi.

Table x GCP Production and Revenue

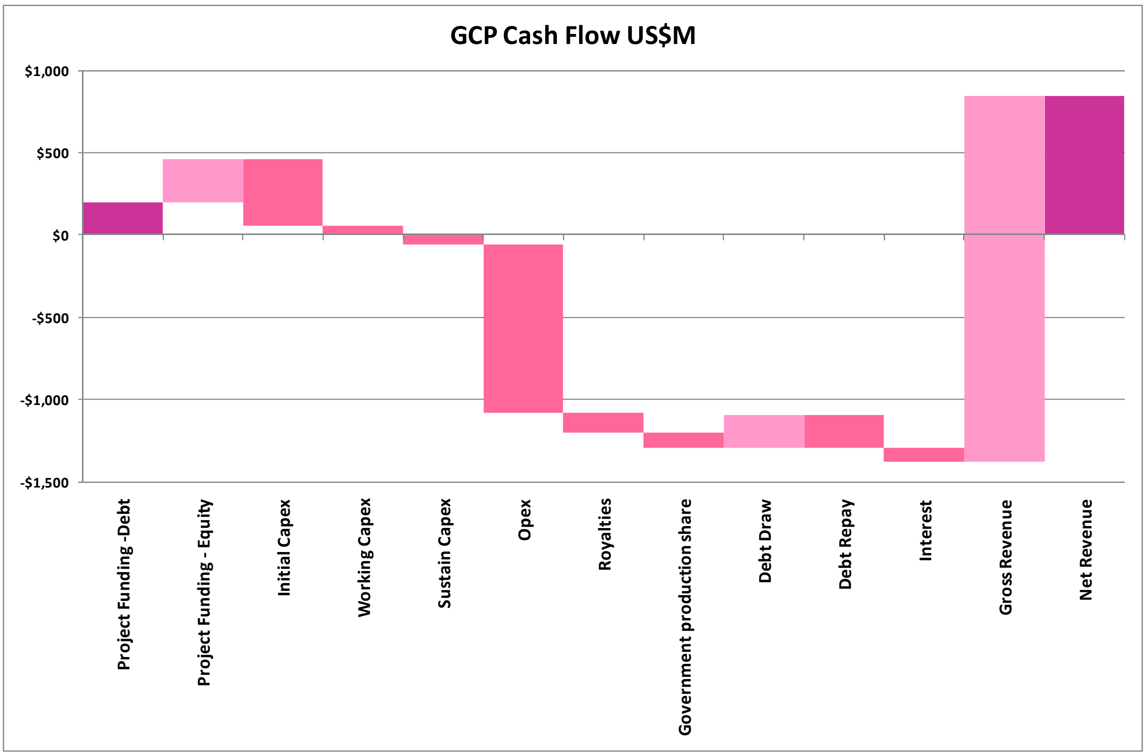
Y/End 30 June	Input	Units	2009	2010	Total/Av	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Year						(2)	(1)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Resource																						
Ore Mined		'000t			748,104	0	0	0	41,084	52,122	54,575	54,575	54,575	54,575	54,575	54,575	54,575	54,575	54,575	54,575	54,575	54,575
Grades																						
Heavy Mineral (HM)		% in ore			1.8%	0.0%	0.0%	0.0%	1.8%	2.0%	1.8%	1.8%	1.8%	1.8%	1.8%	1.9%	1.7%	1.8%	1.7%	1.9%	1.6%	1.5%
Zircon		% in HM			10.7%	0.0%	0.0%	10.7%	10.7%	10.7%	10.7%	10.7%	10.7%	10.7%	10.7%	10.7%	10.7%	10.7%	10.7%	10.7%	10.7%	10.7%
Rutile		% in HM			2.5%	0.0%	0.0%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
Leucoxene		% in HM			3.2%	0.0%	0.0%	3.2%	3.2%	3.2%	3.2%	3.2%	3.2%	3.2%	3.2%	3.2%	3.2%	3.2%	3.2%	3.2%	3.2%	3.2%
Ilmenite		% in HM			74.5%	0.0%	0.0%	74.5%	74.5%	74.5%	74.5%	74.5%	74.5%	74.5%	74.5%	74.5%	74.5%	74.5%	74.5%	74.5%	74.5%	74.5%
Overall Recovery																						
Zircon		%			81.3%	0.0%	0.0%	0.0%	81.3%	81.3%	81.3%	81.3%	81.3%	81.3%	81.3%	81.3%	81.3%	81.3%	81.3%	81.3%	81.3%	81.3%
Rutile		%			24.9%	0.0%	0.0%	0.0%	24.9%	24.9%	24.9%	24.9%	24.9%	24.9%	24.9%	24.9%	24.9%	24.9%	24.9%	24.9%	24.9%	24.9%
Leucoxene		%			30.9%	0.0%	0.0%	0.0%	30.9%	30.9%	30.9%	30.9%	30.9%	30.9%	30.9%	30.9%	30.9%	30.9%	30.9%	30.9%	30.9%	30.9%
Ilmenite		%			84.1%	0.0%	0.0%	0.0%	84.1%	84.1%	84.1%	84.1%	84.1%	84.1%	84.1%	84.1%	84.1%	84.1%	84.1%	84.1%	84.1%	84.1%
Saleable Product																						
Premium, Intermediate, Standard Zircon		'000t			1,127.0	0.0	0.0	0.0	64.1	87.9	85.1	84.2	83.8	81.9	81.4	85.6	79.6	83.8	77.7	88.4	75.4	68.0
Secondary Zircon		'000t			28.6	0.0	0.0	0.0	1.6	2.2	2.2	2.1	2.1	2.1	2.1	2.2	2.0	2.1	2.0	2.2	1.9	1.7
Zircon total		'000t			**1,155.6**	**0.0**	**0.0**	**0.0**	**65.7**	**90.2**	**87.3**	**86.4**	**85.9**	**84.0**	**83.5**	**87.8**	**81.6**	**85.9**	**79.7**	**90.6**	**77.3**	**69.7**
Rutile		'000t			81.9	0.0	0.0	0.0	4.7	6.4	6.2	6.1	6.1	5.9	5.9	6.2	5.8	6.1	5.6	6.4	5.5	4.9
Leucoxene		'000t			131.5	0.0	0.0	0.0	7.5	10.3	9.9	9.8	9.8	9.6	9.5	10.0	9.3	9.8	9.1	10.3	8.8	7.9
Subtotal		'000t			1,369.0	0.0	0.0	0.0	77.9	106.8	103.4	102.3	101.7	99.5	98.9	104.0	96.7	101.7	94.4	107.4	91.6	82.6
Ilmenite		'000t			8,324.9	0.0	0.0	0.0	473.5	649.6	628.9	622.1	618.7	605.0	601.6	632.3	587.9	618.7	574.2	652.8	557.1	502.5
Total Saleable Product		'000t			**9,693.9**	**0.0**	**0.0**	**0.0**	**551.3**	**756.4**	**732.3**	**724.4**	**720.4**	**704.5**	**700.5**	**736.3**	**684.6**	**720.4**	**668.7**	**760.2**	**648.8**	**585.1**
Prices																						
Premium, Intermediate, Standard Zircon		$US/t			1,323.67	0.00	0.00	1,130.00	1,225.00	1,300.00	1,350.00	1,350.00	1,350.00	1,350.00	1,350.00	1,350.00	1,350.00	1,350.00	1,350.00	1,350.00	1,350.00	1,350.00
Secondary Zircon		$US/t			661.83	0.00	0.00	565.00	612.50	650.00	675.00	675.00	675.00	675.00	675.00	675.00	675.00	675.00	675.00	675.00	675.00	675.00
Rutile		$US/t			830.67	0.00	0.00	805.00	815.00	820.00	835.00	835.00	835.00	835.00	835.00	835.00	835.00	835.00	835.00	835.00	835.00	835.00
Leucoxene		$US/t			730.67	0.00	0.00	705.00	715.00	720.00	735.00	735.00	735.00	735.00	735.00	735.00	735.00	735.00	735.00	735.00	735.00	735.00
Ilmenite		$US/t			118.33	0.00	0.00	105.00	110.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00
Revenue																						
Premium, Intermediate, Standard Zircon		US$M			1,509.1	0.0	0.0	0.0	78.5	114.3	114.9	113.7	113.1	110.6	109.9	115.6	107.4	113.1	104.9	119.3	101.8	91.8
Secondary Zircon		US$M			19.1	0.0	0.0	0.0	1.0	1.5	1.5	1.4	1.4	1.4	1.4	1.5	1.4	1.4	1.3	1.5	1.3	1.2
Zircon total		US$M			**1,528.2**	**0.0**	**0.0**	**0.0**	**79.5**	**115.8**	**116.4**	**115.1**	**114.5**	**112.0**	**111.3**	**117.0**	**108.8**	**114.5**	**106.3**	**120.8**	**103.1**	**93.0**
Rutile		US$M			68.2	0.0	0.0	0.0	3.8	5.2	5.2	5.1	5.1	5.0	4.9	5.2	4.8	5.1	4.7	5.4	4.6	4.1
Leucoxene		US$M			96.3	0.0	0.0	0.0	5.3	7.4	7.3	7.2	7.2	7.0	7.0	7.3	6.8	7.2	6.7	7.6	6.5	5.8
Subtotal		US$M			1,692.7	0.0	0.0	0.0	88.7	128.4	128.9	127.5	126.8	124.0	123.3	129.6	120.5	126.8	117.7	133.8	114.2	103.0
Ilmenite		US$M			994.3	0.0	0.0	0.0	52.1	78.0	75.5	74.7	74.2	72.6	72.2	75.9	70.5	74.2	68.9	78.3	66.9	60.3
Total Revenue		US$M			**2,687.0**	**0.0**	**0.0**	**0.0**	**140.7**	**206.4**	**204.3**	**202.1**	**201.0**	**196.6**	**195.5**	**205.4**	**191.0**	**201.0**	**186.6**	**212.1**	**181.0**	**163.2**

Table xi GCP Cash Flows

Y/End 30 June	Input	Units	Total	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Year				-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Resource																				
Ore Mined		'000t		0	0	0	41,084	52,122	54,575	54,575	54,575	54,575	54,575	54,575	54,575	54,575	54,575	54,575	54,575	54,575
Saleable Product																				
Premium, Intermediate, Standard Zircon		'000t	1,127.0	0.0	0.0	0.0	64.1	87.9	85.1	84.2	83.8	81.9	81.4	85.6	79.6	83.8	77.7	88.4	75.4	68.0
Secondary Zircon		'000t	28.6	0.0	0.0	0.0	1.6	2.2	2.2	2.1	2.1	2.1	2.1	2.2	2.0	2.1	2.0	2.2	1.9	1.7
Zircon total		'000t	**1,155.6**	**0.0**	**0.0**	**0.0**	**65.7**	**90.2**	**87.3**	**86.4**	**85.9**	**84.0**	**83.5**	**87.8**	**81.6**	**85.9**	**79.7**	**90.6**	**77.3**	**69.7**
Rutile		'000t	81.9	0.0	0.0	0.0	4.7	6.4	6.2	6.1	6.1	5.9	5.9	6.2	5.8	6.1	5.6	6.4	5.5	4.9
Leucoxene		'000t	131.5	0.0	0.0	0.0	7.5	10.3	9.9	9.8	9.8	9.6	9.5	10.0	9.3	9.8	9.1	10.3	8.8	7.9
Subtotal		'000t	1,369.0	0.0	0.0	0.0	77.9	106.8	103.4	102.3	101.7	99.5	98.9	104.0	96.7	101.7	94.4	107.4	91.6	82.6
Ilmenite		'000t	8,324.9	0.0	0.0	0.0	473.5	649.6	628.9	622.1	618.7	605.0	601.6	632.3	587.9	618.7	574.2	652.8	557.1	502.5
Total Saleable Product		'000t	**9,693.9**	**0.0**	**0.0**	**0.0**	**551.3**	**756.4**	**732.3**	**724.4**	**720.4**	**704.5**	**700.5**	**736.3**	**684.6**	**720.4**	**668.7**	**760.2**	**648.8**	**585.1**
Prices																				
Premium, Intermediate, Standard Zircon		$US/t	1,323.67	0.00	0.00	1,130.00	1,225.00	1,300.00	1,350.00	1,350.00	1,350.00	1,350.00	1,350.00	1,350.00	1,350.00	1,350.00	1,350.00	1,350.00	1,350.00	1,350.00
Secondary Zircon		$US/t	661.83	0.00	0.00	565.00	612.50	650.00	675.00	675.00	675.00	675.00	675.00	675.00	675.00	675.00	675.00	675.00	675.00	675.00
Rutile		$US/t	830.67	0.00	0.00	805.00	815.00	820.00	835.00	835.00	835.00	835.00	835.00	835.00	835.00	835.00	835.00	835.00	835.00	835.00
Leucoxene		$US/t	730.67	0.00	0.00	705.00	715.00	720.00	735.00	735.00	735.00	735.00	735.00	735.00	735.00	735.00	735.00	735.00	735.00	735.00
Ilmenite		$US/t	118.33	0.00	0.00	105.00	110.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00
Revenue																				
Premium, Intermediate, Standard Zircon		US$M	1,509.1	0.0	0.0	0.0	78.5	114.3	114.9	113.7	113.1	110.6	109.9	115.6	107.4	113.1	104.9	119.3	101.8	91.8
Secondary Zircon		US$M	19.1	0.0	0.0	0.0	1.0	1.5	1.5	1.4	1.4	1.4	1.4	1.5	1.4	1.4	1.3	1.5	1.3	1.2
Zircon total		US$M	**1,528.2**	**0.0**	**0.0**	**0.0**	**79.5**	**115.8**	**116.4**	**115.1**	**114.5**	**112.0**	**111.3**	**117.0**	**108.8**	**114.5**	**106.3**	**120.8**	**103.1**	**93.0**
Rutile		US$M	68.2	0.0	0.0	0.0	3.8	5.2	5.2	5.1	5.1	5.0	4.9	5.2	4.8	5.1	4.7	5.4	4.6	4.1
Leucoxene		US$M	96.3	0.0	0.0	0.0	5.3	7.4	7.3	7.2	7.2	7.0	7.0	7.3	6.8	7.2	6.7	7.6	6.5	5.8
Subtotal		US$M	1,692.7	0.0	0.0	0.0	88.7	128.4	128.9	127.5	126.8	124.0	123.3	129.6	120.5	126.8	117.7	133.8	114.2	103.0
Ilmenite		US$M	994.3	0.0	0.0	0.0	52.1	78.0	75.5	74.7	74.2	72.6	72.2	75.9	70.5	74.2	68.9	78.3	66.9	60.3
Total Revenue		US$M	**2,687.0**	**0.0**	**0.0**	**0.0**	**140.7**	**206.4**	**204.3**	**202.1**	**201.0**	**196.6**	**195.5**	**205.4**	**191.0**	**201.0**	**186.6**	**212.1**	**181.0**	**163.2**
Costs																				
Unit Operating Cost		US$/t	1.36	0.00	0.00	0.00	1.59	1.45	1.38	1.37	1.36	1.35	1.34	1.37	1.32	1.35	1.31	1.38	1.29	1.24
Operating Expenses		US$M	(1,024.7)	0.0	0.0	(7.4)	(65.4)	(75.4)	(75.2)	(74.7)	(74.4)	(73.6)	(73.2)	(74.7)	(72.3)	(73.7)	(71.3)	(75.3)	(70.4)	(67.7)
Capital Expenses		US$M	(406.0)	(24.2)	(164.7)	(217.1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Working Capital		US$M	(53.6)	0.0	0.0	(4.8)	(35.6)	(13.3)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sustaining Capital		US$M	(60.3)	0.0	0.0	0.0	0.0	(1.5)	(4.9)	(4.9)	(4.9)	(4.9)	(4.9)	(4.9)	(4.9)	(4.9)	(4.9)	(4.9)	(4.9)	(4.9)
Royalties		US$M	(120.9)	0.0	0.0	0.0	(6.3)	(9.3)	(9.2)	(9.1)	(9.0)	(8.8)	(8.8)	(9.2)	(8.6)	(9.0)	(8.4)	(9.5)	(8.1)	(7.3)
Government production share		US$M	(90.6)	0.0	0.0	0.0	(2.6)	(7.3)	(7.1)	(7.0)	(7.1)	(6.8)	(6.9)	(7.8)	(6.7)	(7.6)	(6.4)	(8.3)	(5.5)	(3.5)
Interest		US$M	(84.4)	0.0	0.0	(6.2)	(13.4)	(13.6)	(12.0)	(10.4)	(8.8)	(7.2)	(5.6)	(4.0)	(2.4)	(0.8)	0.0	0.0	0.0	0.0
Tax		US$M	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Debt Drawdowns		US$M	200.0	0.0	0.0	155.0	45.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Debt repayments		US$M	(200.0)	0.0	0.0	0.0	(20.0)	(20.0)	(20.0)	(20.0)	(20.0)	(20.0)	(20.0)	(20.0)	(20.0)	(20.0)	0.0	0.0	0.0	0.0
Annual Net Cash Flow		US$M	**846.4**	**(24.2)**	**(164.7)**	**(80.5)**	**42.3**	**66.0**	**76.0**	**76.0**	**76.8**	**75.2**	**76.1**	**84.8**	**76.1**	**85.0**	**95.6**	**114.1**	**92.0**	**79.8**
Cummulative Net Cash Flow		US$M		**(24.2)**	**(188.9)**	**(269.4)**	**(227.1)**	**(161.1)**	**(85.1)**	**(9.1)**	**67.7**	**142.9**	**219.0**	**303.8**	**380.0**	**464.9**	**560.5**	**674.6**	**766.6**	**846.4**
IRR				**21%**																

The GCP has a net cash flow of US$846.6M to 2027 (see Figure vii and Table xi).

Figure vii GCP Overall Cash Flow



The net annual cash flow is positive in 2014, as shown in Figure viii and Figure ix.

Figure viii GCP Net Annual Cash Flow

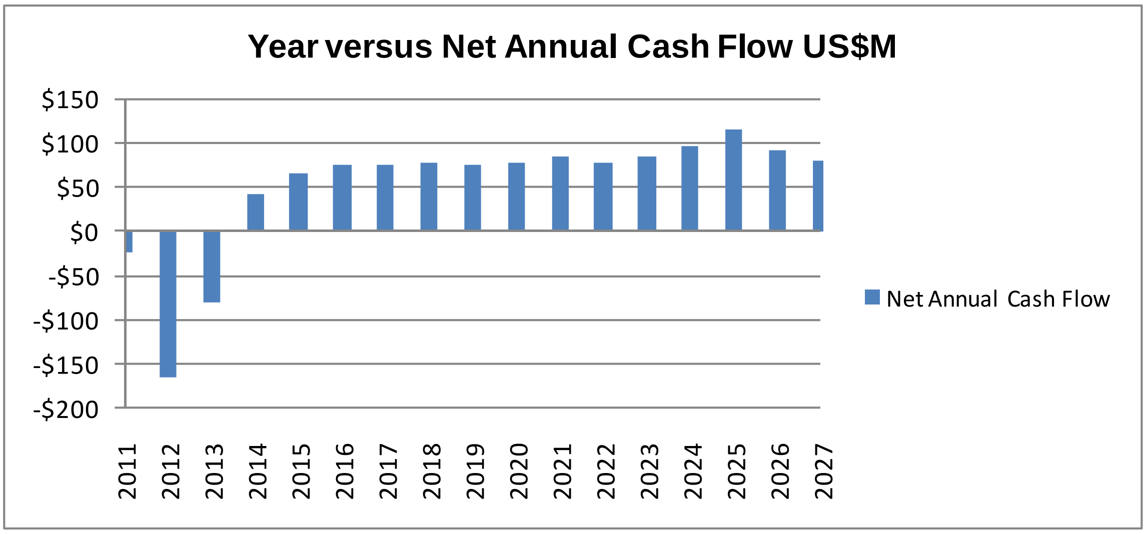
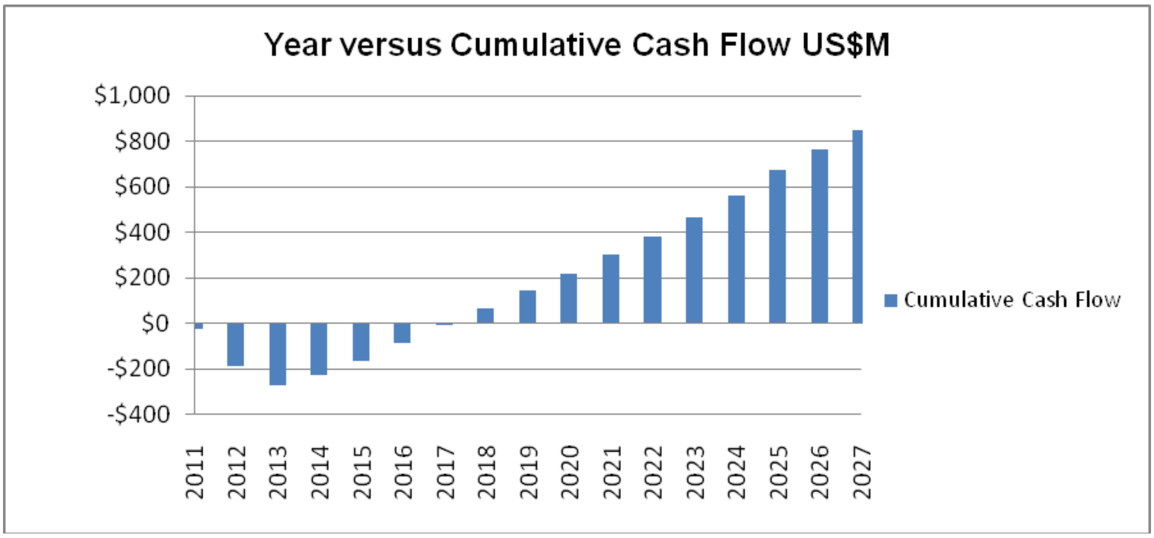


Figure ix GCP Overall Cash Flow (US$M)

The internal rate of return of the GCP to 2027, assuming 50% debt and 50% equity is 21%. The net present value (NPV) of the project to 2027 is US$209.3M.

The GCP experiences positive payback in 2018, shown in Figure vii, with cumulative revenue of US$67.8M in that year (Figure x).

Figure x GCP Cumulative Cash Flow

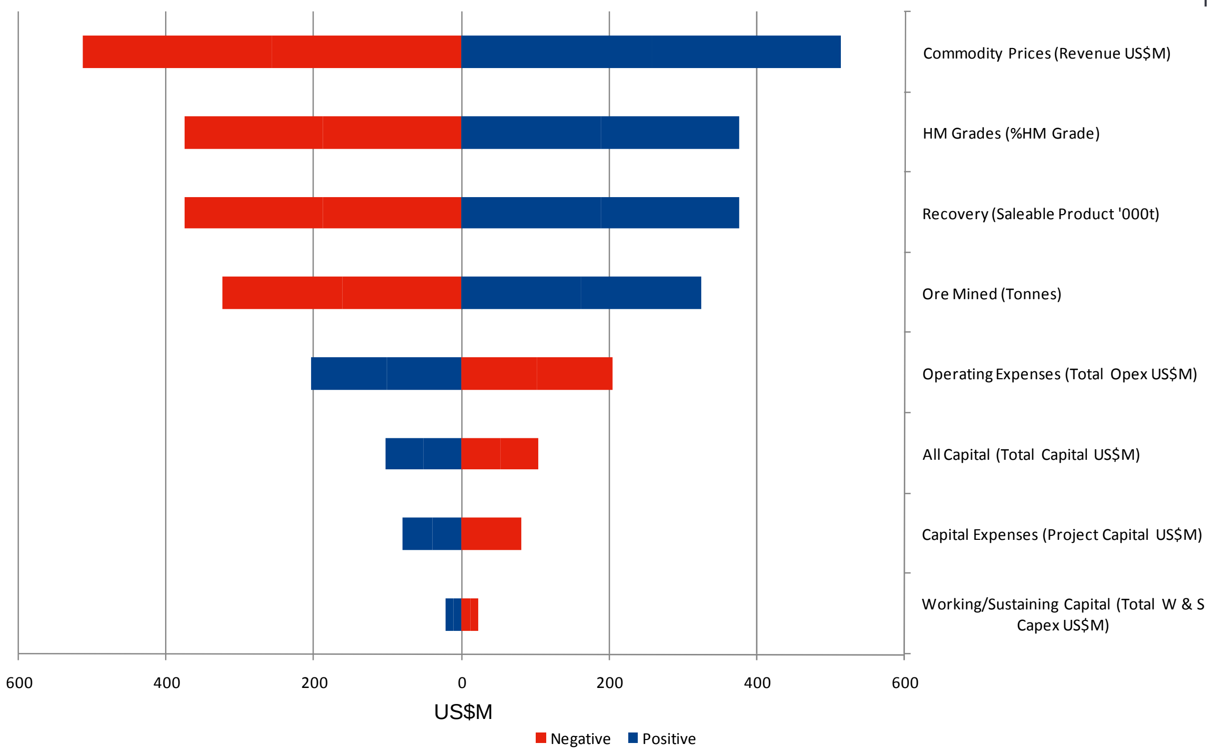


Single-point deterministic sensitivity analysis was conducted whereby a parameter was varied in isolation to all other parameters and the economic performance of the project determined. The parameters that have been selected for single-point sensitivity analysis represent those which could be considered to have a material impact on the project value, either in isolation or combined with other factors. In some cases, such as heavy mineral grade, commodity price, operating and capital costs, the multiple entries were varied as a single entity.

Sensitivities have been evaluated across a range of ±10%. In terms of net revenue, and shown in Figure xi, the GCP is most sensitive to:

- Commodity price.
- Heavy mineral grade.
- Recovery.
- Ore mined.
- Operating expenses.
- All capital expenditure.
- Fixed capital expenditure.
- Working and sustaining capital expenditure.

Figure xi GCP Sensitivity Analysis Impact on Net Revenue



The impact of sensitivity analysis across a range of ±10% on IRR is summarised in Table xii.

Table xii Sensitivity Impact on IRR

Sensitivity	IRR @ 90%	IRR @ 100%	IRR @ 110%	IRR Change +/-10%
Ore Mined (Tonnes)	18%	21%	24%	6%
HM Grades (%HM Grade)	17%	21%	24%	7%
Recovery (Saleable Product '000t)	17%	21%	24%	7%
Commodity Prices (Revenue US$M)	16%	21%	26%	10%
Operating Expenses (Total Opex US$M)	23%	21%	19%	-4%
Capital Expenses (Project Capital US$M)	24%	21%	18%	-6%
All Capital (Total Capital US$M)	24%	21%	18%	-6%
Working/Sustaining Capital (Total W & S Capex US$M)	21%	21%	21%	>-1%

The greatest negative IRR impacts are from:

- All capital expenditure.
- Fixed capital expenditure.
- Operating expenses.
- Working and sustaining expenditure.

The greatest positive IRR impacts are from:

- Commodity price.
- Heavy mineral grade.
- Recovery.
- Ore mined.

Given that commodity price, heavy mineral grade, recovery and ore mined all result in both increased net revenue and project IRR, the greatest potential upside for the GCP can be achieved by optimising internal mining and processing practices in a climate of reasonable macro-economic parameters.

Risks and Opportunities

The risks facing the project were identified and assessed by GCO and the project team in two risk workshops. A risk register was developed that identified each risk, assigned a risk rating based on the likelihood and consequences of the risk event occurring, and identified appropriate control measures to mitigate and manage the risks. Marketing, financing and political risk consideration was not within the scope of the risk assessment workshops.

A total of 92 risks were identified and assessed, the majority of which are associated with project execution. Of these, the nine risks summarised in Table xiii are considered key issues for the project.

Table xiii Summary of Key Issues for Management of GCO Identified in Risk Profile

Class	Risk Summary	Initial Risk Ranking	Proposed Controls	Owner	Revised Risk Ranking
Mining and mineral processing	Poor operational performance at start-up.	High	High level of expatriates with knowledge; budget allowance for ramp-up; design mine path for first 12 months to suit less experienced operators; cross-training; recruitment policy for expatriates and nationals.	GCO	Low
Health and safety	Traffic incidents on roads or rail.	Extreme	GCO road to ICS and village bypasses; traffic management plan; community education; contractor compliance with traffic management plan; logistics contractor selection and management.	GCO	Medium
Health and safety	Public accidents in mine.	Extreme	Fence during construction and security staff control of boundary post construction.	GCO	Medium
Health and safety	Malaria, dengue.	High	Identification and treatment; utilise Sabodala malaria control programs; spraying; nets; removal of standing water; education programs.	GCO	Medium
Socio-economic impact	Lack of community support.	Extreme	Lessons learned from Sabodala; proactive CA plan run by GCO.	GCO	Low
Socio-economic impact	Disruption to livelihood assets.	High	Change in the mining plan; strong community relationships; establishing a baseline and a transparent process for compensation from the beginning of the project.	GCO	Low
Project execution	Forex increasing cost to complete.	High	Hedging; conservative exchange rate assumptions.	GCO	Low
Project execution	Capital escalation.	High	Firm price contracts; equipment pricing.	GCO	Medium
Project execution	Under-resourcing of owner's team and/or EPCM/ contractors.	High	Adequate and timely resource planning.	EPCM/GCO	Medium

The workshop also identified four opportunities for the project. These opportunities are centred on maximising social benefits, value engineering to reduce capital costs, improved mineral processing recoveries and longer mine life. In summary:

- The construction and operation of the GCP is expected to result in very substantial financial and social benefits to surrounding communities. These include direct and indirect job creation, creation of local industry to support the project, and training and skills transfer to local people. Added social benefits include improved health and education levels plus improved local infrastructure such as roads.
- During the DFS Ausenco identified considerable capital cost savings that could be obtained through a fresh look at the MSP design and layout. Rationalisation of the structures and facilities including integration of the ilmenite and zircon building at the MSP could result in savings of the order of US$5-10M. In addition, opportunities for further optimisation of the major structural sections of the plant such as pontoons allowing easier transportation and assembly were identified. Funds and schedule allowances are included in as part of the project execution phase to realise these opportunities.
- Despite repeatable and consistent results the rutile and leucoxene recoveries measured as part of the testwork program were significantly lower than industry standard recoveries at comparable operations. Therefore there is significant project upside for increased recoveries and revenue from these minerals.
- The DFS scope was based on defining Reserves for the first 14 years of mine life. There is a significant portion of the ore body within the Mining Concession that has not been fully explored. Based on existing geological and exploration data a further 10+ years of project life can be reasonably expected.

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SECTION 1

Project and Study Background

Copy 16

AMC CONSULTANTS

CONTENTS

TABLES

FIGURES

1 PROJECT AND STUDY BACKGROUND

1.1 Company Background

Mineral Deposits Limited (MDL) traces its history to Mineral Deposits Syndicate, which started operations in Southport, Queensland in 1940. The company was one of the pioneers of the Australian mineral sands industry and is recognised in the industry as "the oldest brand in the business". MDL is based in Melbourne, Australia.

Throughout its varying corporate iterations MDL has conducted mineral sand operations on the eastern seaboard of Australia. MDL operations have consisted of wet dredging along dunes and strandlines to produce a heavy mineral concentrate. This was then trucked to the dry separation plant near the township of Hawks Nest for the extraction of rutile and zircon. In line with best practice, a complete environmental rehabilitation of each site was undertaken on a progressive basis as dredging moved on. MDL's rutile and zircon premium products have consistently found ready acceptance in global markets.

1.2 Project Acquisition

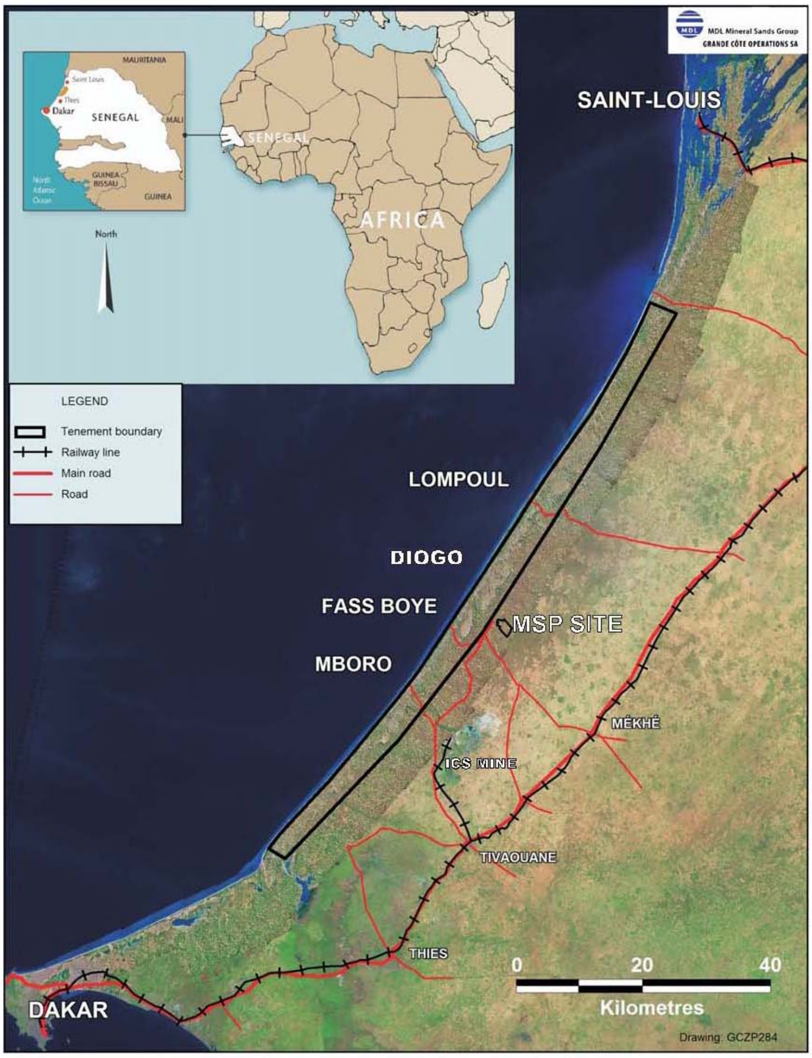
In September 2004, MDL was selected by the Government of the Republic of Senegal (GRS) to develop the Grande Côte Project (GCP). Under a Mining Convention MDL acquired the rights to explore and develop the project, which had been previously held by the United States-based company DuPont. DuPont conducted exploration drilling along a 50 km section of the Grande Côte between 1989 and 1992.

1.3 Project Location

The Republic of Senegal (Senegal) is located on the western bulge of Africa. Senegal is a stable, democratic republic under multi-party democratic rule based on the French civil law system. The country gained its independence from France in 1960 after about 75 years of French rule. The capital, Dakar, is found on the most westerly point of the coastline of Africa. The country is relatively small at 196,190 km^2 and has a population of about 12.5M people of whom 90% are Muslim and 5% Christian (mostly Roman Catholic). While French is the official language, Wolof, Pulaar, Jola and Mandinka are also spoken. Senegal is the location of choice of many foreign embassies and international banks as their headquarters for the West African region.

The topography of the country is generally low, rolling plains rising to foothills in the south-east. The area to be mined as the GCP is located on a coastal dune system. The dunes begin 25 km north-east of Dakar and extend northward for more than 140 km (Figure 1.1).

Figure 1.1 Site Location Plan



The mineralised dune system (Figure 1.2) averages about 2 km in width with some areas extending to up to 4.5 km wide and contains very large, sparsely vegetated sand masses.

The main heavy mineral (HM) areas identified to date, from south to north are Mboro, Fass Boye, Diogo and Lompoul. The dunes are recent in age established 2,000 to 4,000 years before present, are mobile or semi-fixed, pale yellow in colour and overlie older white marine sands. The dunes range between 5 m and 30 m in height and the mineralised zones are essentially flat-lying and average around 15 m in thickness. Both the dunes and the underlying marine sands contain HMs, principally ilmenite with accessory zircon, rutile and leucoxene. Zircon and ilmenite are the main commodities of interest.

The climate is tropical with a hot and humid rainy season (May to November) and a dry season (December to April) dominated by hot, Harmattan winds.

Figure 1.2 Mineralised Dune System

1.4 Project Ownership

MDL's interest in the GCP is held by the Senegal-based company Grande Côte Operations SA (GCO). GCO is 90% owned by a Mauritius-based company Mineral Deposits Mauritius Limited (MDM), which in turn is 100% owned by MDL. The remaining 10% of GCO is held by the GRS.

Prior to the incorporation of GCO, MDM established MDL Senegal Suarl (MDLSS) under a Mining Convention with the Senegal Government September 2004. The Mining Convention was established in accordance with Law No. 2003-36 of 24 November 2003, constituting the Mining Code and in accordance with Decree No. 2004-647 of 17 May 2004, setting out the procedures for the application of the law constituted in the Mining Code.

The purpose of the Mining Convention was to provide a contractual basis for the relationship between the Senegal Government and MDLSS over the entire period of the mining operations. The Mining Convention defines the general, legal, financial, fiscal, economic, administrative and specific corporate conditions under which MDLSS can undertake exploration and mining activities in the Grande Côte Permit Area.

Under the Mining Convention, and prior to the granting of the mining concession, drilling and project studies were conducted. In 2006 independent consultants AMC Consultants Pty Ltd (AMC) estimated mineral resources for the four main deposits of 1,330 Mt of sand averaging 2.0% HM at a cut off grade of 1.5% HM. All of the estimate was classified as Inferred Resources under the *Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves* (2004 JORC Code).

A Mining Concession was applied for by MDLSS and elaborated on in a series of letters from July through October 2007, in conjunction with the submission of a feasibility study.

As required under the Environmental Code (2001) and Mining Convention, an Environmental and Social Impact Assessment Study (Etude d' Impact Environmental et Social, EIES) was completed in December 2005, by Tropica Environmental Consultants, an environmental company registered by the Senegalese Ministry of Environment and Nature Protection. In December 2005, MDL submitted the EIES in support of its application for a Mining Concession. The EIES was approved by the Environmental Department of the Ministry of Environment and Nature Protection of the GRS on 20 January 2006.

The Mining Concession was granted to MDL on 24 September 2007 for a period of 25 years. The mining concession allows for the development, extraction, processing, transport and marketing of zircon, ilmenite, rutile, leucoxene and related minerals. The mining concession is renewable and the Senegal Government has entitlement to 10% participation in the exploitation of the project.

In accordance with the Mining Convention and Supplementary Deed No. 2, MDM and the Senegal Government created a separate Senegal-based company, GCO and MDL transferred the mining concession to GCO. GCO is jointly owned, under a shareholders agreement, by MDM (90%) and the Senegal Government (10%) and is required to subscribe to the terms and conditions of the Mining Convention. GCO is the developer and will be the operator of the GCP. Within the Mining Concession there is potential to identify additional resources beyond the limits of present drilling.

1.5 Project Development Studies

Since the granting of the Mining Concession, GCO has been progressing the GCP. Additional infill drilling, sampling and assaying of the initial mining area, centred at Diogo was completed in 2008, enabling a dredge path to be designed and ore reserves estimated, based on a subsequent JORC compliant Measured and Indicated Mineral Resource (AMC May 2008). This infill represents about 30% of the resource potential within the Mining Concession.

Other studies conducted since 2006 considered all aspects related to the development of the project, including mining, metallurgical, marketing, environmental, legal, economic, social and governmental, based predominantly on producing saleable zircon. Further detailed work in late 2007 was undertaken to consider the production of ilmenite concurrently with zircon.

These development studies have shown that the project can be optimised as a dredging operation, with mineralised sand being treated in a conventional floating spiral pre-concentrator, wet concentrator and dry mineral separation plant. Detailed engineering work completed by Ausenco Limited (Ausenco) in 2006 and 2007 was initially based on using a substantial portion of equipment from MDL's decommissioned Hawks Nest and Viney Creek operations. However, inspection of this equipment and the decision to substantially increase the throughput rate has resulted in the decision to build a new plant for the complete process from dredging to final product separation and grading. Testwork on a series of bulk samples has determined that the project can yield a high-quality zircon product and an ilmenite product along with minor amounts of rutile and leucoxene products.

Furthermore, these development studies indicated a likely output of around 80,000 t of zircon, around 550,000 t of ilmenite, around 15,000 t of rutile and around 12,000 t of leucoxene. Planned zircon output would represent around 7% of the total world production, which would make GCO a significant producer on a world scale.

MDL (on behalf of GCO) has entered into sales agreements with a number of customers covering all of the currently envisaged zircon production long-term on a rolling renewal basis. The agreements will be signed after completion of product quality trials and customer evaluations. These trials are well advanced and have demonstrated that the GCP zircon product would have a competitive edge in terms of product quality against other suppliers. Ilmenite marketing is also being progressed, with a number of customers having expressed interest after receiving samples. Customer benefits are enhanced by the close proximity of the Port of Dakar to the main European and North American markets.

In 2007, long lead time items, including the main dredge pump, cutter gearbox and tower crane for the feed bin, were purchased. Purchased equipment is currently in storage in Scotland, Belgium and Perth (Australia) awaiting shipment to Senegal.

In 2004, MDL acquired the Sabodala Gold Project in eastern Senegal via an open tender from the GRS. The Sabodala Gold Mining Convention was signed in early 2005, and MDL moved to develop the project with additional drilling and studies conducted during 2005 and to exploit the gold deposit in 2006. MDL awarded an engineering, procurement, construction management (EPCM) contract for the Sabodala Gold Project to Ausenco in 2007 and development of the project commenced. In late 2007, the MDL management temporarily suspended development work on the GCP to enable the company to focus resources on the Sabodala Gold Project.

In early 2009, with the Sabodala Mine commissioned and operating, MDL recommenced development work on the GCP with the initiation of this Definitive Feasibility Study (DFS).

1.6 Key DFS Assumptions

The Key Project Assumptions for the DFS are summarised in Table 1.1.

Table 1.1 Key Project Assumptions

Item	Assumption
Saleable products	Four zircon products: premium, intermediate, standard and secondary Two ilmenite products: sulphate ilmenite and chloride ilmenite One rutile product One leucoxene product
Mining method	Dredging operation Owner mining
Mining rate	55 Mtpa of sand 7,200 tpa
Processing method	Floating spiral wet plant WHIMS circuit Non-magnetic table separation and dry plant Ilmenite dry plant
Processing rate	140 t per hour to a maximum of 200 t per hour
Tailings disposal method	Cycloned and discharge with tailings stacker
Product transport method	Road transport in container to Port of Dakar for zircon, rutile and leucoxene. Rail transport to Port of Dakar for ilmenite
Project execution methodology	EPCM contractor
Construction start date	August 2011
Operating period	14 years

1.7 Scope of Work for the Definitive Feasibility Study

The key work packages for the DFS are summarised in Table 1.2.

Table 1.2 Summary of DFS Scope of Work

Area	**Summary of Scope of Work**
Marketing	Updated pricing forecasts based on recent TZMI research.
Drilling	An additional 57,135 m of RC resource drilling and assaying and 96 m of auger drilling and assaying was completed to upgrade sections of the resource.
Geology	Updating previous geological studies based on the new drilling results and a revised mining concept.
Mining	Updating previous mining studies based on the new drilling results and a revised mining concept.
Process testwork	Additional metallurgical testwork to allow the inclusion of high capacity HCIRS spirals and ilmenite production.
Mineral processing and engineering	Revision of the original engineering studies to DFS standard based on additional testwork results and changes to the mining and processing methods. Addition of ilmenite processing facilities.
Mine and site geotechnical	Compilation of existing geotechnical testwork and geotechnical analysis.
Water management and hydrology	Completion and testing of deep water bores to assess the yield of the deep aquifer system. Updating previous hydrogeological studies based on the new drilling results and a revised mining plan.
Infrastructure and services	Update of infrastructure and services designs based on Sabodala experience and inclusion of additional infrastructure for Ilmenite transport.
Health and safety	Compilation of existing occupational health and safety polices and procedures.
Socio-economic impact	Update of field baseline work. Preparation of new management plan.
Environmental	Preparation of an environmental management and monitoring plan. Preparation of an environmental monitoring manual and an environmental emergency response plan.
Project execution	Update of project execution plan including additional ilmenite plant and associated infrastructure.
Management and human resources	Update of management and human resources strategy based on recent MDL experience at Sabodala.
Closure	Update of closure plan and closure cost estimate.
Capital and operating costs	Revision of the capital and operating costs based on recent experience at Sabodala, updated pricing requests and new mine plan.
Financial modelling	Update of financial models based on revised capital and operating costs, new mine plan and new pricing forecasts.
Risk analysis	Revision of risk analysis based on changes to the project concept and engineering and recent experience at Sabodala.

The work completed in the DFS is detailed in two volumes:

- Grande Côte Project Definitive Feasibility Study Volume 1: Technical and Engineering.
- Grande Côte Project Definitive Feasibility Study Volume 2: Environmental and Social.

1.8 Study Accuracies

The overall study accuracies for the GCO Definitive Feasibility Study are as follows:

- AMC has defined, using the JORC Code (2004), a Geological Resource of 50 Mt as Indicated Resource and 980 Mt as Measured Resource.
- AMC has defined, using the JORC Code (2004), a Proved Reserve of 746 Mt and a Probable Reserve of 5 Mt.
- Capital costs estimated by Ausenco and GCO have an accuracy of ±15%.
- Operating costs estimated by GCO have an accuracy of ±15%.
- The base date for the capital costs is 30 November 2009.
- The base date for operating costs is April 2010.

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SECTION 2

Market Analysis

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Copy 16

TABLES

FIGURES

2 MARKET ANALYSIS

2.1 Introduction

The GCP will be commissioned in 2013 and will have an average annual production of the following saleable products:

- 80,000 t of zircon (premium, intermediate, standard, secondary).
- 6,000 t of rutile.
- 11,000 t of leucoxene.
- 575,000 t of ilmenite.

In revenue terms the GCP is predominantly a zircon project, with zircon likely to generate approximately 57% of project revenue. The balance of the revenue will come from ilmenite, rutile and leucoxene. All of these markets have been reviewed in detail by MDL and by the independent consultant, TZMI Minerals International Pty Ltd (TZMI). TZMI is an independent technical and commercial consulting and publishing company, unique in its extensive experience in the mineral sands and TiO_2 pigment sectors.

This Definitive Feasibility Study (DFS) provides an overview of the zircon and titanium feedstock markets, addressing the following issues:

- Product quality.
- End use markets.
- Demand trends and forecasts by end use.
- Demand trends and forecasts by geographic region.
- Production trends and forecasts.
- Market supply/demand balances.
- MDL's marketing strategy.
- Price trends and forecasts.
- Revenue trends and forecasts.
- MDL's marketing resources.

The period to 2027 has been considered for the market analysis.

The DFS draws on the MDL Marketing Report 2006. Much of the statistical data for this report was drawn from TZMI publications, including, Grande Côte Market Report: Bankable Feasibility Study for Mineral Deposits Limited April 2010, provided in Appendix 2.1; The Global Zircon Industry: The New Decade 2009; TZMI Mineral Sands Annual Review June 2009 and RMB Resources Limited: Independent Market Study of Mineral Deposits Limited Grande Côte Zircon Project, May 2006.

2.2 Zircon Product Overview

Zircon ($ZrSiO_4$) is the most commonly occurring mineral of zirconium. It is resistant to mechanical and chemical weathering and is found in mineral sands. In these sands, zircon is commonly found in associated with titanium minerals, ilmenite and rutile and is often considered a co-product of titanium mineral production.

Zircon and titanium minerals are derived from different igneous rock deposits. The hydraulic action of waves, currents and tides collect them together in deposits as they all have high specific gravity and resistance to abrasion and leaching. This forms shoreline deposits such as the Murray and Eucla Basins in South Australia or Volnogorsk in the Ukraine. Wind action can further transport the mineral into dunes, such as North Stradbroke Island, eastern Australia, Capel and Eneabba, Western Australia; Richards Bay on the east coast of South Africa and coastal deposits in India and Sri Lanka.

Much smaller quantities of zircon are derived from hard rock deposits, caldasite, containing the zirconia minerals baddeleyite and zircon and rare earth elements.

Zircon has a high melting point, a low coefficient of thermal expansion despite high thermal conductivity and is extremely refractory, and applications include glazes in ceramics tiles and sanitaryware, raw material in foundry moulds, raw material in refractory products for the steel and glass sectors, as a basis of zirconia and zirconium chemicals and in glass to absorb X-rays generated by cathode ray tubes in televisions.

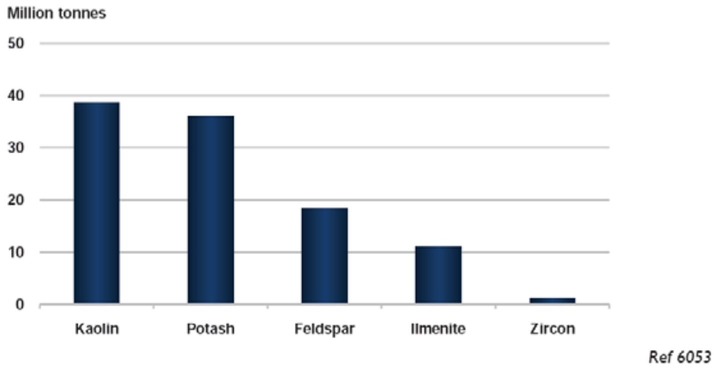
Premium-grade zircon from the GCP will be directed to sand millers associated with the ceramics industry in Europe. Due to low levels of key impurities, the intermediate-grade, standard-grade and secondary-grade zircon are suited to a wide array of market segments for which they are all considered premium for that application.

2.3 The Zircon Industry

2.3.1 Overview

Zircon is considered to be a low-volume, silica-based industrial mineral and while its level of production is low compared to like minerals (Figure 2.1), its revenue is high. The total global zircon revenue was US$1B in 2008.

Figure 2.1 Global Production of Selected Industrial Minerals, 2008



Source: USGS

The zircon Industry is shown in Figure 2.2 and can be divided into three phases:

- **Primary production:** Mining of heavy mineral (HM) sands and processing them into a heavy mineral concentrate (HMC) using physical separation techniques. Primary production is dominated by producers in Australia and South Africa.
- **Intermediate processing and milling:** Further chemical processing to zirconium chemicals or milling of zircon into a form more readily usable by end users. 60% is milled to flour or very fine-grained opacifier. Milling is generally completed in China, Spain, Italy, Germany and the US.
- **End uses:** Incorporation of the zirconium chemicals or milled zircon into final applications or products. Each end use has its own demand growth rates (Table 2.1) and price at which zircon remains attractive.

The top five producers of zircon account for 80% of world output, with South Africa and Australia accounting for 72% in 2008. There is a high level of international trade across a range of product industries. For intermediate processors of zircon, much is consumed in the country where it is refined, with only 15% to 20% of milled product exported.

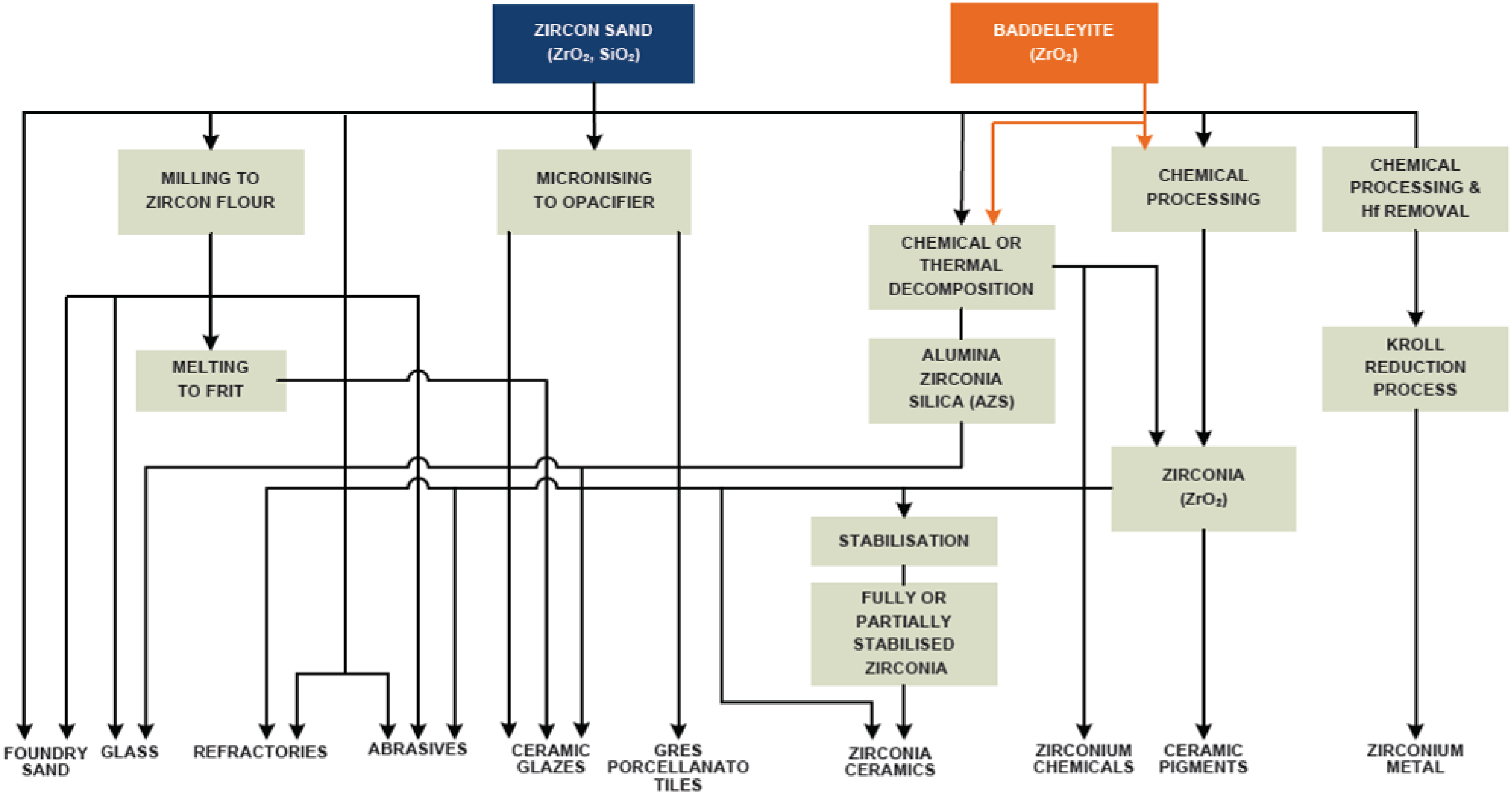
Table 2.1 Production Growth in End Use Sectors 2003–2008

	Five years average growth rate
Ceramics	1.2%
Specialty chemicals & materials	8.1%
Foundry casting	-3.2%
Steel	-1.5%
Glass	-2.4%

Source: TZMI 2009

TZMI anticipates that zircon demand growth will average 5.2% per annum to 2015 and 3.7% growth per annum from 2015, in the face of a widening supply deficit.

Figure 2.2 Schematic Structure of the Zircon Industry



Source: TZMI 2009

2.3.2 Zircon Production and Processing: Milled Zircon Sand

Zircon sands vary in particle size, with the average range varying depending on the application, for example, sand containing 80% of the particles between 70 and 200 microns is ideal for foundry sands, as a feedstock for fused zirconia or chemical zirconia or in some refractories (see Table 2.2).

Table 2.2 Zircon Size Range for Different Applications

	Product classification	95% passing (micron)	Median size (micron)
Frits for ceramic glazes	Flour	45	30 - 40
CRT glass manufacture	Flour	45 - 75	35 - 45
Opacifier for glazed tiles and gres porcellanato	Opacifier	5.0	0.9 - 1.0

Source: TZMI 2009

For commercial comparison, a milled product is said to have a maximum particle size, or d_{50}, which means that 50% by weight of the particles in the product are smaller than that specified. The d_{50} of zircon flour is 30 microns, whereas opacifier is 1.2 microns.

The impurities in the milled products are also important as they can impact on the effectiveness of the end use. For example, sands with higher uranium and thorium levels may contain metamict zircon, in which the crystal structure of the zircon has been damaged and weakened by radiation.

Milled zircon accounts for 60% of zircon consumption. In 2007, TZMI estimated the global milling capacity was 1.28M tpa, which exceeds their estimate of world supply of zircon sand in 2020. It is anticipated that this may create competition, encourage process efficiency and increase side-stream revenue.

China now accounts for 68% of the global total milling capacity (see Figure 2.3). Milling capacity in the US and India have also increased. Since 2008, milling capacity in Europe has decreased to 600,000 tpa, attributed to the closure of several operations due to declining demand and unfavourable operational economics for milling.

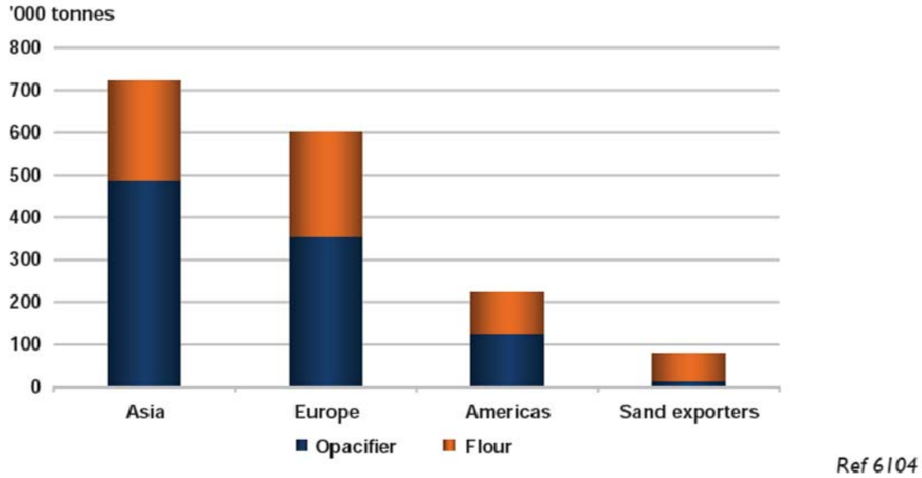
According to TZMI, milling capacity is generally located close to end use markets. Trade of milled zircon is dominated by Europe, accounting for 70% of the global milled zircon exports and 50% of milled zircon imports in 2008. Italy, the Netherlands and Germany are responsible for the exports, whereas France is the largest importing country.

Asia accounts for 25% of global milled zircon trade, with China only trading very small volumes. The Pacific accounts for 16% of global milled zircon trade, in which Australia is the largest exporter.

Companies involved in zircon milling can be divided into two types:

- Mineral processing companies, which purchase unprocessed sands, mill or process and sell their product downstream to companies that will develop the end use product.
- Ceramics companies (coloroficios), a smaller group, which mill the zircon sand and also manufacture end use products such as frits and glazes.

Figure 2.3 Regional Concentration of Milling Capacity



Source: TZMI 2009

Milling of zircon sand accounts for a significant proportion of the cost of the final fine-grained zircon materials. Zircon milled to flour demands an additional US$90 to US$260/t, and finer opacifier an additional US$210 to US$580/t.

Given the importance of ceramics in the milling sector, this end use is expected to drive growth in demand for milled zircon. The prices of milled zircon are expected to move in accordance with zircon sand prices.

2.3.3 Zircon Production and Processing: Zircon from Titanium Feedstock

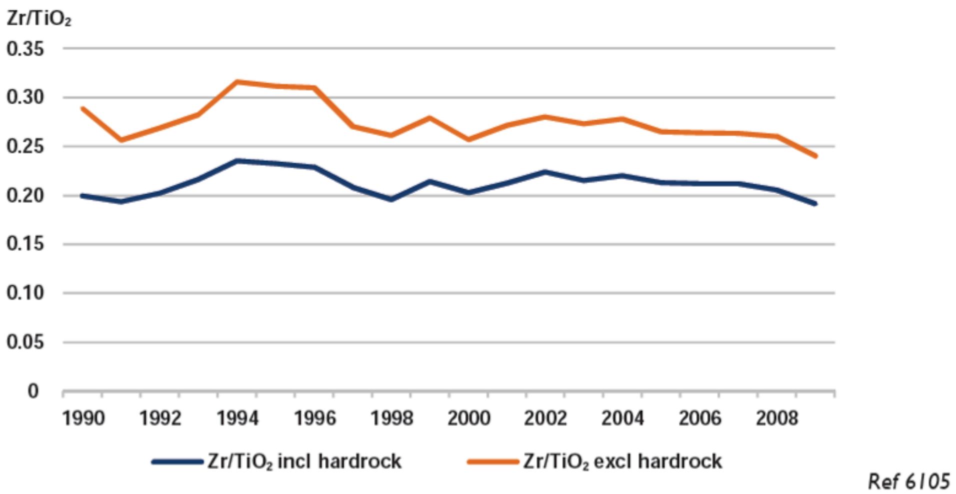
In all current mineral sands operations, zircon is always mined in conjunction with TiO_2 feedstock. TiO_2 feedstock includes TiO_2 slag, synthetic rutile, ilmenite, rutile or leucoxene. The ratio of zircon to TiO_2 feedstock production varies from mine to mine.

Consequently the production of zircon is typically controlled and constrained by changes in the production of titanium feedstock. Historically, new mine developments have been driven by the TiO_2 feedstock business.

The increase in zircon prices and forecast future undersupply has driven these companies to exploit zircon-rich areas and zircon stockpiles or to seek ventures that are zircon dominant.

TZMI uses a ratio of zircon to titanium feedstock minerals to quantify this relationship for an orebody and to aid in estimating realistic volumes of zircon supply. Globally, the ratio has been declining since the mid 1990s as shown in Figure 2.4, indicating less zircon produced per unit of titanium over time.

Figure 2.4 Ratio of Zircon to TiO_2 Unit Production, 1990–2009



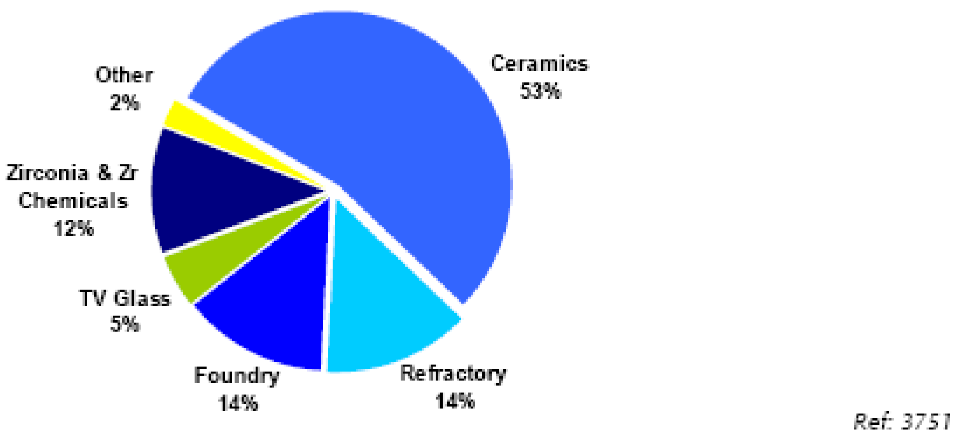
Source: TZMI 2009

2.4 Zircon End Uses

Zircon has a number of diverse applications, many of which represent important quality of life and industrial uses. The various end use markets, shown in Figure 2.5, have been split over the following areas:

- Ceramics.
- Specialty chemicals, materials and metals.
- Foundries, refractories and glass.

Figure 2.5 Zircon Consumption by End Use Market, 2005



Source: TZMI 2005

2.4.1 Zircon End Uses: Ceramics

Zircon is an opacifier, used to hide the clay substrate, thereby beautifying the end product of tiles. Zircon is used for the production of wall and floor tiles and in sanitaryware for the beautification of homes and buildings. This sector consumed 54% of world zircon production in 2008.

There are three main areas of use for zircon in ceramics:

- **Glazed ceramic tiles:** Zircon is used to alter a glaze from translucent to opaque. It is placed on the surface layer of a clay based body or “biscuit”. This hides the ceramic substrate, reduces porosity and staining, providing greater mechanical strength and allowing surface decoration. Glazes contain 10% to 20% zircon.

  Alternatively, zircon can be introduced to the glaze as a component of a frit, an intermediate fine powder. This powder becomes vitrified during the firing of the glaze. Frits allow glazes to mature at lower temperatures, around 1,150°C. Spain is the largest producer of frits in the world.
- **Glazed or unglazed porcelain tiles:** Zircon can be incorporated into the actual clay body of the tile, as in the case of *gres porcellanato* tiles. Upon firing, the tile vitrifies, hence replicates granite or marble. The zircon can be introduced to the glaze as a component of an opacifier, an intermediate fine powder. These tiles contain 10% to 18% more zircon than glazed tiles. Italy is the dominant producer of *gres porcellanato* tiles and this business is growing in other parts of the world.
- **Sanitaryware and tableware:** This includes basins, toilets and cisterns, consuming 9% of total zircon used in the ceramics market. In 2008, 300M pieces were manufactured. Sanitaryware is made of a body of china coated in an engobe, which is a glaze undercoat or intermediate layer in the tile. White colours typically account for 70% of total sanitaryware production.

All ceramic production requires high-grade zircon because liberation of Fe_2O_3 and other impurities such as TiO_2 upon firing can discolour the final product. However, in the case of frit, the zircon is already locked up into the frit so this does not present the same problem. Therefore, lower-grade zircon can be used for frit manufacture, representing the lower-paying market sector.

2.4.1.1 Ceramic Tiles

TZMI estimates that 680,000 t of zircon was used in ceramic tile production in 2008. Since 1980, the ceramics sector has experienced an average annual growth rate of 8% and is responsible for the large growth in world zircon demand.

In 2008, China manufactured 40% of global tile production. Due to its significant urban development, China has a strong domestic demand and its exports are increasing. China will remain the dominant tile producer for four reasons:

- The cost of the raw material, such as white clays, ball clays and feldspars is lower as many are domestically supplied and have lower delivery and mining costs.
- The hourly rates paid to workers are significantly lower than in Western countries.

- The cost of polishing is a major cost accounting for one-third of total cash cost, but is 40% lower per m^2 than, for example, in Italy.
- Chinese producers spend little on distribution outlets so avoid sales commissions.

According to TZMI, 60% of China's tile production can be classified as "low-quality", suitable for external cladding, 30% is "medium-quality", used for domestic decoration and 10% is considered "high-quality", suitable for modern buildings.

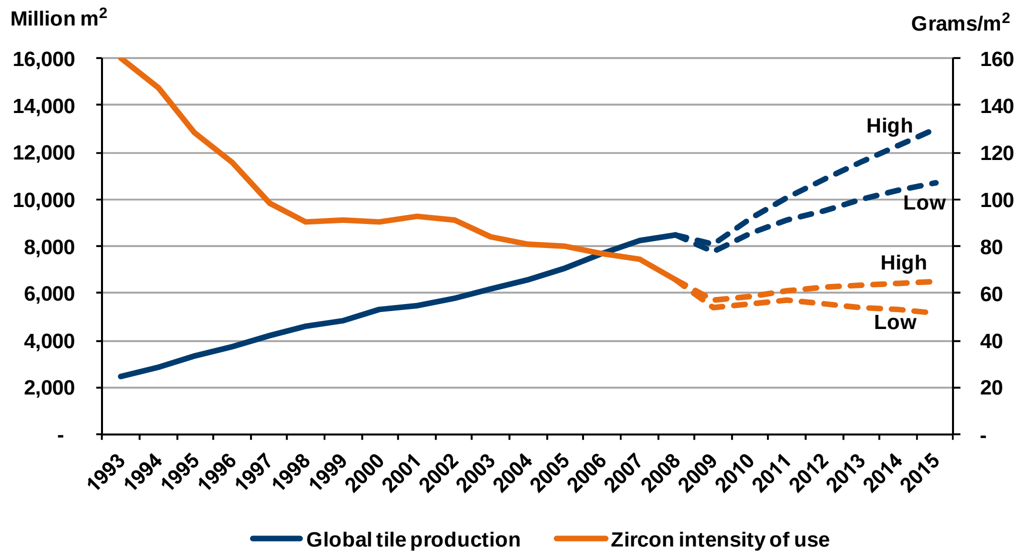
The majority of zircon consumed in Italy is in the manufacture of *gres porcellanato* tiles and unglazed white porcelain tiles directed at high-end consumers in Western Europe and the US. Therefore, the Italian tile market and zircon consumption have been impacted upon by demand downturns mirroring decreases in construction activity.

In Spain, traditional glazed ceramics dominate tile production, and glazed porcelain production has grown from 4% to 15% in the last decade. While being predominantly an export market, the downturn in its own domestic construction market was linked to the drop in Spanish tile output in 2008 of 15%.

In 2008, Brazil experienced a 7% increase over 2007 in tile production. This increase is attributed to a dry manufacture process that reduces processing energy costs by 50% and allows a subsequent reduction in selling price.

The projected global growth rate of zircon use in ceramics is shown in Figure 2.6.

Figure 2.6 Zircon Intensity of Use in Global Ceramics, 1993–2015



Source: TZMI 2009

Factors that influence the extent of use of zircon in tiles include:

- Zircon is more expensive than other components. For example, zircon is approximately 0.3% by weight of a glazed ceramic tile but attributes to 4% of the raw material cost. In *gres porcellanato* tiles, the zircon constitutes 5% of the composition by weight but 50% of the raw material cost.

- The supply of zircon has relied on a small number of global sources.
- There are no minerals that directly substitute for zircon in tile manufacture. Other minerals can be used as opacifiers, but not all of these minerals are suitable for use in ceramics. Some become costly in the required volumes and some are also expensive, such as anatase TiO_2.
- The intensity of use of zircon in ceramic glazes has decreased while opacification has been retained. This is due to improved milling of zircon sand increasing reflectivity per unit weight and application of thinner glazes.

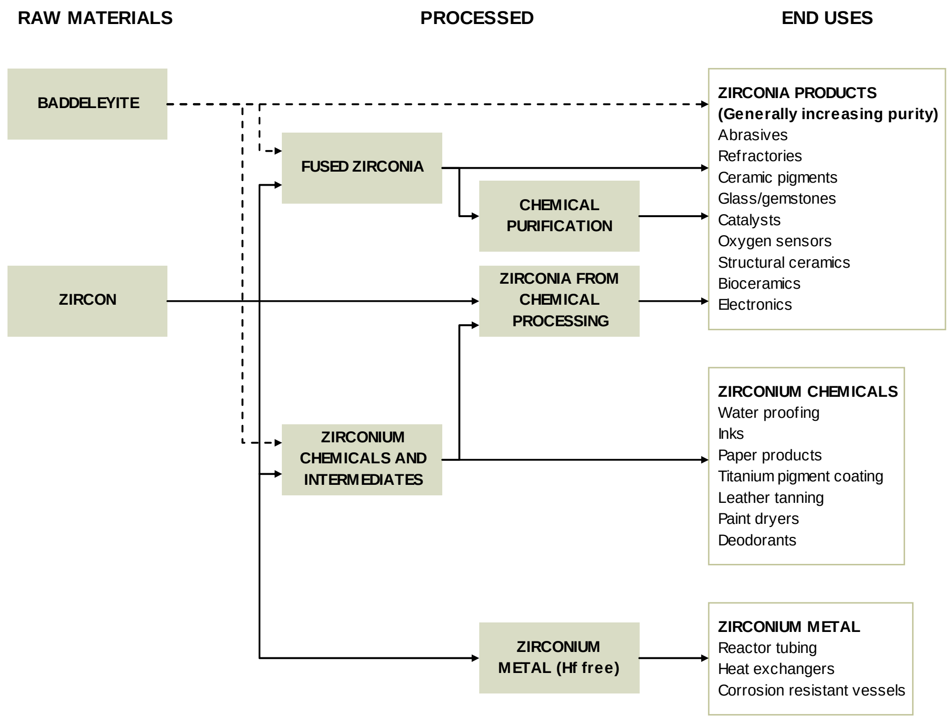
Zircon is still considered the preferred opacifier. TZMI forecast that further gains from efficiency of zircon usage are now relatively limited.

2.4.2 Zircon End Uses: Specialty Chemicals, Materials and Metals

The “zirconia/zirconium chemicals and metals” market sector requires the chemical processing of zircon into zirconium chemicals. This market sector represented 16% of world zircon consumption in 2008. This sector has experienced rapid growth over the last two decades, with a CAGR 1990 of 8.5%.

Zircon sand is used to manufacture two intermediate zircon products known as fused zirconia (ZrO_2) and zirconium chemicals (zirconium oxychloride octohydrate, ZOC). Two-thirds of the zirconium chemicals are used to produce chemical zirconia and zirconium metal, leading to the manufacture of end use products as shown in Figure 2.7.

Figure 2.7 Zirconia, Zirconium Chemicals and Zirconium Metal Industry



Source: TZMI 2009

2.4.2.1 Fused Zirconia

Fused zirconia is batch processed in an electric arc furnace from zircon ($ZiSO_4$) sand to monoclinic zirconia (ZrO_2). Shape change occurs at a range of temperatures that is undesirable, so oxides of yttrium, calcium or magnesium are added. The resultant fixed crystalline structure, "stabilised zirconia", is stable between 0°C to 2,700°C.

Partially stabilised zirconia (PSZ) is a variant of stabilised zirconia, where the oxides are not added in sufficient volume to fully stabilise the molecule, such as that made with 3% yttrium. This variant is extremely wear resistant.

The various types of fused zirconia are used for ceramic pigments, refractory components and wear materials.

China and the US are the largest producers of fused zirconia. China has experienced significant domestic demand given its increasing industrialisation and development of smelters.

The price of zirconia depends on the type being considered. For example, that of monoclinic fused zirconia that has simply been treated in an electric arc furnace can sell for US$2,400/t compared to a tonne of yttrium stabilised zirconia selling at US$3,800. The cost of zircon is subject to the effect of increasing power costs and the industry is operating significantly below capacity, which may result in cost rationalisation in the future.

2.4.2.2 Zirconium Chemicals

Zircon is used for the production of zirconium oxychloride octohydrate (ZOC) or zirconium basic sulphate (ZBS) using two main methods:

- **The caustic fusion route:** which converts zircon sand in a bath of molten caustic soda (sodium hydroxide, NaOH) to zirconyl hydroxide. This intermediary can be used to produce ZBS. Alternatively, it is reacted with hydrochloric acid to form ZOC ($ZrOCl_2.8H_2O$). Impurities such as iron, uranium and thorium are displaced in this step and need to be disposed of. This is the dominant process used in China.
- **The chloride process:** which dissociates zircon from its associated elements, such as iron, chromium, uranium and thorium using highly reacting chlorine. The resultant zirconium tetrachloride ($ZrCl_4$) is reacted with water to form hydrolysed ZOC, $ZrOCl_2$. This $ZrOCl_2$ is hydrated into ZOC. This technique is rarely used as it is capital-intensive and requires multiple process steps.

A range of end use products are then produced from ZOC or ZBS, including pigment, paper coatings, antiperspirants and paint dryers.

China was responsible for 94% of global ZOC or ZBS production in 2008, with half being exported and processed to final products in other locations. The selling price of ZOC is influenced by increasing capital and operating costs due to a tightening waste management initiative in China and this may cause cost rationalisation in the future.

2.4.2.3 Chemical Zirconia

Chemical zirconia is used for catalysts, optical fibre ferrules, ceramic and plastic colours, wear materials, dielectrics, piezo devices, oxygen sensors and fuel cells. In 2008, 85% of the global production of chemical zirconia was in China and Japan.

ZOC is used as a feedstock to produce ZrO_2, with zirconium hydroxide (ZOH) an intermediary in the process. The ZrO_2 is passed through a magnetic separator to remove iron impurities and milled to reduce the particle size.

The specialised nature of the end use product dictates its price. For example, some very pure chemical zirconia products have obtained prices in excess of US$20,000/t. This is driven by the cost of production and processing to obtain such purity. Substitute materials are still being considered in this sector.

2.4.2.4 Zirconium Metal

Zirconium metal can be produced from chemical zirconia, ZOC or directly from zircon sand. Zirconium metal has applications in the chemical processing industry as pumps, valves and heat exchangers, bone and joint prostheses, and in powdered form is used in military and civilian pyrotechnics to produce a bright white light.

Zirconium metal that is extremely pure and free of hafnium allows neutrons to pass through without absorption, hence is ideal for use in nuclear reactors. In 2008, 80% of produced zirconium metal was consumed by the nuclear power plant industry.

The stringent quality requirements mean that only the highest-quality zircon can be used as feedstock for chlorination. This is a high-quality, high-paying sector of the zircon market. In 2009 there were 436 nuclear reactors in operation worldwide, accounting for half of the energy generation in the US, France and Japan.

The key end use products of zirconia each have an influence in forecasting an outlook for the demand for zircon:

- In refractories, demand is driven by the steel industry, particularly cast iron refractories. As evidenced through the Global Economic Crisis, zirconia demand for refractories has fallen in line with demand for steel output.
- For fused zirconia, key demand drivers are the construction and steelmaking industries, both of which were impacted upon by the economic slowdown.
- In wear materials, demand is driven by global industrial output. However, only average growth is anticipated as cheaper alternatives exist.
- In catalytic converters, demand is driven by automotive demand, which is anticipated to be high. The market share of catalyst-fitted vehicles is expected to increase from 70% to 80% over the next five years.
- The demand growth of zircon in paints used to prevent yellowing and enhance drying is expected to follow GDP.

- Nuclear reactors and superalloys are set for strong growth, with the International Atomic Energy Agency expecting nuclear power generation to increase by 60% by 2020. This will increase demand for construction and operating. However, nuclear power plants take a long time to establish.
- Specialty applications such as peizoelectrics, dielectrics and oxygen conductivity are expected to experience high growth, in line with increasing global demand for faster communications, energy efficiency and precise machinery.

2.4.3 Zircon End Uses: Foundries, Refractories and Glass

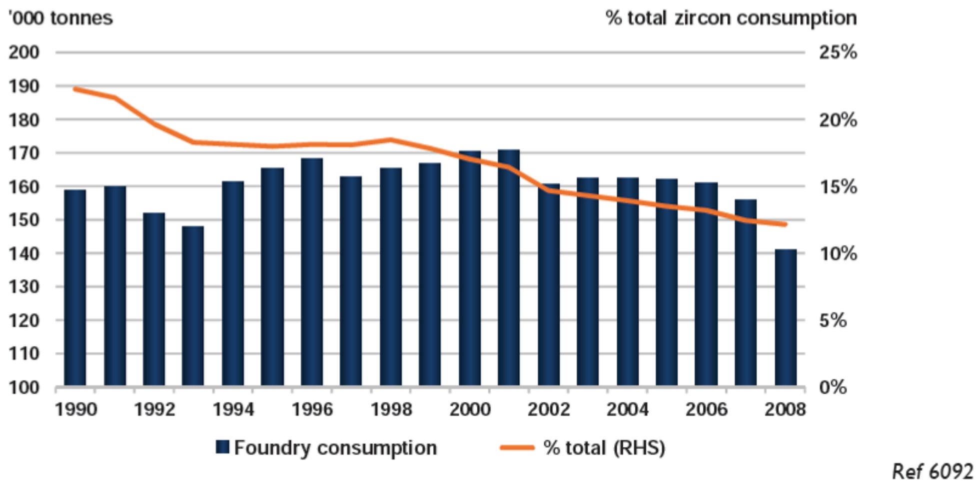
In 2008 the foundries, refractories and glass sectors consumed 27% of global zircon, equivalent to 312,500 t. This was the lowest level since 1980, and the decline is attributed to the significant drop in demand for cathode ray television glass.

2.4.3.1 Foundries

In the foundry sand business, complex metal components are made by pouring molten metal into pre-formed moulds. In 2008, China accounted for 31% of global production, and Europe and North America 26% each.

Zircon used in the foundry industry can have higher alumina (Al_2O_3) contents and even ZrO_2 contents as low as 50%. Some specialist investment castings can have more demanding specifications but most zircon concentrates tend to meet these. Figure 2.8 shows the changes in consumption of zircon in foundry castings from 1990 to 2008.

Figure 2.8 Consumption of Zircon Sand in Foundry Casting, 1990–2008



Source: TZMI 2009

There are three main casting techniques that consume zircon:

- Sand casting.
- Aluminium casting.
- Investment casting.

The key drivers of demand for use of zircon in foundries are:

- Specific size and shape requirements of products, such as in aerospace and medical instruments.
- Substitution of zircon in sand castings by chromite or synthetic products.
- Demand decreases experienced by the North American automotive sector, which will decrease demand for aluminium casting to 2015.
- Variations in the reliability and quality of zircon supply or price, which may encourage some substitution by mullite in investment casting. However, this sector is considered a growth area for zircon consumption.
- Overall steady growth stimulated by industrialisation in China and India.

2.4.3.2 Refractories

Large volumes of refractory materials are required to line the various processes in a blast furnace, such as the oxygen furnace and ladles. The refractories selected vary depending on the range of temperature, chemical and mechanical conditions of the molten metal.

Refractories accounted for 12% of global zircon consumption in 2008. Western Europe, the US and China dominate the sector with 31%, 21% and 15% of global zircon and zirconia-based refractories respectively.

Zircon is used in the refractories industry either as zircon, zircon–pyrophyllite mixtures, zirconia or fused alumina–zirconia–silica (AZS). AZS contains up to 41% zircon but up to 95% zircon is required for the production of specialty glasses.

Two types of smelting dominate the global smelting sector:

- **Glassmaking refractories**: In 2008, the consumption of zircon in glassmaking refractories was estimated at around 500,000 t. Continued urbanisation in China is expected to drive glass demand growth throughout the next decade.
- **Steelmaking refractories:** In 2008, global iron and steel production was estimated at 1.33 Bt, accounting for 70% of global zircon use in refractories. The world steel refractory market fell in response to the Global Economic Crisis and high steel output in China is expected to drive recovery in demand growth.

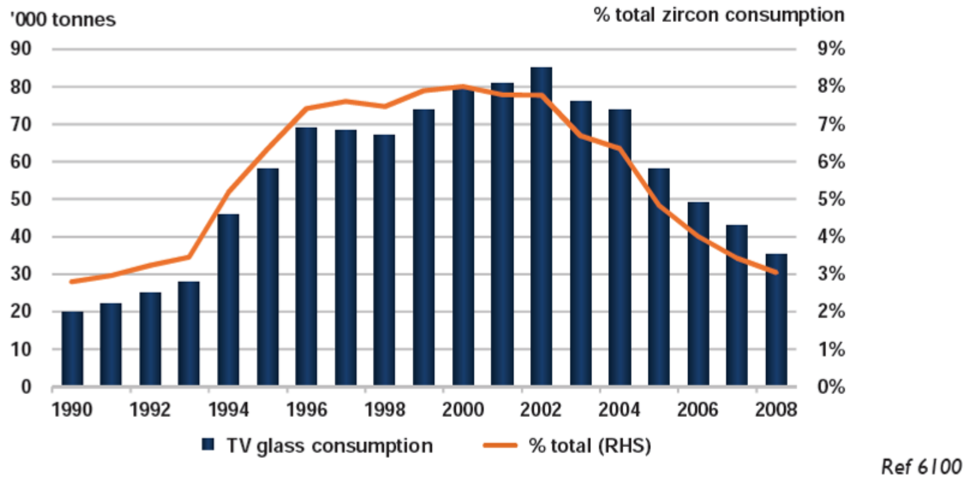
Significant growth in glass and steel output prior to the GEC did not translate to a growth in zircon consumption as 80% of expansion in production of steel occurred in Asia, where lower-quality refractories do not use zircon. TZMI anticipates that as steel production further migrates to China and India the weighted average of zircon use will decrease.

2.4.3.3 Television Glass

Zircon is used in cathode ray tubes (CRTs) for television and computer screens, as zircon can absorb X-rays. This market sector only represents 2% of world zircon consumption and this is forecast to drop to <1% by 2013.

The declining demand for zircon for use in TV glass is shown in Figure 2.9, attributed to the switch to new flat panel displays such as liquid crystal displays (LCDs) and plasma display panels (PDPs). PDPs contain some zircon in the glass but none of the current glasses used in LCDs use zircon. LCDs have been the major growth area.

Figure 2.9 Consumption of Zircon in TV Glass, 1990–2008



Source: TZMI 2009

2.5 Zircon Market Product Quality Specification

The naturally occurring mineral zircon is represented by the variable formula (Zr, Hf, U, Th, Y) SiO_4. Incorporated into its crystal structure is 2% to 5% hafnium (Hf), some uranium (U) and thorium (Th) and the rare earth element yttrium (Y), which can only be removed by destroying the zircon grains. Impurities can be found in zircon crystals in cracks, including alumina (Al_2O_3), silica (SiO_2) and iron (Fe).

Zircon occurs as a component in sand concentrate. Quality specifications for zircon and its associated sand are quoted in terms of zirconia content (ZrO_2 + HfO_2), iron oxide (Fe_2O_3), alumina (Al_2O_3), titania (TiO_2) and radioactive uranium and thorium (U + Th). The free silica, or quartz, content is quoted (SiO_2), as is grain size, bulk density and residual pH. An ideal zircon product is low in all of these contaminating minerals.

Guaranteed quality levels (see Table 2.3) are normally quoted for the following:

- ZrO_2 + HfO_2: Minimum level of 65.0% to 66.0% for ceramic-grade products, but lower for other applications.
- Fe_2O_3: Maximum levels range from 0.07% for the high-grade ceramics industry to 0.25% for foundry-grade products.

- TiO_2: Maximum levels range from 0.10% to 0.20% depending on end use.
- Some consumers request other guarantees, such as specific levels of Al_2O_3 or phosphate (P_2O_5) for some foundry or zirconium chemical applications.

The iron (Fe_2O_3) content is the key specification in determining suitability of a zircon sand product to end use consumer. In the case of ceramic opacifier, the commonly accepted maximum in premium-grade zircon is 0.07% Fe_2O_3. Higher quantities can be used successfully subject to satisfying glaze tests and customer trials. Iron content is controlled by grain surface cleaning and by minimisation of contamination of leucoxene and staurolite by mineral separation. Non-ceramic sectors such as the foundry and refractory industries have a higher tolerance for iron levels.

In the ceramics sector, titanium dioxide (TiO_2), caused by the presence of ilmenite or leucoxene in the concentrate, is undesirable as it can cause discolouration of glazes. Premium-grade zircon generally has to meet a TiO_2 specification of below 0.12%. The TiO_2 levels in the premium-grade and intermediate-grade zircon as produced by the GCP are particularly low by world standards at 0.03%, 0.05% and 0.10% respectively.

Radioactivity is not desirable in end uses where the uranium (U) or thorium (Th) is upwardly concentrated into the final product, such as in the production of zirconia or zirconium metal. Alternatively, U and Th can be released into waste streams, such as during the production of zirconium chemicals. Contaminating particles can be removed by magnetic or wet and dry gravity separation. The uranium and thorium caught in the crystal lattice cannot be removed without destroying the zircon. The GCP zircon is particularly low in U + Th.

Silica (SiO_2), or free quartz, which can dilute the zircon (ZrO_2) grade can cause lung fibrosis and is a carcinogen. Its occurrence must be reduced to <0.1% using gravity separation to ensure it meets acceptable occupational health and safety standards.

Table 2.3 Zircon Product Specifications from Selected Zircon Producers

Company	Deposit	Quality	ZrO_2 (%)	Fe_2O_3 (%)	TiO_2 (%)	Al_2O_3 (%)	U + Th (ppm)
Namakwa	Brand-Se-Baai	Premium	66.3	0.05	0.11	0.24	400
IRE	Chavara	Standard	65	0.12	0.27	n.a.	n.a.
Tiwest	Cooljarloo	Premium	66.4	0.06	0.13	< 0.5	n.a.
Iluka	Eneabba	Premium	66.5	0.07	0.13	0.35	440
Iluka	Murray Basin	Standard					
DuPont	Maxville	Premium	66.7	0.03	0.13	0.3	350
		Standard	65.9	0.04	0.25	1.3	350
		Zircon T	65.2	0.2	1.2	1	n.a.
CRL	North Stradbroke Is.	Premium	66.4	0.06	0.11	0.2	440
RBM	Richards Bay Area	Prime	65.9	0.08	0.12	0.14	450
		Intermediate	65.5	0.12	0.25	0.25	450
Bemax	Pooncarie	Premium	65.5	0.04-0.07	0.10-0.15	0.25-0.5	425-450
Iluka	Capel	Premium	65.5-66.0	0.05-0.07	0.10-0.15	0.5-0.7	360-440
		Coarse	66.1-66.4	0.07-0.13	0.13-0.18	0.05-0.15	400-470
Vilnohirsk	Vilnohirsk	Standard	65.7	0.09	0.2-0.3	1.2-1.5	320
		Improved	66	0.09	0.2	1	320

Source: TZMI 2009

2.5.1 GCP Zircon Product Quality Benefits

The various grades of zircon that will be produced by GCO have potential to supply a range of market sectors. The chemistry and sizing of the various GCO products also have relevance in important niche markets.

The tonnes per annum of zircon will be made up of approximately:

- 32,000 tpa premium-grade zircon.
- 25,000 tpa intermediate-grade zircon.
- 20,000 tpa standard-grade zircon.
- 2,500 tpa secondary-grade zircon.

The typical composition for GCP zircon products is shown in Figure 2.4, compared to current suppliers.

Table 2.4 Typical GCP Zircon Specifications Compared to Competing Products

Analysis	Grande Côte Premium	Grande Côte Inter	Grande Côte Std	CRL Premium	Iluka Eneabba Premium	Iluka Virginia Premium	Tiwest Premium	RBM Prime	Namakwa Sands
ZrO_2	66.7	66.4	66.0	66.4	66.5	66.0	66.4	65.9	66.3
Fe_2O_3	0.05	0.09	0.12	0.05	0.07	0.06	0.06	0.08	0.05
TiO_2	0.05	0.07	0.09	0.11	0.13	0.10	0.13	0.12	0.11
Al_2O_3	0.19	0.27	0.37	0.20	0.35	0.40	<0.5	0.14	0.24
SiO_2	32.6	32.9	32.9	33.2	32.5	32.7	33.2	32.0	32.6
P_2O_5	0.08	0.12	0.11	0.10	0.09	0.09	0.08	–	0.11
U + Th (ppm)	280	333	389	440	440	150–330	400	450	400

Source: TZMI

In TZMI's view, the 32,000 tpa of GCP premium zircon:

- Will be the best quality premium zircon available globally.
- Has very low levels of Fe_2O_3, TiO_2 and Al_2O_3, which is favourable.
- Has among the lowest U + Th levels for commercial zircon sand at 280 ppm.

In TZMI's view, the 25,000 tpa of GCP intermediate zircon has:

- Fe_2O_3 levels (at 0.09%) are just above the levels required for a premium zircon classification.
- Very low levels of TiO_2 and a favourable Al_2O_3 content.
- The U + Th level at 333 ppm, while somewhat higher than for the GCP's premium zircon, will be below most other available zircon products from competitors. Premium-grade zircon from Iluka's mine in Virginia is lower, but TZMI forecasts that this mine will close in 2015, two years after the market entry of the GCP.
- TZMI's assessment is that if the intermediate product stream was mixed with the premium product, the combined tonnage could be classified as a premium zircon (Fe_2O_3 would be at the upper threshold for premium classification), and still remain "best-in-class" with respect to U + Th levels.

In TZMI's view, the 20,000 tpa of GCP standard zircon has:

- Fe_2O_3 content 0.12%, slightly higher than the intermediate product.
- 0.09% TiO_2 and 0.37% Al_2O_3. This TiO_2 level is very low by world standards and the Al_2O_3 is acceptable and lower than some large producers such as Tiwest.
- U + Th levels that remain lower than most competing products at 389 ppm.

In TZMI's view, the 2,500 tpa of GCP Secondary Zircon:

- Is a foundry product comparable to many other standard-grade zircons used for non-ceramic applications.

- Has U + Th levels at 440 ppm at the upper end of what is acceptable by end users and international transport regulations.

2.5.2 TZMI Recommended GCP Zircon Target Markets

Overall, the Grande Côte zircon products have very favourable specifications that are likely to afford the products a competitive advantage in the marketplace that should allow product differentiation and a targeted niche marketing strategy to be undertaken. The low levels of U + Th in the Grande Côte zircon will be the main favourable product differentiator relative to virtually all other products, for both existing producers and likely new projects.

The key opportunity for the GCP premium zircon would be sand millers in Europe, which have operations throughout the world, including Endeka Ceramics, the Colorobbia Group, Mario Pilato Blat in Spain, Helmut Kreutz in Germany and Eggerding in the Netherlands. Trebol in Mexico would be a target for the North American markets.

For the intermediate and standard zircon, there is a wide array of potential non-ceramic end use applications and consumers across a number of regions, for which the product specifications would be highly competitive against existing commercially available standard-grade products. These grades have also been approved for opacifier production in the ceramics industry in India. Given the forecast undersupply beyond 2013, TZMI expects the market will easily absorb the planned zircon output from the GCP and scope exists to market the products to a wide number of existing consumers.

2.6 Zircon Market Balance

2.6.1 Supply and Demand Dynamics Prior to the Global Economic Crisis

Over each 10-year period from 1970, there was a deficit of new zircon sources, yet zircon supply growth has varied (Table 2.5) due to:

- Reduction of dominance of the eastern Australian supply since the 1970s.
- Increase in production from Eneabba in 1970 and its subsequent decline.
- Increase in supply from South Africa from the late 1970s.
- Recent establishment of new operations in the Murray and Eucla Basins.

Prior to the Global Economic Crisis, Australia, South Africa and the US accounted for 82% of global zircon supply. During 2007 to 2008 there was an increase in production from China through the processing of imported non-magnetic concentrates from Kalimantan, Indonesia and Vietnam. However, current production from China has since decreased from the 2007 levels, due to access and production problems in Kalimantan. Growth in demand is being dominated by the ceramics sector in China. (Table 2.5).

Table 2.5 Demand By Sector and Region 1970–2020

Demand by sector	1970	1980	1990	2000	2010[f]	2020[f]
Ceramics	110	169	272	479	586	1,022
Refractories	110	205	190	165	131	150
Foundries	195	162	159	170	125	141
Chemicals	0	21	46	94	201	332
Other	45	54	48	92	42	44
Total	**460**	**611**	**715**	**999**	**1,085**	**1,689**
Demand by region						
Europe	160	222	300	359	241	305
North America	150	132	151	194	100	121
Japan	85	159	134	78	41	45
China	5	10	28	167	443	858
Other Asia-Pacific	30	49	51	125	156	212
Other	30	39	51	77	105	148
Total	**460**	**611**	**715**	**999**	**1,085**	**1,689**
% growth over decade		32.8%	17.0%	39.7%	8.6%	55.6%

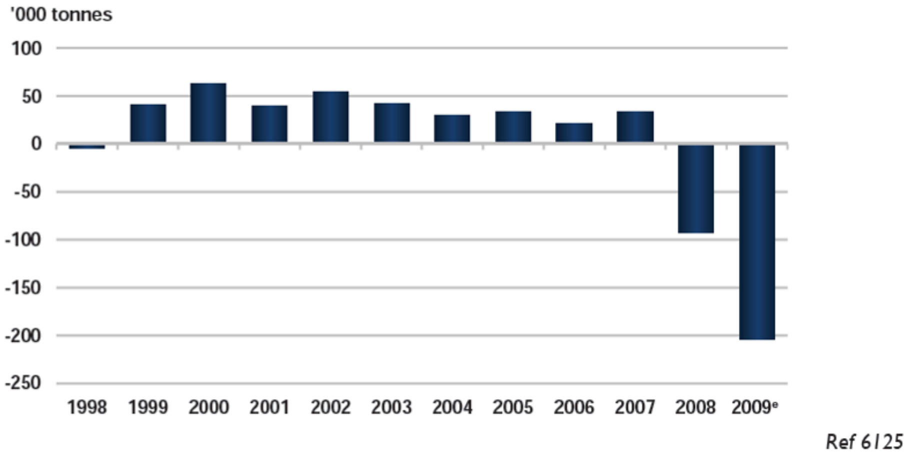
f = forecast

Source: TZMI 2009

2.6.2 Supply and Demand Dynamics in the Global Economic Crisis 2008–2009

For the period of 1980 to 2008, the average annual growth in production was 2.6%. TZMI estimates that the demand for zircon fell by 7.4% in 2008 in response to the Global Economic Crisis, equivalent to 2003 levels. This was the first year of consumption decline since 1998 (see Figure 2.10).

Figure 2.10 Year-on-year Consumption Growth, 1998–2009

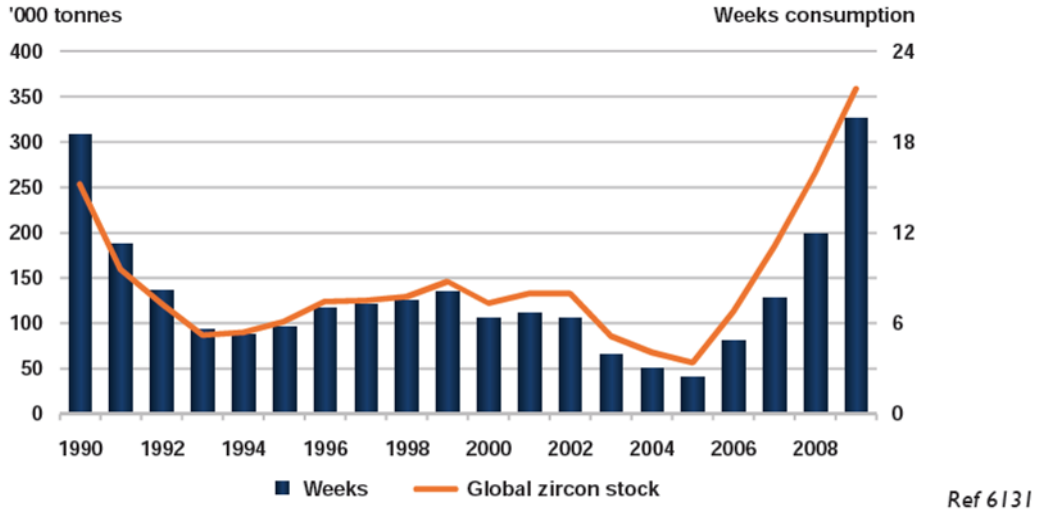


Source: TZMI 2009

TZMI estimates the annual global production of zircon for 2009 to be 14.9% down on 2008 as producers responded to decreasing demand by lowering production. Australia and Africa accounted for 73% of production.

In 2009, China and Europe accounted for 63% of total global zircon consumption (Table 2.5). Changing demand was also reflected by very low trade volumes in 2009. TZMI anticipates global inventory levels in 2009 will be the highest ever, due to decreased demand and in anticipation of the decline of Eneabba (see Figure 2.11).

Figure 2.11 Global Zircon Inventories, 1990–2009



©TZMI 2009 2009 = estimated

2.6.3 Supply and Demand Recovery and Forecasts to 2027

TZMI estimates that there is an overall known global zircon resource of 150M t. Six regions contain almost all of the known resources of zircon in the world, of which Australia accounts for 50.3% (see Table 2.6). Not all are in operation, approved for development; some have no immediate prospect for development.

Table 2.6 The Global Zircon Resources, by Country, End of 2008

	Resource Base	
Region	**million tonnes ZrO_2**	**million tonnes zircon**
Murray Basin - Australia	32.5	48.7
East Africa	25.7	38.5
Southern Asia	15.7	23.5
Western Australia	6.9	10.3
Eucla Basin - Australia	10.5	15.7
US Atlantic coastal plain	3.7	5.5
Other regions	5.0	7.4
World Total	**99.8**	**149.7**
Country		
Australia	50.3	75.4
India	12.7	19.1
South Africa	7.2	10.8
Mozambique	5.9	8.8
Madagascar	5.8	8.7
United States	3.7	5.5
Ukraine	3.1	4.6
Kenya	1.8	2.8
Other countries	9.3	13.9
World Total	**99.8**	**149.7**

Source: TZMI 2009

In terms of supply, with the exception of RBM, in the next decade, all of these operations will either maintain flat or declining production rates, or will cease production:

- Iluka's Mid West Eneabba deposit is due to cease in 2010.
- The Tiwest joint venture, Cooljarloo, is experiencing lower grades with production expected to halve over the next 10 years.
- Iluka's Old Hickory is expected to be exhausted in 2015.
- DuPont closed its Trail Ridge and Highland operations in 2008 due to declining grades and Maxville has a forecast for a reduced output until 2012.
- Iluka has scaled back its significant South West operations since 2007 due to adverse economics and production was suspended in 2009.
- KZN Sands, KwaZulu–Natal, expects to exhaust its Hillendale deposit by 2012 and will no longer develop the Fairbreeze deposit.
- CRL, North Stradbroke Island will move to a single dredge in 2012.
- Hainan Island is being pressured to undertake non-mining activities.

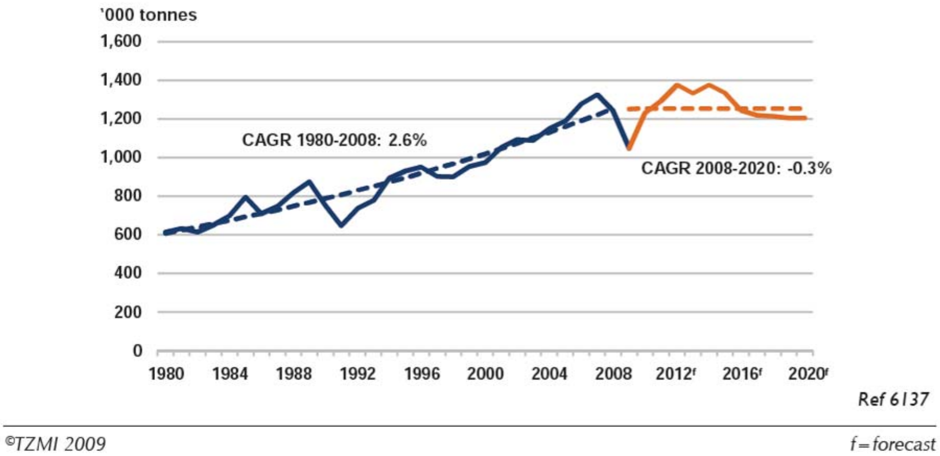
In terms of forecast supply, the total possible production from new projects and the extra production from Jacinth–Ambrosia will not enable sufficient growth in supply to meet anticipated demand. Table 2.7 shows the forecast production of zircon from known approved and potential projects. These are discussed in more depth in Appendix 2.1. TZMI concludes that not only is there a deficit of new zircon supply from future projects, but TiO_2 investment economics are weak. There is only a slim opportunity for additional zircon as titanium feedstock co-product credits, so significant supply deficits are anticipated from 2015.

Table 2.7 Approved and Potential Projects

			Additional Capacity		
Project	Country	Company	TiO_2 units pa 000	Zircon tpa 000	Earliest Start-up
Approved projects not yet commissioned					
Snapper	Australia	Bemax Resources	70	20	Q2 2010
RBM Tailings Plant	South Africa	Richards Bay Minerals	25	50	Q1 2011
			95	**70**	
Projects with completed technical feasibility studies					
Coburn Sands	Australia	Gunson Resources	66	40	2013
Tormin	South Africa	Mineral Commodities Ltd	8	40	2013
Keysbrook	Australia	Matilda Zircon Ltd	59	15	2013
Tamil Nadu	India	Tata Steel Ltd	294	28	2014
Kwale	Kenya	Tiomin Resources	246	40	2013
			673	**163**	
Projects under active investigation					
Donald	Australia – Murray Basin	Astron Ltd	122	86	2013
Moma Expansion	Mozambique	Kenmare Resources	270	30	2012
Xolobeni	South Africa	Mineral Commodities Ltd	155	15	2014
Grande Côte	Senegal	Mineral Deposits Ltd	330	85	2014
Athabasca Oil Sands	Canada	Titanium Corporation	NA	55	2014
			877	**271**	
Total projects not yet commissioned			**1,645**	**504**	

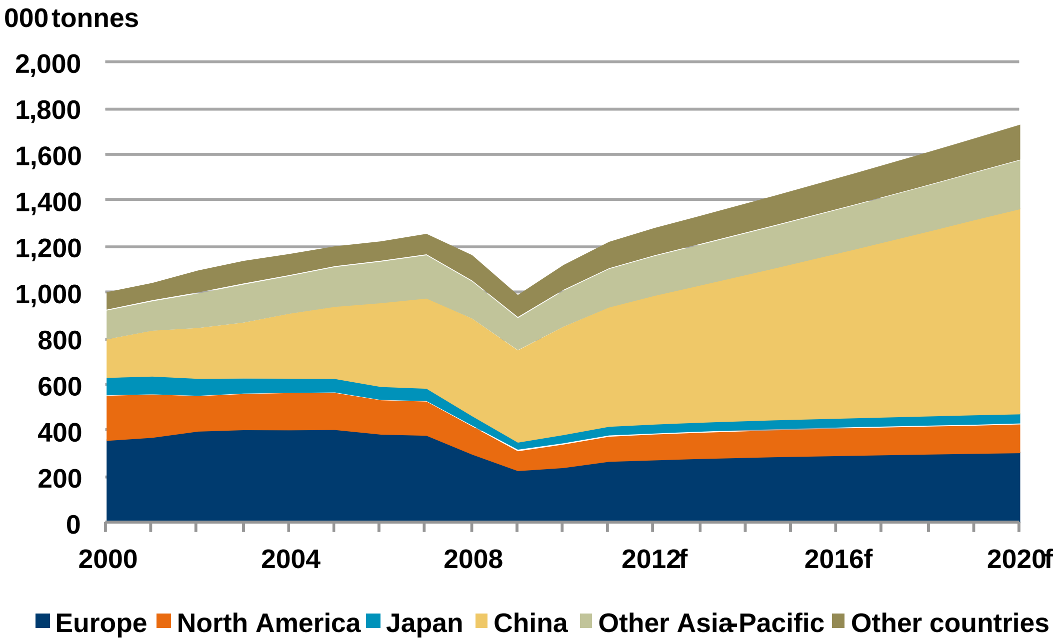
The greatest cause of uncertainty in the global zircon market has been with its supply, rather than demand, reflected by troughs in supply correlating to variations in production by the largest zircon producer, the Eneabba mine. The actual and projected production of zircon from 1980 to 2008, shown in Figure 2.12, illustrates an annual production growth rate of 2.6%. TZMI anticipates that the forecast annual production growth rate to 2020 will be flat as new projects offset the depletion of existing operations.

Figure 2.12 Actual and Projected Production of Zircon, 1980–2020



In TZMI's view, the Global Economic Crisis has altered the global market structure of zircon demand as each geographic region responds. Consequently, China's strong demand now dominates the market, with producers having to respond by shifting their marketing focus from Europe and North America to China, shown in Figure 2.13.

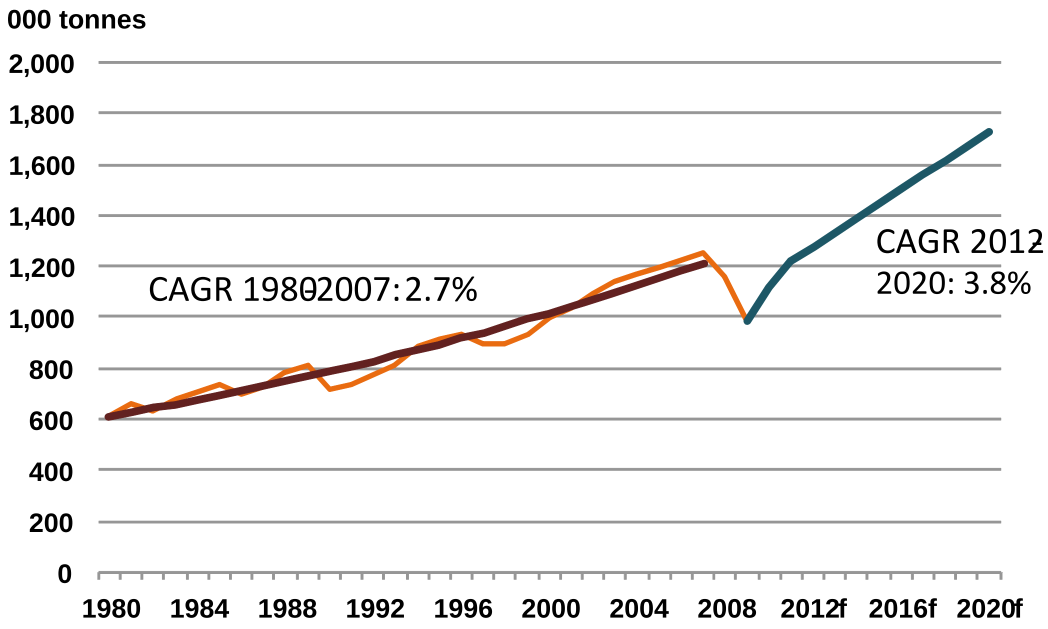
Figure 2.13 Global Zircon Demand by Region, 2000–2020



Source: TZMI 2009

Overall, the long-term demand picture is shown in Figure 2.14, with underlying demand for zircon climbing 1.8% from 1980 to 2015. From 2015 to 2020 the growth rate averages 3.7% per annum are expected.

Figure 2.14 Actual and Projected Zircon Demand, 1980–2020



Source: TZMI 2009

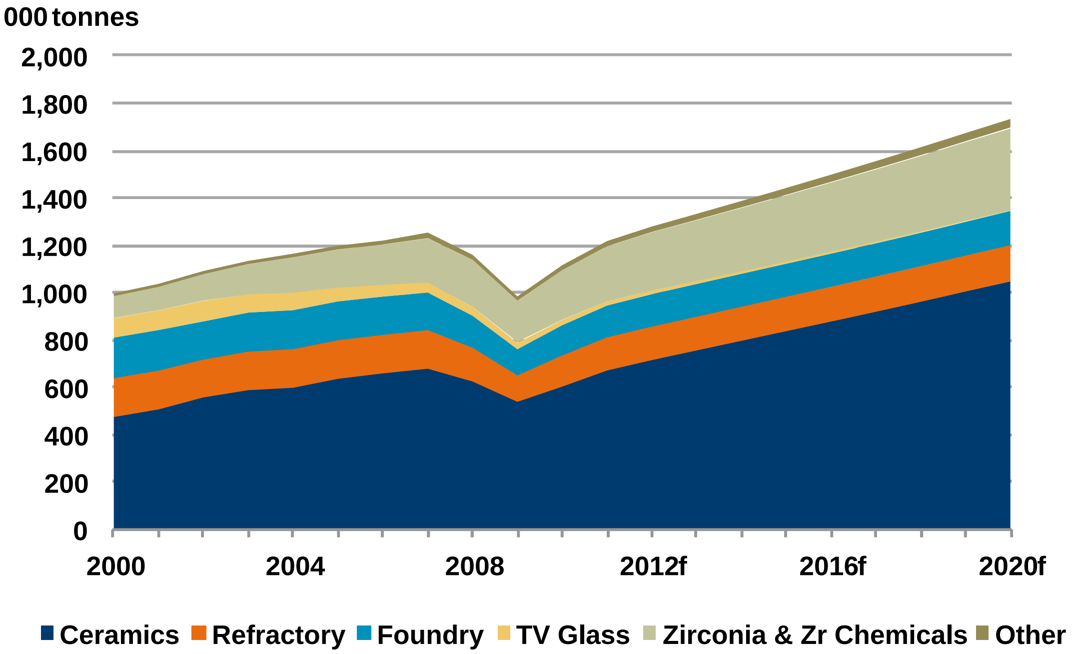
These actual and projected demand growth rates, in five-year periods, are shown in Table 2.8.

Table 2.8 Five-year Actual and Projected Demand Growth Rates, 1980–2020

	1980-1985	1985- 1990	1990-1995	1995- 2000	2000- 1005	2005- 2010	2010-2015	2015-2020
Average annual demand growth	3.8%	–0.6	5.2%	1.7%	3.7%	–2.0%	5.2%	3.7%

The ceramics industry is the major driver for zircon demand, accounting for 55% of global zircon consumption in 2009 and shown in Figure 2.15. Growth in zircon consumption will be determined by intensity of use in *gres porcellanato* tiles and the rate of urbanisation in China and India. TZMI's view is that a return to the demand levels seen in 2007 will be achieved by 2012 with an average demand growth of 6% per annum moving forward.

Figure 2.15 Global Zircon Demand by End Use Segment, 2000–2020



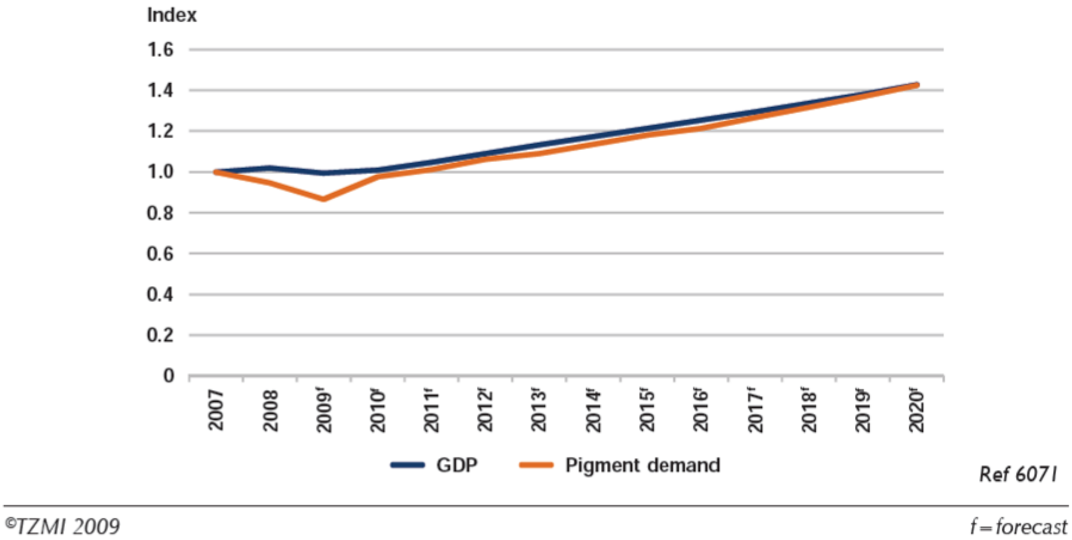
Source: TZMI 2009

For zircon sand in speciality chemicals a recovery in demand is expected of 11% to 2012 followed by an average growth rate of 4.4% to 2020. Zirconium metal for the nuclear industry and chemical zirconia for auto catalysts and the various technology-driven applications will drive growth.

The foundry, refractory and TV glass segments are expected to decline to 7% below current consumption levels by 2015. Most of the decrease comes from the TV glass segment. For the foundry and refractory segments, zircon demand will remain flat, although this masks differential growth prospects such as that in investment castings. Zircon refractory use in glass making and steel refractories is expected to recover by 2015, after which it should show modest growth for the balance of the forecast period.

The forecast growth of the TiO_2 pigment industry is also important as zircon has significant co-product contribution to this industry. Figure 2.16 shows projected global GDP against anticipated global TiO_2 demand to 2020. Titanium feedstock will be in short supply from 2013, requiring the expansion of existing operations or new projects from 2013 to 2020, which would bring with it some co-product zircon.

Figure 2.16 TiO_2 Pigment Consumption and GDP Outlook to 2020

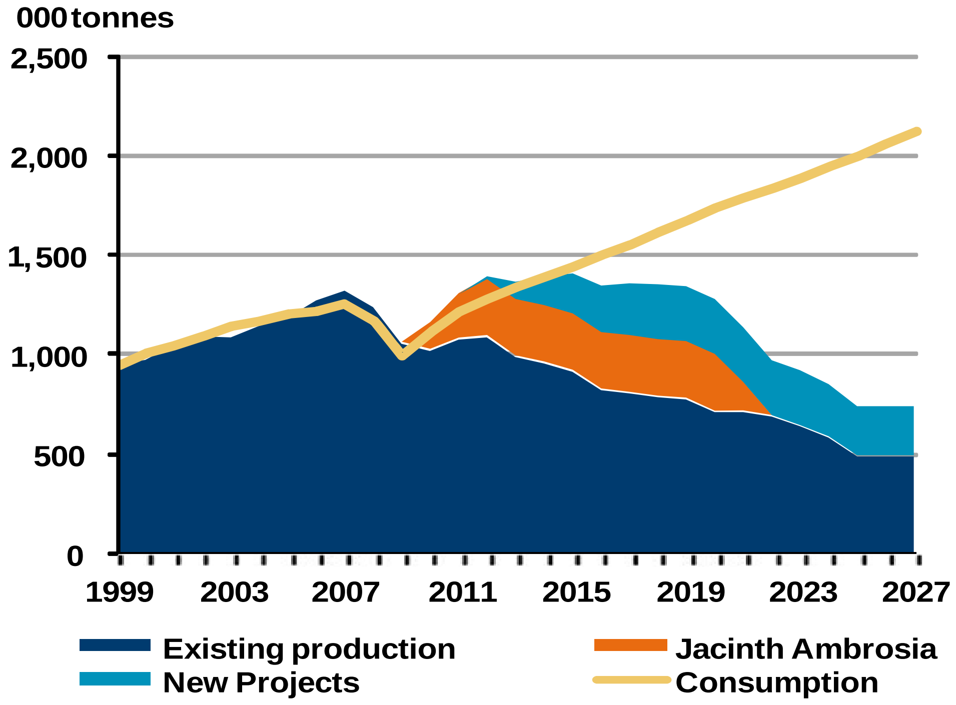


The TZMI forecast of global market supply and demand to 2027 is shown in Figure 2.17.

The key features of this forecast include:

- **2010–2012:** Characterised by high inventory levels and surplus supply. This production–consumption gap remains as demand recovers through 2010 to 2011 and producers are anticipated to manage production to prevent excessive stock.
- **2012–2015:** A transitional period of market production–consumption balance with an additional 110,000 tpa from new projects by 2015. A situation of tight supply is expected as adverse economics have delayed the establishment or expansion of some projects.
- **2015–2020:** Global supply decreasing as demand is increasing. The existing projects such as Iluka's Jacinth–Ambrosia and Murray Basin 2 will not supply enough zircon to maintain supply growth. Additional supply from new projects will need to be entering the market to offset declines from current operations. A widening deficit in supply is anticipated as existing operations reduce production or cease. According to TZMI, significant new sources of zircon are needed but not enough have been identified or sufficiently developed.

Figure 2.17 TZMI Base Case Global Zircon Supply and Demand to 2027



Source: TZMI 2009

2.7 Zircon Price Trends and Forecasts

The pricing of zircon products varies according to the level of impurities and the particle size distribution. Most zircon sold as "premium-grade" infers a standard appropriate to the ceramics industry with 0.08% Fe and <0.15% TiO_2. However, there are no internationally defined quality parameters, so a range of quality products are marketed under this label.

The price differential between premium and standard grades can fluctuate widely. For example, when the market is adequately supplied, the differential is generally lessened as consumers are more able to select a suitable quality product. Generally, in a balanced market, the non-premium zircon grades have sold for 10% less than premium-grade, equivalent to US$35 to US$50/t FOB.

2.7.1 Factors Influencing Zircon Prices

The pricing and forecasting of pricing for zircon is considered complex due to a number of factors, including:

- Recent observed fluctuations associated with the Global Economic Crisis.
- Downward price pressure on titanium feedstock resulting in a decrease in the total revenue for the titanium feedstock industry. This may result in producers seeking

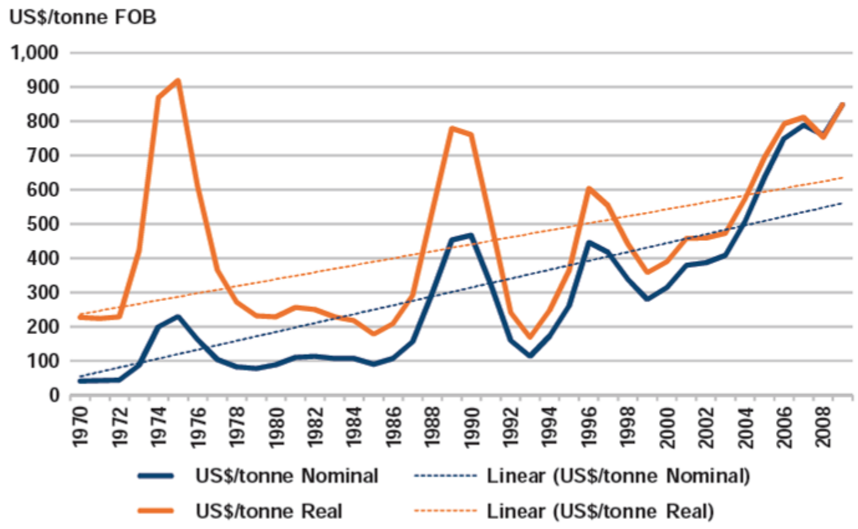
greater revenue from zircon co-product, with co-product revenue for 2009 titanium feedstock operations already a record 49%.

- The anticipated overall level of demand, with the ceramics sector the largest consumer and having the largest influence on demand pricing.
- Market supply and demand, with a range of views on the timing and magnitude of new projects, and moderated production seen from the Eucla Basin.
- The significant rate of demand growth in China.
- Overall economic activity influencing demand and therefore price.
- Opportunistic pricing policies at times of supply uncertainty, with the high rate of recently attained prices forming precedents for future pricing strategies.
- The ability of zircon sand millers in the opacifier industry to pass on zircon sand price increases to customers.
- Exchange rate fluctuations.
- Packaging and volume of shipments.
- Geographic location impacting on freight charges.
- Potential for thrifting-of-use of zircon by consumers, resulting in responsibly moderated price curves as opposed to spikes. Substitution potential can act to cap prices, although TZMI believes that this risk is now low for zircon.

2.7.2 Long-Term Trends in Zircon Prices

Australia is the largest exporter of zircon and Australian export statistics provide reliable long-term price data from 1970 to 2009 Figure 2.18.

Figure 2.18 Australian FOB Bulk Zircon Prices US$, 1970–2009



Ref 6141

Source: TZMI 2009

The graph in Figure 2.18 should be viewed in two parts:

- History up to the Asian Currency Crisis around 1998–99. The growth rate trend line was 2.5% per annum when refractories and foundries dominated the end use market.
- The most recent 10-year history, which demonstrates, for the first time, a 10-year period of sustained growth in the zircon market. From the mid-1990s, annual zircon consumption growth was 4%, driven by growth in global ceramic production, Chinese industrialisation and growth in the zirconium chemicals sector.

The price spikes and fluctuations experienced in the period up to 1998–99 had in common disruption to the supply/demand balance due to major new mining capacity being brought into production, such as Eneabba and Richards Bay in the later 1970s; Eneabba West, Tiwest and a major expansion announced by Richards Bay around the end of the 1980s, and the Namakwa mine in the mid-1990s:

- Spike of 1974 to 1975: Occurred after years of low zircon prices and quadrupled global oil prices, triggered by strong demand from the Japanese refractory sector:
  - Zircon production overcompensation when supply shortage was suspected.
  - The price spike encouraged increased production from the new mines at Eneabba and Richards Bay, resulting in stockpiling and 10 years of low, stable prices from 1976 to 1987.
  - The foundry sector experienced irreversible reduction in minor technical applications where zircon was being used for its previously low price rather than its technical merit.
- Spike of 1989 to1990: Also coincided with a global boom in commodity prices:
  - Increased demand growth in the US encouraging capacity expansions.
  - Progressive overstocking fuelled by unfounded fears of a supply shortage.
  - Stronger efforts by Australian producers to increase prices to offset the decline of the Australian dollar against the US dollar.
  - The acquisition in 1985 of Allied Eneabba by RGC Mineral Sands Ltd (RGC), reducing excessive price competition.
  - Increases in speculative activity, opportunistic pricing by smaller producers resulting in large price differentials between bagged and bulk product.
  - Substitution had occurred in some end uses, particularly in the Japanese refractory sector. However, this was a technically based substitution in favour of alumina spinels, led by Nippon Steel to avoid silica disassociation at high temperatures, which was causing problems with the final steel product quality. This substitution was not a reaction to zircon price, although the subsequent higher prices may have accelerated the speed of the technical substitution that had been underway since 1987.
  - New zircon mining capacity was announced, including the new Eneabba West mine, the Tiwest mine and Richards Bay.

  - Eventually, the supply/demand balance shifted in favour of buyers. The extent of previous overstocking in was apparent and consumers held back physical buying of zircon while negotiating for lower prices.

- In the 1998 to 1999 price spike, surplus stock was placing pressure on small producers to sell to manage cash-flows. The growing European ceramics industry experienced a shift in the supply/demand balance as Namakwa Sands commissioned a large zircon mine in the mid-1990s and exacerbated by the Asian Currency Crisis.

- The period after 1999 had the benefit of consumers with a high level of dependency on the technical merits of zircon. This was also a period of high growth in China as well as other countries. As a result, this 10-year period established a solid history of price growth, notwithstanding some adverse events that occurred during that period, including:

  - Some continuing reduction in per unit zircon consumption associated with thrifting-of-use and the contraction in TV glass business.

  - Expansion of zircon production using non-magnetic concentrates produced in Kalimantan, Indonesia. This caused a rapid increase in zircon entering the market for final processing in China. However, this production fell quickly due to resource depletion and access problems.

  - The Global Financial Crisis.

  - Commissioning of some very large mines, including Iluka's Murray Basin (Stage 1 and Stage 2), Bemax in the Murray Basin and Iluka's very large mine in the Eucla Basin.

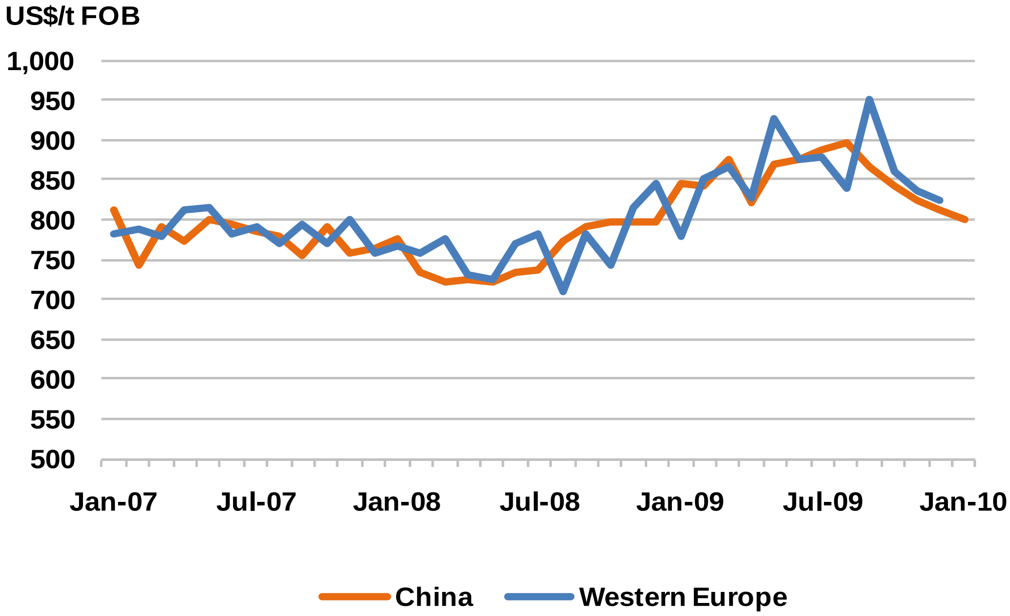
These events were significant and, had they occurred in previous years, a collapse in the zircon price would have been likely. However, the modern market has demonstrated its strength by absorbing these issues to record a sustained upward trend in price over the last 10 years.

TZMI report that Iluka's new mine in the Eucla Basin, which was thought to have potential to cause a slump in the zircon market, is now a valued source of supply to underpin the market during the process of transition into a time of structural deficits in supply/demand.

2.7.3 Zircon Price Trends for 2008 to 2027

In the first half of 2009 producers built inventory rather than drop prices in response to the decreased demand because of the GEC. Zircon sand prices ranged between US$850 to US$1,000/t FOB, with a premium of up to US$100/t observed between premium-grade and standard-grade products. The weaker end of the spectrum reflected competition by suppliers for market share in China, rather than Europe (Figure 2.19).

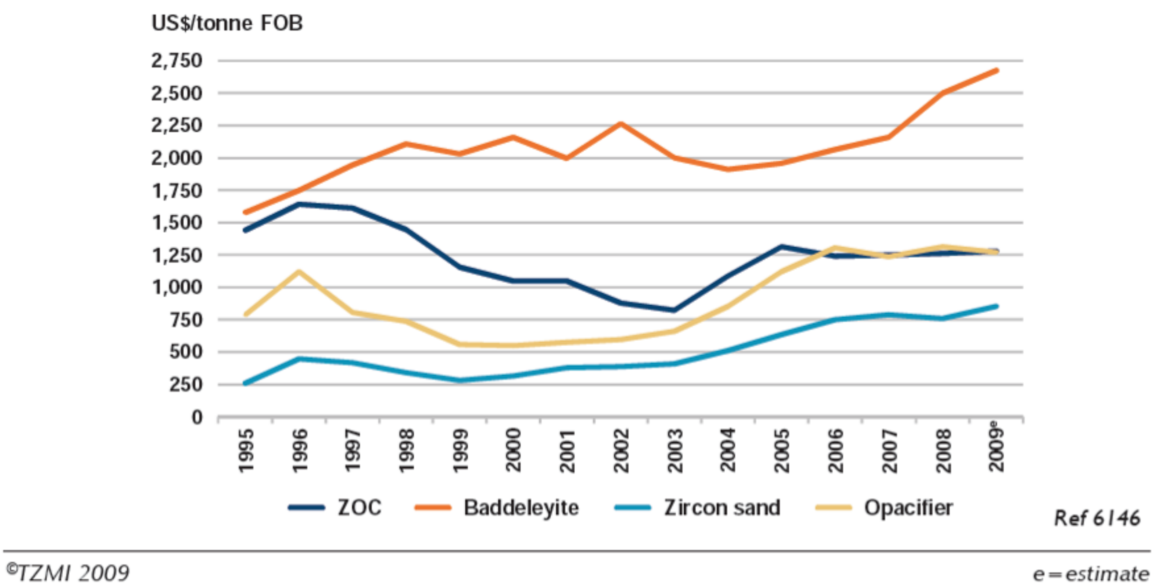
Figure 2.19 Zircon Import Prices for Western Europe and China, 2007–2010



Source: TZMI 2009

The demand for zircon by various end uses is influenced by the prices of the intermediate processed zirconium chemical, zirconia or milled zircon such as opacifier (see Figure 2.20). Opacifier prices are expected to mirror zircon sand price changes heading towards 2020.

Figure 2.20 FOB Prices for Selected Zircon Products, 1995–2009



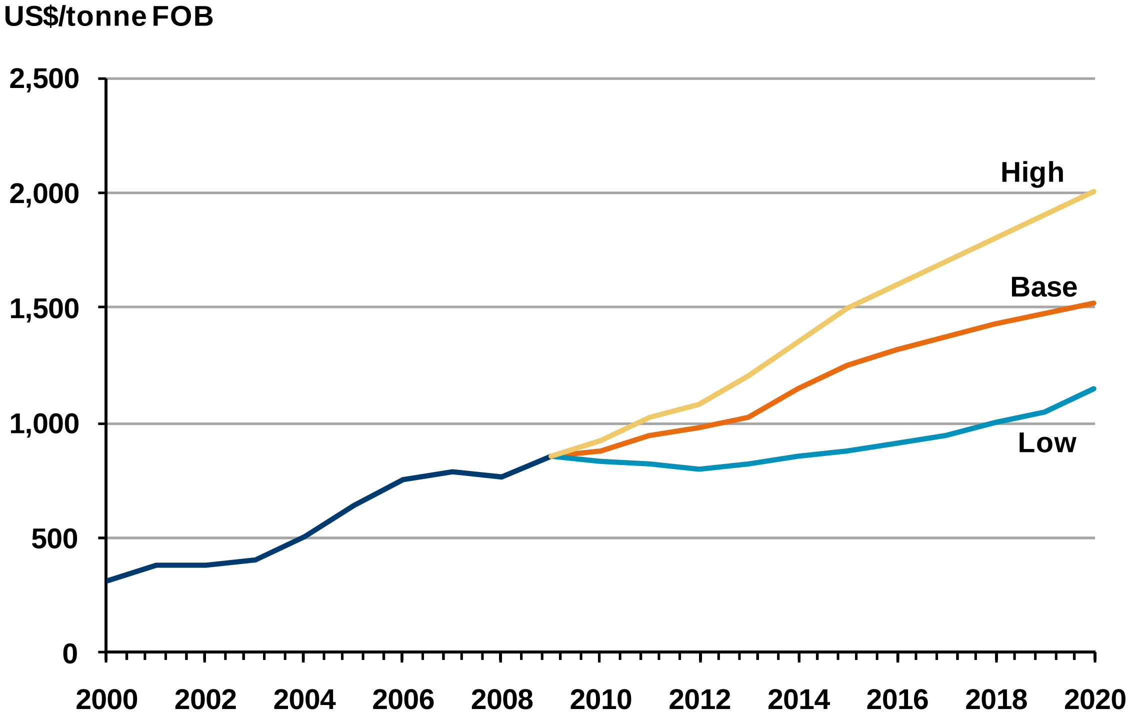
TZMI expects that the zircon sand price will increase throughout 2010, determined by the pace of recovery of China and, to a lesser extent, Europe. A global average price of

US$875/t FOB is expected for 2010. Moderate price increases are expected in 2011 and 2012 as producers manage supply to meet demand.

Beyond 2012, steady price increases are forecast due to pending supply deficit felt from 2014. Many new projects will not be viable unless zircon prices are over US$1,000/t FOB.

Overall, in TZMI's view, zircon sand prices can be expected to rise to US$1,000/t FOB and above in future and their three scenarios estimate a window of two to six years in which this may occur, shown in Figure 2.21. TZMI's average, bulk forecast prices are provided in real dollars in Table 2.9.

Figure 2.21 Annual Nominal US$ Zircon Prices, 1970–2015



Source: TZMI 2009

Table 2.9 TZMI Forecast Average Zircon Prices

Product	US$ Real 2009 Prices (FOB/t)			
TZMI bulk average $ FOB	2013f	2014f	2015f	Post 2015
Bulk premium zircon	928	1,023	1,088	1,150

2.8 MDL Zircon Marketing Strategy

MDL's marketing objective is to optimise the sales mix, thereby improving the overall weighted average sales price for GCP zircon products.

This will be achieved by having a wide customer base and a sales mix based entirely on small lot sales by container shipments. This enables the sale of zircon into a range of niche markets, establishing price competition, as consumers will have varying capacities to pay and appetites for more tonnage.

To support this approach and generate leverage for price settlements, all off-take agreements are structured to be negotiated at the same time. This enables negotiating methods to vary in response to current market conditions. Price determinations will depend on the ability to negotiate a price settlement that extracts fair commercial value from the various customers close to the final timing of shipments.

In addition, MDL expects to achieve premium prices through targeted product differentiation for selected end use markets, leveraging off a number of product and project benefits.

2.8.1 GCP Market Window

A number of factors are considered to be advantageous to the GCP, creating a favourable market window for zircon GCP and creating a strong negotiating position:

- High product quality as noted in Section 2.2.3, such as:
  - Good chemistry, which has particular relevance in niche markets. For example, the zirconia and electro-fused refractory sectors do not require the Fe_2O_3 levels to be as low.
  - GCP zircon exceeds the quality of South African zircon, and competitors such as Namakwa are unable to meet demand. For example, Namakwa Sands has a high-quality premium-grade zircon, which contains about 400 ppm U + Th, compared to 244 ppm U + Th in the GCP premium-grade zircon. Namakwa's product is fully contracted, demonstrating a demand window for the high-quality product.
  - GCP zircon has particularly low U + Th, similar to the better grades out of Florida and the Ukraine, which are forecast by TZMI to decline in production.
  - Good sizing, which allows efficiency of grinding in the production of opacifier and flour as it reduces power consumption.
- Access to a range of global markets at a critical time:
  - A strategic proximity advantage to those headquartered in Europe, such as the ceramics and milling sectors. Europe and North America provide a clear logistics benefit over the large distant suppliers from Australia, but also from the large suppliers in South Africa. In 2008, Europe imported 382,000 t of zircon sand and North America imported 51,000 t.
  - GCP enters the market in 2013 with an annual production of 80,000 t, TZMI estimates a reduction in domestic zircon production of 115,000 tpa over the period 2012 to 2015. 30,000 t of this reduction will be in Europe and 85,000 t will be in USA. TZMI also estimates that world zircon consumption will grow at an average of around 60,000 tpa over that same period.

  - A strategic proximity advantage to Brazil: Brazil has significant presence in the ceramics industry and growth potential. It is currently the second largest tile producing country in the world and the second largest importer of tiles. Brazil's domestic mines currently supply about 26,000 t of moderate quality zircon sand and it imports about 17,000 t annually. TZMI forecasts that the Mataraca mine in Brazil, which currently produces 23,000 tpa of zircon, will stop production in 2015. Market growth is anticipated due to the development of the *gres porcellanato* tile sector and urbanisation when Brazil hosts the World Cup in 2014 and the Olympic Games in 2016.
  - Access to other spot markets in growing regions, such as India and China.
  - China is a valuable back-up market, particularly for GCP's small tonnage of foundry-grade zircon and for the intermediate-grade and standard-grade products in niche markets, such as fused products.
- Faster container shipments from Dakar to Europe:
  - Container shipments can be organised in weekly or fortnightly deliveries spread evenly over the year. The timing and quantity of deliveries by way of bulk shipment from more distant suppliers takes a long time to organise and is dependent on availability.
  - Just in Time Inventories can be serviced as extra tonnage can be supplied quickly for consumers who experience unexpected new business or to protect against an unexpected stock shortage. For example, shipping times to Western Europe from Dakar are 10 days compared to 31 from Australia or 25 from South Africa.
  - Inventory reductions for consumers. Container shipments can operate in regular shipments of 100 t to 200 t. Storage and handling needs and inventory levels are therefore lower, which is advantageous to consumers under internal pressure to keep inventories down.
  - Statistics for Australian bulk shipments represent average prices for different product grades and also constrained pricing arrangements by Iluka for its large customers. These arrangements need not apply to smaller blocks of business as is the case with container shipments.
- Cheaper freight rates for container shipments:
  - Freight charges for containers range from 3% to 10% of the CIF price over major shipping routes. Whereas bulk shipment freight costs from Australia have been up to US$40 to US$60/t higher. In some market conditions it has been difficult to secure a vessel at all, even at a higher cost.
  - Container shipment rates are held valid for 6 or 12 months whereas bulk shipments can be negotiated on a vessel-by-vessel basis.
  - Freight cost will be cheaper compared to other major producers as they are driven by operating costs, corresponding to the length of the voyage. Dakar offers a long-term benefit to Europe with 25 days less steaming time.
- Port advantages for container shipments from Dakar:

- The Port of Dakar services a number of nearby developing markets as well as Senegal itself.
- The container service into the Port of Dakar has a level of imports that far exceeds the level of available exports. Between 2006 and 2008, approximately 102,000 containers per year were returned from Dakar, empty.
- GCP offers new export business to Senegal to fill containers. The GCP requires approximately 5,000 containers per year. This will enable negotiation of a good freight rate on containers that were otherwise shipped empty.

• Market attraction of the GCP:

- Large market size: The annual production from the GCP at about 7% of current world production makes this a mine of international significance. It will have a very large production of high-quality zircon, which will place GCP in position to negotiate for sustainable high price premiums.
- Long mine life: The “in excess” of 20-year projected mine life enables development of long-term customer relationships.
- The GCP will be entering the market at a time of forecast emerging market supply deficits, coinciding with the closure of a number of domestic operations in the GCP’s nearby markets. This will result in the removal of approximately 115,000 tpa from this region, coinciding with reduced availability of high-quality zircon.
- While there are other mineral sands mines under development as noted in Table 2.7, potential exists for further price increases because of slower than expected development, hence supply.
- Many buyers have a preference to widen the supply base and decrease the influence over supply from a few key producers.

• Price negotiation advantages:

- The negotiation process for zircon has no formal reference points such as the London Metal Exchange in the case of non-ferrous metals and a forecast of tight supply can be advantageous therefore for spot price premiums.
- Unfavourable mineral economics, coupled with increasing operating and capital costs will continue to place upward price pressure on zircon product. In periods of market tightness, price premiums of several hundreds of dollars have historically been achieved over the average Australian prices for bulk shipments effectively set by the dominant Iluka by companies such as RZM and those in the Ukraine. This can be expected to continue moving into the forecast supply deficit.

2.8.2 MDL’s Price Premium Strategy

MDL’s opinion, supported by TZMI, is that the future tight market zircon will see a widening in price premiums that will exceed the premium levels experienced in the past, particularly for high-quality grades of zircon.

MDL believes that the commercial benefits outlined above will position them to negotiate price premiums for GCP zircon of approximately US$200/t above TZMI price forecast levels. This is based on TZMI's assessment that a price premium of US$200 is realistic for the GCP zircon over prevailing market prices in any given year based on:

- A favourable freight differential for the European and US markets: The US market is supplied from domestic sources, and this situation has resulted in US prices being upwards of US$100 to US$200/t higher than in other regional markets reflecting domestic advantages on freight and handling costs. After 2015, US domestic supply will be largely depleted and all of GCP zircon could be absorbed in the US market alone, attaining a freight differential alone of US$25/t FOB over competitors.
- The low levels of U + Th for all Grande Côte zircon: TZMI's informal discussions with selected customers suggested that low U + Th zircon products could command in the region of US$50 to US$75/t price premiums in future, as many new sources of zircon have radionuclide levels approaching the upper threshold. The GCP zircon would also meet previous high product quality specifications once met by domestic US supply.
- Niche marketing with shipments via bulk-in-container: In TZMI's view niche marketing strategies have been adopted successfully by other companies such as Tiwest in Australia enabling them to achieve average zircon prices of US$75 to US$100/t above the annual average for premium zircon.

TZMI's forecast prices are for average Australian prices for bulk shipments expressed in US$/t FOB. This compares with the anticipated prices for GCP zircon as shown in Table 2.10.

Table 2.10 Annual Forecast Price for GCP Zircon

Product	**US$ Real 2009 Prices (FOB/t)**			
TZMI Bulk Average $ FOB	**2013f**	**2014f**	**2015f**	**Post 2015**
TZMI bulk premium zircon	928	1,023	1,088	1,150
GCP project evaluation $ FOB				
GCP zircon (average for all products)	1,130	1,225	1,300	1,350

2.8.3 Contracts Status

MDL has a number of sales contracts in place. The contract terms and conditions for the larger buyers relate to premium-grade zircon and, to a lesser extent, intermediate-grade zircon.

MDL has effectively oversold its zircon product, intending to manage these quantities downward. One buyer has agreed to all the terms and conditions for a 15,000 tpa supply on the understanding that the project is currently fully committed and that this draft arrangement is a standby arrangement and not a sales commitment.

Final signing of the contracts is to be delayed until closer to sale to enable product testing and to ensure optimisation of the initial sales mix, such as allowing small-lot sales into areas such as India and China and creating buyer interest at the time of price negotiation.

Contracts have been prepared to enable MDL to retain the flexibility to respond to changing market dynamics by repositioning its tonnage when necessary.

2.8.4 Structure of Zircon Contracts

The terms and conditions of sale to larger buyers are as follows:

- **Confidentiality:** All contracts are protected by secrecy agreements.
- **Contract duration:** Contracts are for a fixed initial period of three years (minimum) with evergreen intent. After the first initial period, the contracts automatically extend to maintain an ongoing contract period of three years. These roll-over provisions will apply throughout the life of the mine. However, either party has the right to terminate the contract at the end of each contract period, subject to 12 months notice.
- **Credit risk/working capital:** Contracts are with high-quality buyers with no perceived credit risk who have assisted in further reducing credit risk by:
  - Paying FOB, whereas the norm in industry is for the buyer to pay CIF and the seller to cover freight and insurances.
  - Paying with a line of credit, whereas the norm in industry is payment by electronic funds transfer.
  - Paying 30 days after the bill of lading, whereas the norm for long-term business in Europe is 90 days.
- **Special provisions with large buyers:** One buyer has first investment rights if expansion of project occurs or extra quantities become available for sale. Another buyer has agreed to a standby arrangement to 15,000 tpa on the understanding that the project is already overcommitted.
- **Annual contract tonnages:** The final tonnages to be delivered will be agreed closer to the time of shipment, generally in the last quarter of the year preceding shipment. Tonnages agreed in the years of production ramp-up and beyond are sufficient to cover the expected production for each of these years.
- **Production ramp-up tonnages:** Rateable tonnage reductions apply to the contract tonnages in the years of ramp-up of production to ensure volumes are within the capacity of the mine to deliver.
- **Prices:** Prices are to be agreed every three or six months or for any agreed longer period. Price agreements are protected by a detailed price resolution process.
- **Governing law:** The UK law, mediation and arbitration applies. The Seller is protected by force majeure provisions.
- **Contract positions:** Smaller tonnage and higher price contract positions are also in place, covered by general conditions of sale. Short-term contracts of sale covering tonnage and price will be agreed closer to the time of sale. The terms of the general conditions are strict with payment by irrevocable letter of credit.

2.9 Titanium Feedstock Product

2.9.1 Overview

The mineral sands industry supplies titanium (Ti) raw materials and titanium feedstock for the production of titanium dioxide (TiO_2) pigment and titanium metal. The main commercial supply of titanium raw materials is ilmenite, rutile and leucoxene.

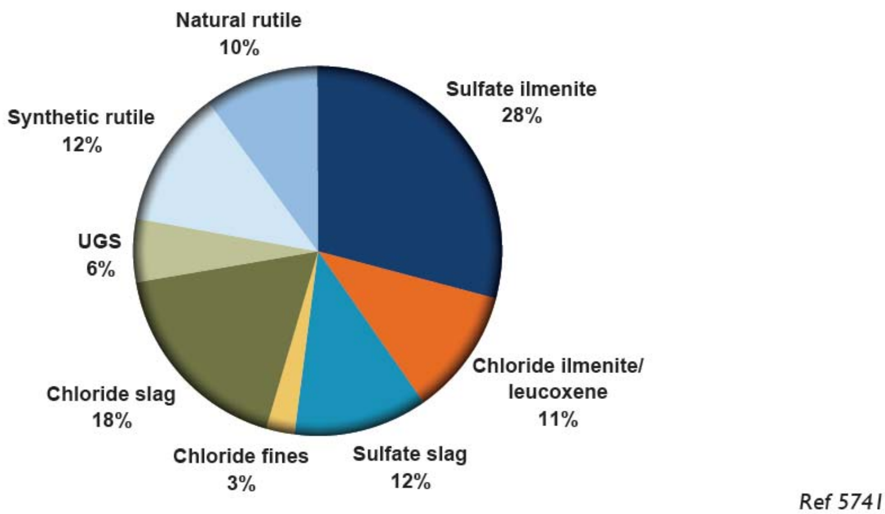
The majority of titanium feedstock producers mine heavy minerals (HM) in alluvial environments by dredging beach sands, although significant production of ilmenite also comes from mining “hard rock” deposits, mainly in Canada, Norway and China. Ilmenite is frequently upgraded from these deposits into synthetic rutile (SR) and titanium slag. These industries supplement the revenue derived from TiO_2 feedstock, generally with the sale of zircon and, in some cases, with the sale of pig iron. Zircon and pig iron have been traditionally regarded as by-products of the industry but have become more commercially significant over recent years and are now regarded as co-products.

Titanium feedstock consists of:

- Ilmenite, which is the most abundant titanium mineral. It theoretically contains 52.7% TiO_2 but this varies in naturally occurring deposits from 35% to 65%. Ilmenite containing high levels of TiO_2 and greater proportions of digestible, ferrous iron (FeO) than ferric iron (Fe_2O_3) is referred to as chloride ilmenite, as it lends itself to a chloride-based processing method known as the chloride process, discussed below. Alternatively, ilmenite containing slightly less TiO_2 and with more undigestible ferric iron is referred to as sulphate ilmenite, requiring a sulphuric acid-based processing method known as the sulphide process.
- Leucoxene, an oxidised and altered mineral of ilmenite, can contain 65% to 90% TiO_2. The weathering process results in the removal of iron from the mineral, effectively upgrading the TiO_2 content. Leucoxene is often used as a feedstock for the chloride process in pigment manufacture and in the welding electrode market, competing against rutile, SR and chloride slag.
- Rutile, which in its natural theoretical state is composed of 100% TiO_2, but due to impurities can contain 94% to 96% TiO_2. Natural rutile is ideal for use in the chloride process to produce TiO_2 pigment.
- Synthetic rutile (SR, or upgraded ilmenite [UGI]), which has been developed to address the limited availability of very highly concentrated titanium products. Commercial beneficiation removes contaminating iron oxides from ilmenite in a rotary kiln, to produce more concentrated TiO_2 products known as synthetic rutile (SR), upgraded ilmenite (UGI) and titanium slag. SR competes in all high-grade feedstock markets against rutile, such as the pigment and titanium sponge/metal markets.
- Titanium slag, which is made by smelting ilmenite in a furnace under reducing conditions to separate the high-purity pig iron from a molten slag of TiO_2. The composition of the slag and pig iron is highly dependent on the composition of the ilmenite and can be referred to as sulphate or chloride slag, accordingly.

The proportions of the different titanium feedstock produced globally in 2008 are shown in Figure 2.22.

Figure 2.22 Global Titanium Feedstock Production by Type, 2008



Source: TZMI 2009

Ninety three per cent of titanium feedstock produced is used to make titanium pigment (TiO_2 pigment). This pigment is used in paints and papers as it is a good opacifier, making brilliant whites and hiding tonal variations and colours.

Titanium minerals also exhibit high dispersion, an ability to separate light into component parts, and are therefore highly effective in the absorption of ultraviolet radiation and used in sunscreens to protect against UV-induced skin damage. Other uses of titanium feedstock include the manufacture of titanium metal, inert fluxes for welding electrodes, chemicals, vitreous enamels, catalysts, glass and electro-ceramic products.

The GCP will produce the following titanium products:

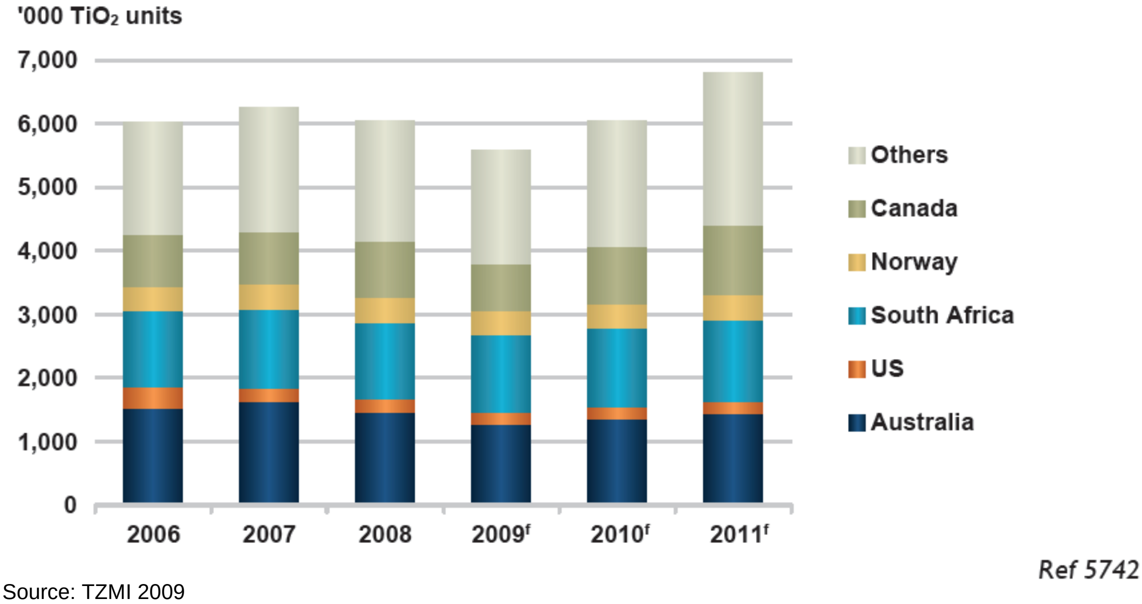
- Approximately 575,000 t of ilmenite, beginning in mid-2013. The GCP will produce 53% TiO_2 sulphate ilmenite for use as a blended feedstock for sulphate process pigment manufacture and a 58% to 60% TiO_2 chloride ilmenite for use in chloride process pigment manufacture, synthetic rutile (SR) or chloride slag production. Alternatively, a single 55% TiO_2 ilmenite product can be produced. Technical evaluations conducted by CSIRO and customers have established that this ilmenite can be used for standard-grade synthetic rutile manufacture.
- Approximately 6,000 t of rutile. GCP rutile is a premium product that will be directed mainly to the premium paying welding markets.
- Approximately 11,000 t of leucoxene. GCP leucoxene will predominantly be directed to the premium paying welding electrode sector.

2.10 The Titanium Feedstock Industry

2.10.1 Overview

The titanium feedstock industry is dominated by five producers, which accounted for 62% of the total ore mined in 2008; three by dredge and two using dry mining. Only 2% of total production was from hard rock deposits. Australia is and has been the largest producer of feedstock, accounting for 24% of global supply and South Africa is the second largest producer, with a 20% market share, shown in Figure 2.23.

Figure 2.23 Titanium Feedstock Production by Country, 2006–2011



Source: TZMI 2009

Titanium mineral consumption over the last 30 years has been geographically dominated by North America, Europe and Japan. Annual growth in these mature markets is only 2%. Alternatively, growth opportunities of 6% to 9% are being experienced this decade in developing regions such as China and India due to urbanisation and industrialisation.

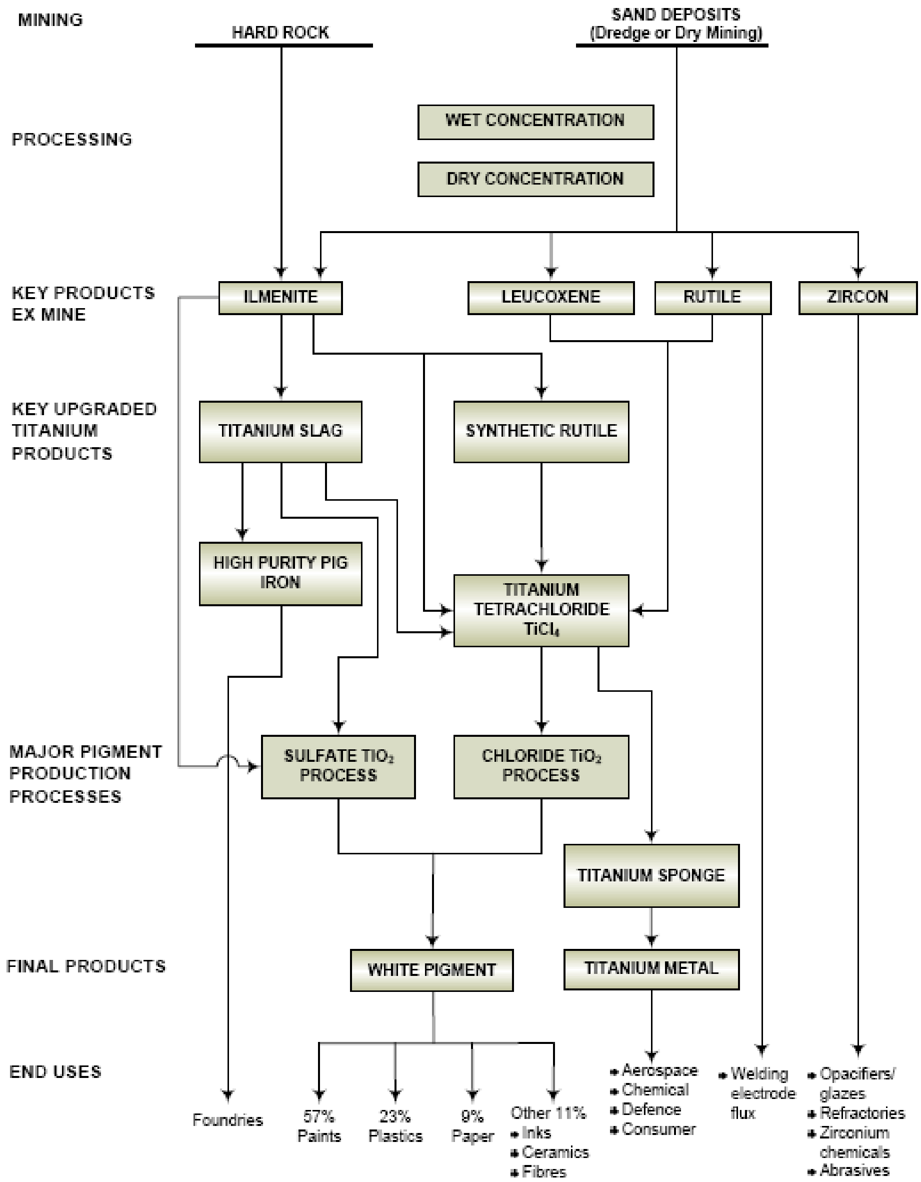
TZMI anticipates that titanium feedstock consumption demand is expected to grow at 3.4% overall, 4% per annum for sulphate ilmenite, 12% for chloride ilmenite and 4.4% for rutile towards 2027 in the face of a widening supply deficit.

2.10.2 Titanium Feedstock Production and Processing

Mineral sand deposits typically contain 1% to 15% heavy mineral (HM) but have been known to contain up to 40% HM. The HM concentrate (HMC) produced from the wet concentration process contains 90% to 98% HM.

This is transported to a mineral separation plant (MSP) where, as shown in Figure 2.24, the various mineral components are separated using magnetic, electrostatic and gravity techniques, or even froth flotation, according to their different physical properties into a variety of end use products.

Figure 2.24 Titanium Feedstock Processing into a Range of End Uses



Source: TZMI 2009

2.10.3 Titanium Feedstock End Uses

Titanium feedstock has a number of diverse applications, many of which represent important quality of life and industrial uses. The various end use markets have been categorised as follows:

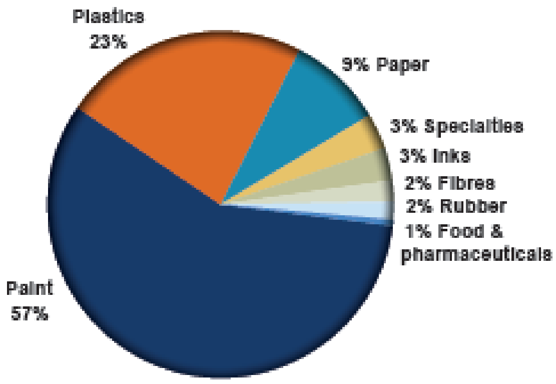
- TiO_2 pigments.
- Titanium metal.
- Titanium other uses.

2.10.3.1 TiO_2 Pigment

In 2008, the use of TiO_2 pigment in paints accounted for 57% of total TiO_2 pigment consumption.

Titanium minerals are ideal for the production of brilliant white pigments used in paints, plastics, paper and foods as they have high refractive indices and fine crystal grain sizes providing a large surface area to reflect light, and are chemically inert. They are also used as architectural applications, industrial coatings and for other specialty uses, as shown in Figure 2.25.

Figure 2.25 Global Pigment Consumption, 2008



Source: TZMI 2009

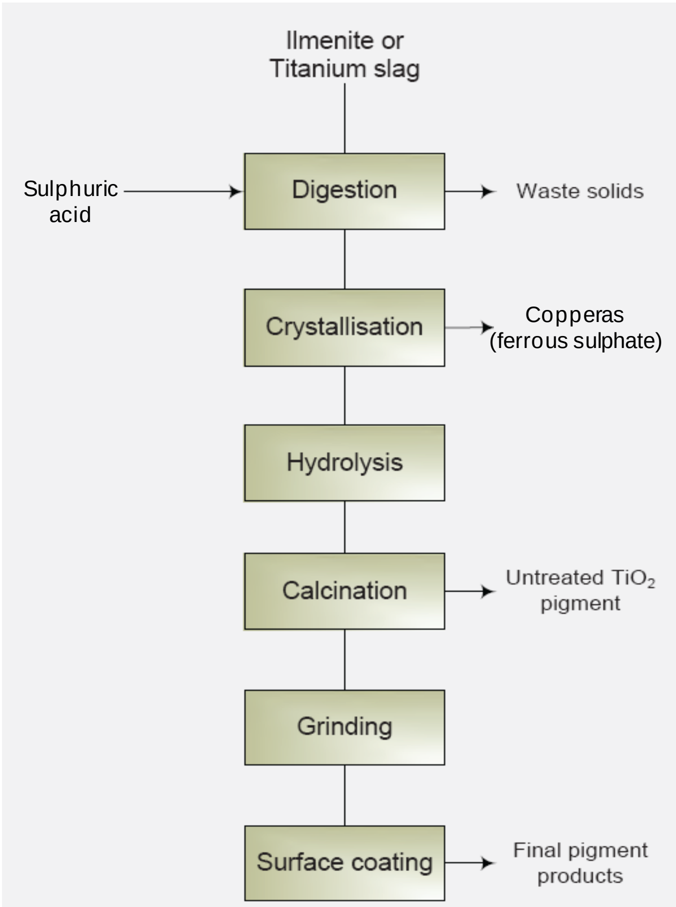
Production of TiO_2 pigment is achieved by one of two processes, each using different quantities and types of raw materials and producing different wastes.

The sulphate process, as shown in Figure 2.26:

- Uses ilmenite or titanium slag as raw products.
- Feedstock is digested in 85% to 92% sulphuric acid (H_2SO_4) at 150°C to 180°C.
- Insoluble silica or zircon residues are removed using precipitation techniques.
- To remove the ferric iron impurities, scrap iron is added to encourage conversion to ferrous iron then extracted by cooling and crystallisation. This produces ferrous sulphate (copperas), often sold as a by-product.
- Hydrolysis is performed to produce hydrous titanium dioxide. The composition of solution and speed of crystal growth determine the particle size and pigment properties.
- Sulphuric acid is used to remove any impurities from the crystals.

- The crystals are calcinated in a rotary kiln at 900°C to 1,250°C, producing rutile or anatase-quality TiO_2 pigment.
- This high-quality TiO_2 pigment is milled, surface treated and bagged.
- Higher volumes of acidic waste, which are processed for acid recovery or as saleable products in preference to disposal.

Figure 2.26 The Sulphate Process

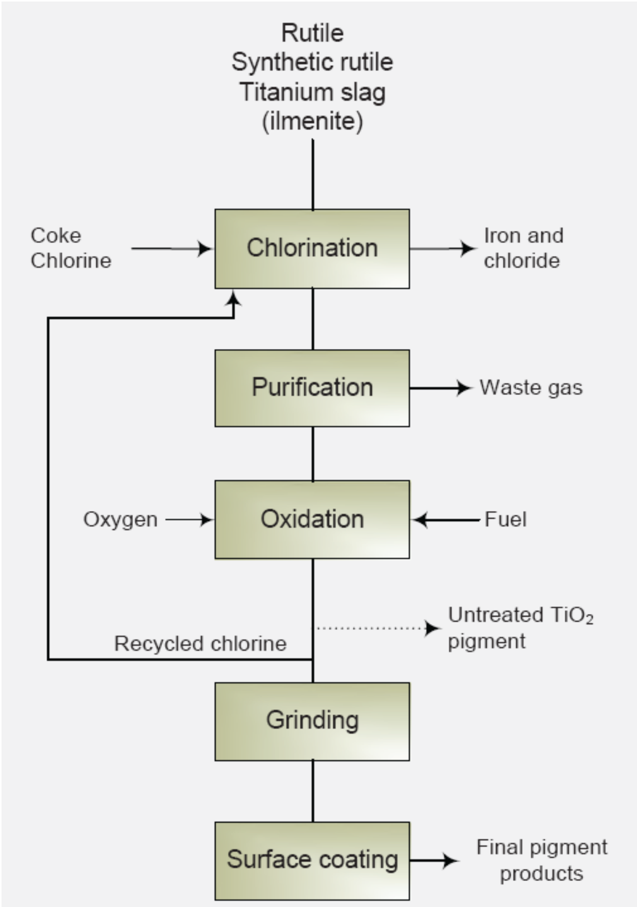


The chloride process, as shown in Figure 2.27:

- Uses high-TiO_2 feedstock such as titanium slag, upgraded slag, synthetic or natural rutile as raw products.
- Only DuPont has the technology to chlorinate ilmenite, although this lower-grade feedstock generates more waste as it contains more impurities.
- The feedstock is chlorinated in fluidised bed reactors at 850ºC to 950ºC to produce volatile titanium tetrachloride ($TiCl_4$), and chlorides of other impurities.
- Cooling and distillation enables the removal of the chloride impurities.
- Purified $TiCl_4$ is oxidised at high temperatures to displace chlorine and form TiO_2. The chlorine is recycled for use in the chlorination step.

- The rutile-grade TiO_2 pigment is milled, surface treated and bagged.
- Iron chlorides and hydrochloric acid (HCl) are waste products that are disposed of in deep wells or through the development of co-product markets.
- This process is technologically difficult with intellectual property on processing tightly held and high capital costs.

Figure 2.27 The Chloride Process

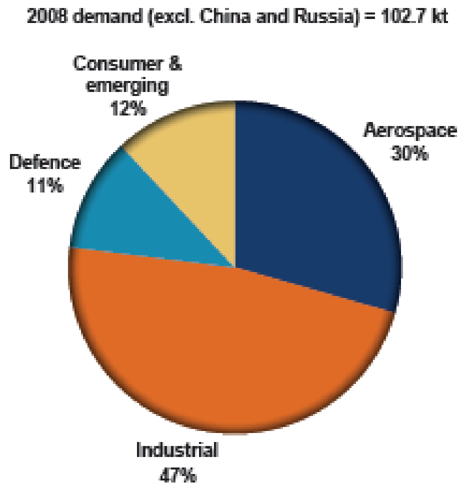


2.10.3.2 Titanium Metal

The titanium metal end use is the second largest market for titanium feedstock, accounting for 5% of total feedstock consumption. Titanium feedstock is processed into titanium sponge, the most basic form of refined titanium metal, which is then used to make titanium metal.

Titanium metal has a high strength-to-weight ratio, a high melting temperature and is resistant to corrosion. As such, it is ideal for use in a range of applications such as airframe construction, jet engines or in highly corrosive chemical processing environments, such as desalination plants. Usage is shown in Figure 2.28.

Figure 2.28 Global Titanium Metal Consumption, 2008



Source: TZMI 2009

Titanium sponge is formed by the reduction of titanium tetrachloride ($TiCl_4$) with magnesium (the Kroll Process) or with sodium (the Hunter Process) and is purified to ingots.

The major producers of titanium sponge are in the US and Japan, which purchase raw materials such as rutile, UGS or high TiO_2 synthetic rutile as feedstock. Producers in Russia, Kazakhstan and the Ukraine use ilmenite to produce a slag, then a molten salt process to produce $TiCl_4$.

In 2008, titanium sponge production in the US and Canada declined. However, Chinese annual production of titanium sponge grew rapidly from 2005 to 2008 exceeding 23%, with a further 11% in 2008. Chinese growth is attributed to:

- A number of new plants built in 2005 and 2006 in anticipation of high prices.
- China becoming a net exporter of sponge, exporting 6,300 t in 2008.
- Growth in production of sponge in China, mirrored by that of milled titanium metal products in 2008 at 17.3%.

The key drivers of titanium metal demand include:

- Production cut-backs and build-up of sponge inventories due to the GEC.
- Delays or cancellations of such projects in the short term due to weakening oil and gas prices.
- Consumer markets, such as medical and automobile, will only experience moderate growth unless titanium becomes more cost competitive.
- Strong growth from the commercial aircraft sector.

As the titanium metal industry is relatively small, it is not expected to have a significant influence on the global titanium feedstock demand over this period.

2.10.3.3 Other End Uses

The ‘other uses’ end sector accounted for 6% of global titanium feedstock use in 2008, across a range of applications, including:

- **Welding electrode flux:** Rutile is the dominant material sold in the welding electrode flux sector at 33% of the global rutile market in 2008. However, some leucoxene and ilmenite are also consumed in these end sectors.
- **Metallurgical flux:** For metallurgical flux, the quality of titanium materials used depends on the nature of the welding process, the materials to be welded and the desired characteristics of the join. Consistent particle size and chemical composition is important, requiring silica, alumina and alkaline earth oxides with very low levels of phosphorous, sulphur and moisture. As such, leucoxene can be undesirable for the high-quality end of this sector because of its lower grade and sometimes varied composition. According to TZMI, the emergence of new welding technologies and metal alloys will eventually lead to a reduction in the amount of rutile used in welding fluxes.
- **Sandblasting and drilling muds:** Lower-quality titanium feedstock is suitable for smelting operations for iron and steel production, as a medium for sandblasting and as a component in drilling muds.

2.11 Titanium Feedstock Market Product Quality Specification

The various end uses of titanium feedstock require feedstock of different specification. These are discussed below.

2.11.1 Quality Specifications for TiO_2 Pigment Production

Production of TiO_2 pigment is achieved by a sulphate or chloride process, each requiring different feedstock and each being sensitive to different minor contaminants.

2.11.1.1 The Sulphate Process Quality Specifications

The feedstocks considered suitable for the sulphate process are:

- Sulphate-grade ilmenite.
- Sulphate-grade slag.
- Chloride slag fines.

The chemical specifications preferred by sulphate-grade titanium feedstock consumers for the sulphate processing method are:

- Easily digestible feedstock; the iron in the feedstock must be predominantly in the ferrous (FeO) rather than ferric (Fe_2O_3) state to react with sulphuric acid.
- Low levels of chromium (Cr_2O_3), <0.05%, and vanadium (V_2O_5), <0.3%, as these remain in the product and cause discolouration of the pigment.
- Low levels of U + Th to minimise the radioactive contamination of waste streams.

- Low levels of niobium (Nb_2O_5) as it causes crystal lattice defects. Some prefer Nb_2O_5 below 0.05%, but at 0.1% to 0.2% its blue colour can hide other contaminants.
- A phosphate (P_2O_5) level below 0.2% as more phosphate is added before calcination to help with crystal growth.
- Low levels of silica (SiO_2), zircon (ZrO_2), alumina (Al_2O_3) to reduce inert waste.
- Low levels of toxic elements or heavy metals such as lead, arsenic, chromium, manganese, vanadium are required for pigments used in food and to decrease contamination of waste streams.
- Grain size is not important, as sulphate producers grind the feedstock to 15 microns to increase the surface area before acid digestion.

2.11.1.2 The Chloride Process Quality Specifications

Higher TiO_2 feedstock is considered suitable for the chloride process, such as:

- Chloride-grade ilmenite.
- Leucoxene.
- Rutile.
- Chloride-grade slag.
- Upgraded slag (UGS).
- Synthetic rutile.

The chemical specifications preferred by chloride-grade titanium feedstock consumers for the chloride processing method are:

- Higher TiO_2 content to minimise the production of ferric chloride wastes.
- Low levels (<1.0%) of alkalis, calcium (CaO), magnesium (MgO) and manganese (MnO) to avoid forming high-boiling-point chlorides.
- Low levels of U + Th to minimise the radioactive contamination of waste streams.
- Alumina levels <1.0%, as greater levels can cause capacity constraints in chlorination.
- Particle size greater than 100 microns is generally preferred for effective chlorination.
- For feedstock used to make titanium sponge, levels of tin (SnO_2) need to be below 0.05%, as it can make titanium metals brittle, although some sponge producers specify a maximum threshold of 0.1% SnO_2.
- For welding electrodes, sulphur (S) contents are required below 0.03%.

DuPont is the only company with the technology to use ilmenite for the chloride process as it can dispose of increased volumes of ferric chloride waste.

The surface of the pigments that are produced by either method are treated to modify their physical and optical properties to suit different applications. Combinations of aluminium, silicon, zircon and titanium oxides are precipitated onto the surface of the particle, dried, micronised and bagged.

2.11.2 Rutile Production Quality Specifications

Rutile as a feedstock also has industry preferred chemical specifications:

- Premium-grade rutile is understood by the market to contain >95% TiO_2.
- Low levels of iron oxide (Fe_2O_3), as the rust is a contaminant.
- Low levels of silica (SiO_2) and zircon (ZrO_2), <1% of each, to reduce inert waste.

Rutile is considered a feedstock suitable for titanium sponge manufacture due to the low level of metal impurities in the sponge. Alternatively, some sponge producers use ilmenite to produce a slag, which is then used to make the sponge. These businesses can use feedstock with higher calcium and magnesium levels.

In welding electrode flux, the most important quality requirement is particle size distribution. Rutile and leucoxene are considered suitable feedstock but low levels of phosphorous, sulphur and heavy metals are essential.

2.12 GCP Titanium Feedstock Product Quality

The various titanium products that will be produced by GCP have potential to supply a range of identified market sectors. The chemistry and sizing of the various GCP products also have relevance in important niche markets.

2.12.1 GCP Sulphate Ilmenite (53% TiO_2) Product Quality

The typical composition of GCP sulphate ilmenite is shown in Table 2.11, compared to current suppliers.

Table 2.11 Grand Côte Sulphate Ilmenite Compared to Competing Products

Constituent	Grande Côte %	Tellnes %	Bemax WA %	Iluka Capel %	CRL %	Moma Ilmenite %	Vietnam Ilmenite %	IRE Orissa %
TiO_2	53.20	44.30	54.10	54.00	50.70	52.40	52.00	50.20
FeO	18.90	34.00	17.00	13.00	25–29	21.40	31.10	34.10
Fe_2O_3	23.30	12.50	20.00	27.00	16–19	27.90	11.60	12.80
$FeO{:}Fe_2O_3$	0.81	2.70	0.85	0.50	1.50	0.95	2.70	2.70
Al_2O_3	0.55	0.60	1.03	0.50	0.45	0.47	0.30	0.60
CaO	0.01	0.28	0.02	0.02	0.02	0.02	–	–
Cr_2O_3	0.16	0.08	0.05	0.05	0.30	0.09	0.05	0.05
MgO	0.61	4.12	0.20	–	0.85	0.30	–	0.60
MnO	1.02	0.25	1.60	1.40	1.30	1.40	2.00	0.55
Nb_2O_5	0.08	0.01	–	0.16	0.05	–	–	–
P_2O_5	0.04	0.02	0.05	0.04	–	0.02	0.04	0.03
SiO_2	0.55	2.55	1.00	0.60	0.44	0.30	0.70	0.80
V_2O_5	0.25	0.20	0.16	0.16	0.22	0.16	0.15	0.24
ZrO_2	0.09	na	0.20	–	0.12	–	–	0.01
U + Th (ppm)	76	3	>100	>100	<20	70	75	–

After reviewing the GCP sulphate ilmenite specification, TZMI comments that the product:

- Has fairly high TiO_2 at 52%, acceptable FeO and Fe_2O_3 content and generally, relatively low levels of other impurities hence is suitable for sulphate pigment manufacture.
- Has relatively high Cr_2O_3 and V_2O_5 and would result in poor colour performance of final pigments. The ilmenite would need to be blended to lower the Cr_2O_3 content if it is to be utilised as a feedstock for sulphate pigment manufacture.

2.12.2 GCP Chloride Ilmenite (58% TiO_2) Product Quality

The typical composition of GCP chloride ilmenite is shown in Table 2.12, compared to current suppliers.

Table 2.12 Grand Côte Chloride Ilmenite Compared to Competing Products

Constituent	Grande Côte Chloride %	Iluka Eneabba %	IRE Q Grade %	Tiwest %	Vilnohirsk %	Moma High TiO_2 Ilmenite
TiO_2	58.6	60.0	60.0	61.0	64.0	58.0
FeO		4.3	9.7	3.6	–	–
Fe_2O_3 (T)	36.2	28.8	25.5	32.5	26.0	32.5
Al_2O_3	1.01	0.7	1.1	1.1	2.8	0.76
CaO	0.02	0.01	–	0.02	–	0.01
Cr_2O_3	0.28	0.18	0.13	0.11	1.2	0.30
MgO	0.44	0.15	0.60	0.23	0.48	0.36
MnO	1.08	1.1	0.40	1.06	0.8	1.55
Nb_2O_5	0.10	0.17	–	0.16	–	na
P_2O_5	0.08	0.03	0.20	0.14	0.12	0.07
SiO_2	0.79	0.8	0.90	0.85	1.8	0.60
V_2O_5	0.22	0.16	0.15	0.18	0.19	0.07
ZrO_2	0.10	0.15	0.40	0.25	0.3	0.25
U + Th (ppm)	149	<470	–	160	<100	150

After reviewing the GCP chloride ilmenite specifications, TZMI comments that the product:

- Has a TiO_2 content of 58.6%, making it acceptable for slag manufacture and in the lower end of the acceptable range for direct chlorination or SR use. Further testwork is occurring with a view to producing a product, with TiO_2 closer to 60%.
- Has relatively low levels of other impurities, although Cr_2O_3 and V_2O_5 are higher than comparable products.

2.12.3 GCP Rutile Product Quality

The typical composition of GCP rutile is shown in Table 2.13, compared to current suppliers.

Table 2.13 Grand Côte Rutile Compared to Competing Products

Analysis	Grande Côte Rutile	CRL Rutile	Iluka Eneabba	RBM Rutile	Namakwa Rutile	Tiwest Rutile
TiO_2	95.7	95.5	95.5	93.3	94.5	95.8
Fe_2O_3	0.51	0.53	0.9	0.7	0.8	0.94
Al_2O_3	0.50	0.25	0.3	0.9	0.6	0.27
CaO	0.01	0.02	0.01	0.10	0.04	<0.02
Cr_2O_3	0.12	0.14	0.15	0.11	0.14	0.15
MgO	0.01	0.04	0.03	0.06	0.03	0.02
MnO	0.01	–	0.01	0.01	<0.01	0.01
Nb_2O_5	0.31	0.40	0.35	0.30	0.4	0.34
P_2O_5	0.02	0.02	0.02	0.03	0.04	<0.02
SiO_2	1.24	0.90	0.8	2.0	2.0	0.60
V_2O_5	0.21	0.60	0.55	0.4	0.33	0.43
SnO_2	0.03–0.04	0.01	–	–	0.2	<0.02
ZrO_2	0.70	0.80	0.95	1.3	1.2	0.92
S as SO_3	0.03	<0.05	<0.05	<0.05	< 0.05	<0.05
U + Th (ppm)	80	70	100	100	105	90
d_{50} (μm)	95–100	110	170	125	130	170

After reviewing the GCP rutile specifications, TZMI comments that the product:

- Meets the industry standard of a ‘premium’-grade rutile with TiO_2 above 95% at 95.7%. Generally producers tend to maximise output by adjusting mineral recoveries to achieve a TiO_2 content just above the industry standard of 95%.
- Has acceptable levels of the other impurities, with SiO_2 content slightly elevated and U + Th levels favourably low.
- Has a d_{50} of 95–100 microns, which is slightly finer than competing products.
- Has SnO_2 levels of 0.03–0.04%, which is below the stated maximum for use as a feedstock in titanium sponge (metal) production. SnO_2 levels >0.05% make titanium metal products brittle.

2.12.4 GCP Leucoxene Product Quality

The typical composition for leucoxene is shown in Table 2.14, compared to current suppliers.

Table 2.14 Grand Côte Leucoxene Compared to Competing Products

Analysis (%)	Indicative Grand Côte	Iluka HyTi 91	Bemax	Tiwest
TiO_2	89.9	91.5	90.0	92.8
Fe_2O_3	1.8	3.0	2.3	4.0
Al_2O_3	1.7	0.9	–	0.7
CaO	0.03	0.03	–	–
Cr_2O_3	0.66	0.12	–	0.2
MgO	0.05	–	–	–
MnO	0.03	0.1	–	0.04
Nb_2O_5	0.40	0.37	–	0.4
P_2O_5	0.17	0.09	0.09	0.06
SiO_2	2.83	1.3	2.5	0.6
V_2O_5	0.16	0.35		0.35
ZrO_2	0.93	1.4	2.3	0.4
U + Th (ppm)	360	–	170–390	170

After reviewing the GCP leucoxene specifications, TZMI comments that the product:

- Has a lower TiO_2 level, 90%, than the main competing commercial products, which will not impact on end use.
- Has acceptable levels of other impurities, with ZrO_2 and V_2O_5, lower and Al_2O_3, Cr_2O_3 and P_2O_5 levels higher than comparable products.
- Has a d_{50} of 105 microns, which is slightly finer than competing products.

2.13 TZMI Recommended GCP Titanium Feedstock Target Markets

2.13.1 GCP Sulphate Ilmenite (53% TiO_2)

This 53% TiO_2 ilmenite can be used in the production of titanium slag. The production of slag using the chloride process can generate the production of fines in feedstock with particle size less <100 microns. This accounts for 10% to 15% of total slag production, which is alternatively directed into the sulphate route process. This 53% TiO_2 ilmenite can be used in the production of chloride route titanium slag but the Cr_2O_3 content in particular will be important in the product quality of these fines and would require some blending with some other ilmenite to achieve the correct average final product quality.

The 53% TiO_2 ilmenite can be sold directly for sulphate route slag or as a direct feed for the production of TiO_2 pigment by the sulphate route process.

The key opportunity for GCP ilmenite for the sulphate pigment industry is as a blended feedstock, which is a common practice in the industry, for the growing Chinese market. This is in a similar manner to Australia's CRL, which has sold 200,000 tpa of high-Cr_2O_3 ilmenite as a blend for many years, despite having approximately twice the chromium content of Grand Côte ilmenite, shown in Table 2.15. Bemax has also sold significant quantities of ilmenite from its Murray Basin operations, which have Cr_2O_3 levels reported at two to three times the level of CRL.

In addition, Trimex, Moma and Kwale represent approved and likely new projects, which also have high chromium contents of 0.07–0.09% above the desired threshold and, as a consequence, are also targeted to the Chinese market. Moma also has a much higher Fe_2O_3 level, which is undesirable for the manufacture of TiO_2 pigment via the sulphate route process.

TZMI has assessed the Chinese companies that form the core of the sector and recommends a range of priority markets for Grand Côte sulphate ilmenite, shown in Table 2.15 and more details can be found in Appendix 2.1. These companies are considered more technologically progressive, with some experience in blending feedstock, and have capability to absorb higher chromium supply. The secondary targets are larger companies whose processing is less sensitive to product quality.

Table 2.15 Recommended Target Companies for Grand Côte Sulphate Ilmenite

Priority Target Companies	Remarks	Secondary Target Companies	Remarks
Billions	Progressive, uses feedstock blends	Xingmao	Relatively large second-tier producer
Lomon	Progressive, uses feedstock blends	Annada	Potentially large producer
Nanjing	Progressive, advanced technology	Jiangsu	Progressive producer
Pangang	Progressive, uses feedstock blends	Dahua	Potentially large producer
Zibo	Progressive, uses feedstock blends	Xingzhong	Potentially relatively large second-tier producer
Xinfu	Large producer	Hainan	Potentially relatively large second-tier producer
Jinan	Progressive, advanced technology		
Tianguang	Progressive, advanced technology		
Seastar	Large producer		
Jiahua	New entrant looking for feedstock supply		
TCC	New entrant looking for feedstock supply		

TZMI is of the view that given over 50% of the forecast incremental growth in pigment demand will be realised by the sulphate process. Therefore, there is “significant potential” to market sulphate ilmenite to China.

2.13.2 GCP Chloride Ilmenite (58% TiO_2)

The GCP Chloride ilmenite at 58% TiO_2 can be used for direct chlorination to produce pigment. DuPont dominates global purchases under long-term contract. While it is the obvious customer for the Grande Côte chloride ilmenite, alternatives to pigment use will be sought to ensure a competitive pricing environment for the GCP product.

Grand Côte chloride ilmenite is suitable as a chloride slag feedstock, at the maximum cut-off for calcium (CaO) alkali content at 0.2%. TZMI tests, shown in Appendix 2.1 confirm its suitability as for chloride slag for RTIT at Sorel in Canada, as a possible blend feed from Rio Tinto’s Madagascar Operation. It may, however, result in a higher than desirable P_2O_5 content in the pig iron by-product, which would be addressed by additional processing.

The Grande Côte chloride ilmenite could be utilised as a feedstock for SR production, particularly in Western Australia, where existing resources of the necessary quality ilmenite are being depleted rapidly. Technical evaluations conducted by CSIRO and TZMI have established that the GCP ilmenite is suitable for this purpose (see Appendix 6.8).

Given the forecasts of substantial supply deficits for chloride-grade ilmenite, TZMI expects sale of the total volume of GCP's planned ilmenite production.

2.13.3 GCP Rutile

After reviewing the GCP rutile specifications, TZMI comments that given only limited volumes will be produced by the GCP and rutile supply is forecast to remain tight, there should be no impediment in selling the product. The relatively fine grain size of the product and the low volume suggests the flux core wire segment of the welding electrode sector is the preferential target, as this would attract a premium price for the quality and fine grain size of the GCP rutile.

TZMI does, however, recommend three alternative markets for the sale of GCP rutile:

- Bulk sale of GCP rutile to pigment producers, such as DuPont and Cristal, which accounted for 51% of total rutile consumption in 2009. Tronox, Huntsman and Kronos or ISK in Japan and Singapore can also be considered.
- The welding flux markets of South-East Asia, Europe and North America, accounting for around 29% of total rutile consumption in 2009. While some leucoxene and ilmenite are used, rutile is dominant.
- Titanium sponge markets include producers such as TIMET in the US and Sitix and Toho in Japan. Others exist in Kazakhstan, Russia, Ukraine and China, but these producers tend to use domestic sources of titanium feedstock.

2.14 Titanium Feedstock Market Balance

2.14.1 Supply and Demand Dynamics in the Global Economic Crisis 2008–2009

According to TZMI, 2008 began with a degree of supply tightness, which eased as the effect of the GEC decreased demand, instigating a period of de-stocking into 2009. By the end of 2008, there was a small excess in supply of 42,000 TiO_2 units.

In 2009, the recovery from the GEC was slower than expected, with 14% decrease in demand. Producers responded to the decrease in demand by cutting costs and moderating supply with extended maintenance. Two new Australian suppliers, Monto Minerals and Australian Zircon, were placed in administration in 2009.

Global supply of TiO_2 feedstock exceeded demand by 220,000 TiO_2 units by the end of 2009.

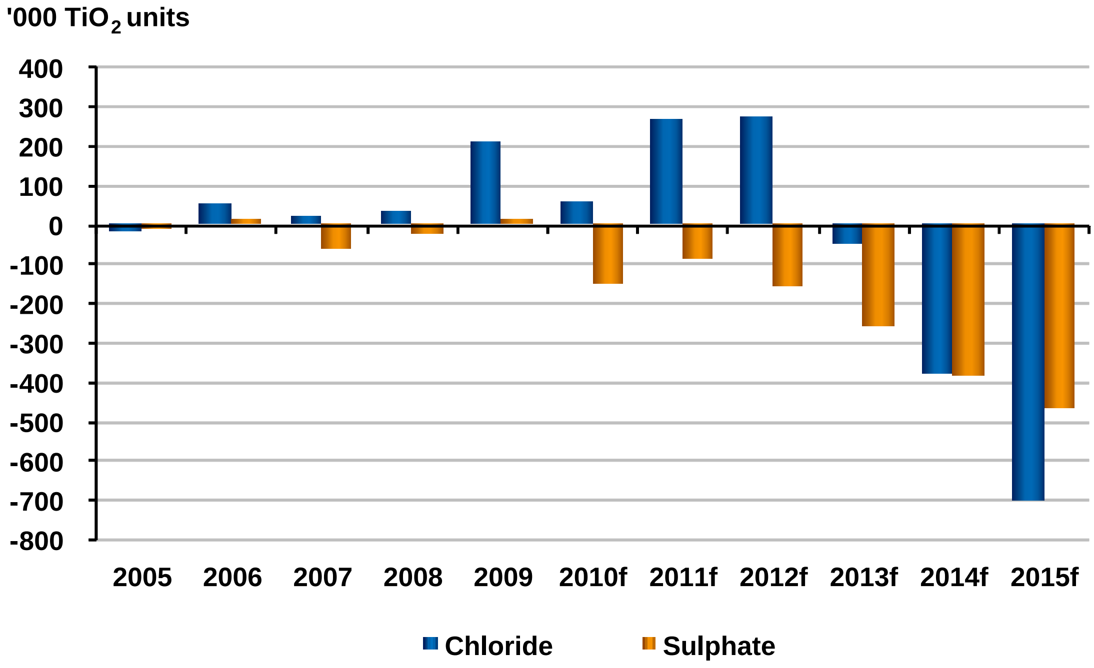
2.14.2 Supply and Demand Recovery 2010 to 2011

TZMI anticipates that a rebound in demand through 2010 will create tight market conditions for chloride ilmenite. Production from new projects would create surpluses for high TiO_2 chloride feedstock including rutile, chloride slag and chloride ilmenite, by 2011.

According to TZMI, overall industry performance has been supported by several historically significant resources, which are now being depleted. For example, Iluka's Eneabba and DuPont's Florida operations are to come to an end by the end of 2011. TZMI estimates that a significant gap in TiO_2 feedstock supply will begin to occur. Therefore a supply deficit will begin to be observed for sulphate ilmenite. The supply/demand balance forecast to 1025 is shown in Figure 2.29.

Shortages in SR quality ilmenite feedstock are expected by 2011 due to increased production costs and lack of co-product credits. TZMI anticipates pigment plant closures in the short to medium term due to financial hardship and this will impact on sulphate feedstock.

Figure 2.29 Supply/Demand Balances for all Titanium Feedstock, 2005–2015



Source: TZMI 2009

2.15 Supply and Demand Forecasts to 2027

In terms of estimating future supply and demand forecasts, the key influences on the feedstock market include:

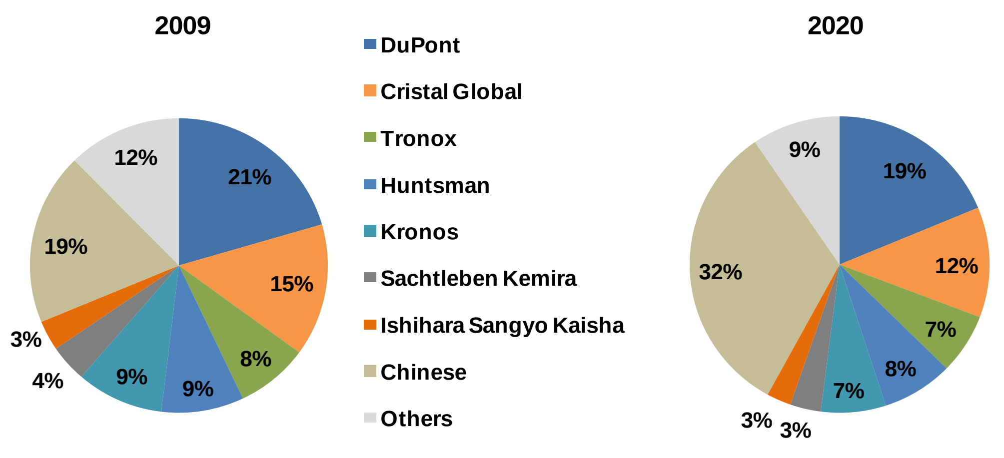
- The continued potential for supply disruptions and maintenance programs.
- The lower volume of supply from projects not yet working to capacity.
- The likely, albeit deferred, supply from new projects.
- Decreasing grade and availability of resources.
- A significantly decreased demand in feedstock in the short term due to the Global Economic Crisis, also creating:
  - Uncertainty regarding the pace of economic recovery.
  - Regional differences in timing and extent of demand recovery.

2.15.1 Global TiO_2 Pigment Supply and Demand Forecasts

The titanium pigment production industry is the world's third-largest inorganic chemical business behind ammonia and phosphoric acid, consuming 93% of titanium feedstock produced in 2008. The chloride route accounts for 52.6% of total pigment production capacity. TZMI estimates global pigment production in 2009 was 4.37 Mt, 11.8% lower than in 2008 in response to decreased demand in the GEC.

North America, Europe and Asia–Pacific account for over 87% of global pigment production. Most major producers reduced output and several closed in response to reduced demand. TZMI anticipates more plant closures in 2010 and 2011, then resuming a 3.2% global production growth to 2020. Chinese production of titanium pigment (Figure 2.30) will dominate given lower production costs, tighter margins and improving technology.

Figure 2.30 Global Titanium Pigment Production, 2009 and 2020

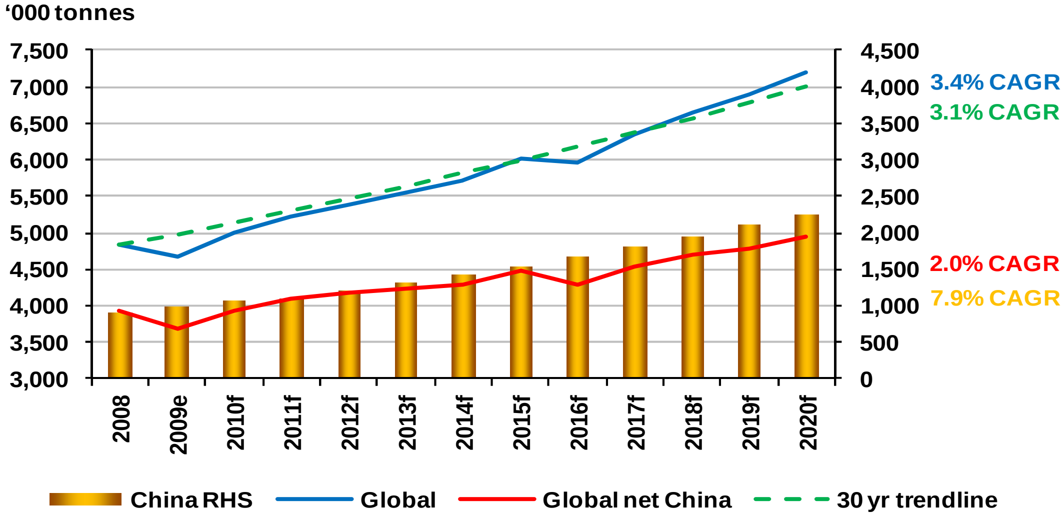


Source: TZMI 2009

According to TZMI, global demand for TiO_2 pigment decreased by 5.3% to 4.83 Mt in 2008. This has been attributed to the decrease in construction activity due to the GEC.

However, global demand for 2010 is expected by TZMI to increase by 6.8%, attributed to restocking of inventories. Figure 2.31 shows the anticipated CAGR of global pigment demand from 2008 to 2020 is 3.4%. This is in line with growth in gross domestic product (GDP).The annual demand volume of TiO_2 Pigment, shown on the left axis is expected to reach more than seven million tonnes by 2020.

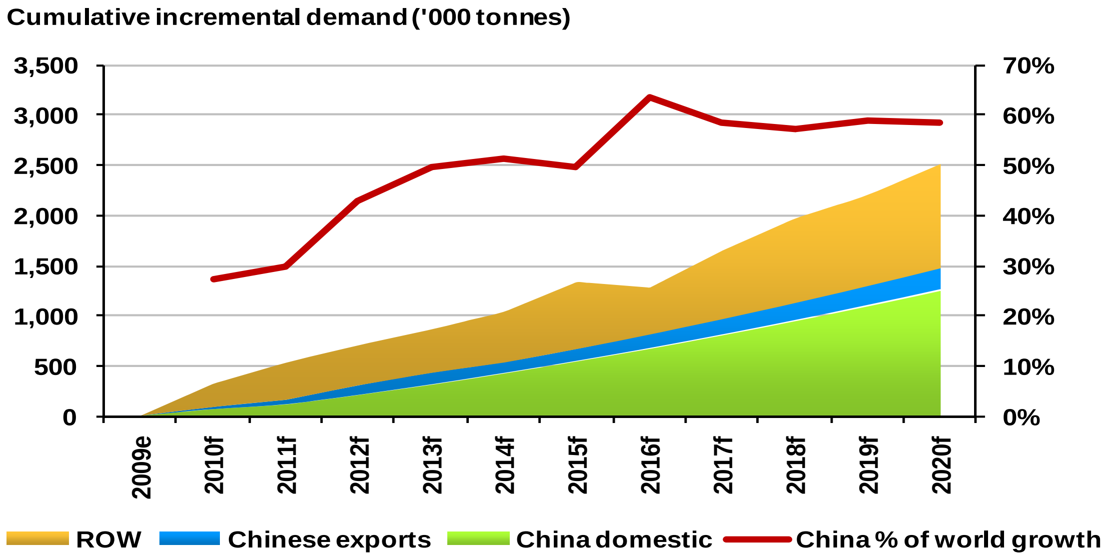
Figure 2.31 TiO_2 Pigment Demand and GDP Outlook to 2020



Source: TZMI 2009

This growth is consistent with the long-term, stable growth experienced prior to the GEC averaging 3.1%. TZMI is confident this will continue, with growth markets in developing countries such as China and India that currently have lower per capital consumption than other more developed countries. China is anticipated to account for nearly 60% of global TiO_2 pigment demand by 2020, shown in Figure 2.32, below.

Figure 2.32 China's Increasing Share of World TiO_2 Pigment Demand Growth to 2020



Source: TZMI 2009

2.15.2 Sulphate-Grade Feedstock Supply and Demand Forecasts

According to TZMI, the total global production dropped 5% to 1.62M TiO_2 units in 2009, compared to a peak of 1.93M TiO_2 units in 2007. The decrease was attributed to producers in China reacting quickly to the decrease in market demand by holding ilmenite inventory. In addition, a number of other operations have been affected by maintenance issues or the negative economics of the GEC:

- From March 2008, Furnace 2 at Exarro Resources' KZN Sands has been out of service due to repairs from water ingress.
- The Carnegie Minerals Project in The Gambia, Matilda Minerals' Tiwi Island Project and Monto Minerals' Goondicum Ilmenite all ceased production in 2008.
- As a result of market uncertainty early in 2009, Rio Tinto shut down the Quebec metallurgical complex and Havre-Saint-Pierre mining operation for the first time in 60 years. One of the furnaces at Richards Bay Minerals has also been idled for five months for a complete rebuild.

Forecast supply is further impacted upon by:

- Depletion of Iluka's and Bemax's sulphate ilmenite resources in Australia. Those of the Murray Basin have high Cr_2O_3 content, which limits their market in China.
- Supply from Trimex and V.V. Mineral in India will increase with new projects and expansions commissioned, effective from 2012.
- A domestic beneficiation policy in India may restrict the availability of sulphate ilmenite to Europe and Chinese markets beyond 2015 as it is blended to form more concentrated products for slag or SR use.

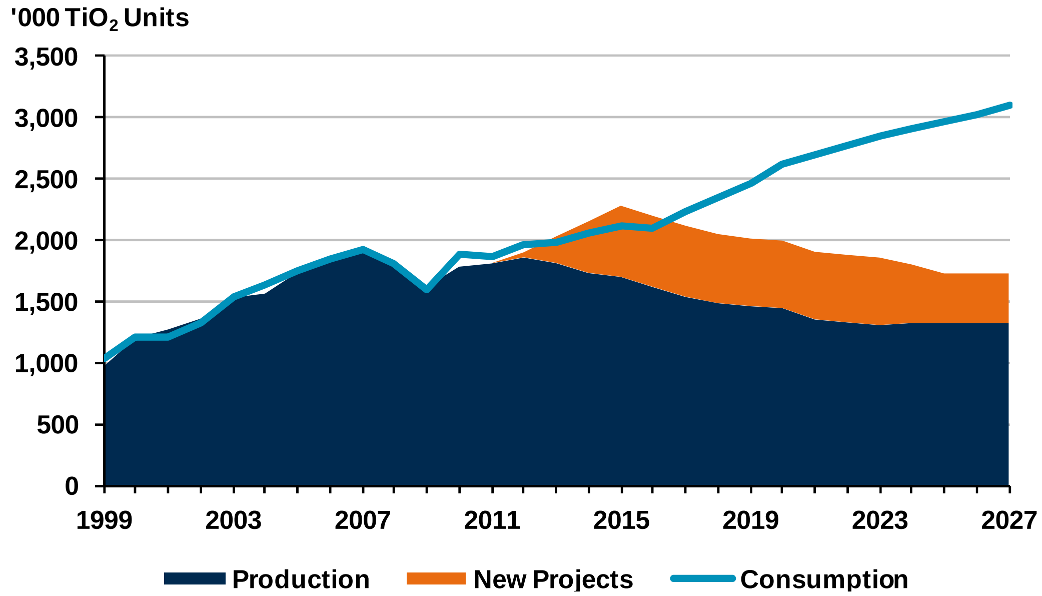
- The Vietnamese government previously implemented plans to abolish the export of ilmenite but this has proven unsuccessful. TZMI anticipates the closure of smaller sulphate ilmenite producers in Vietnam to support the development of a domestic beneficiation and pigment industry, whereby sulphate ilmenite export supply could diminish, around 2015.
- China has strong sources of hard rock ilmenite, which will support increasing slag production to 2015 but create an effective decrease in the availability of feedstock for direct pigment demand, which will need to be met by imported ilmenite. Currently Vietnam supplies a significant proportion of ilmenite to China.

TZMI forecasts demand for sulphate ilmenite to grow at 4% per annum to 2015, excluding that used in slag manufacture. Forecast demand is impacted upon for the following reasons:

- China will account for 41% of demand growth to 2015 given the strong pigment production sector and most Chinese pigment production uses the sulphate process due to technological limitations.
- India also has increasing pigment production capacity, with new projects expected to be commissioned by 2012.
- Europe/CIS regions will experience expansion from existing producers and new pigment production capacity from 2013.
- Very little demand growth in Western pigment production companies given economic rationalisation of their capacity.

TZMI expects that titanium feedstock will be in short supply from 2013, requiring TiO_2 units from either the expansion of existing operations or new projects from 2013 to 2027. India and Africa provide some hope to ease the supply gap with a number of new projects under investigation. Beyond 2015, depletion of resources also threatens supply. The forecast supply gap is shown in Figure 2.33, which includes supply from known new projects, including the planned 215,000 TiO_2 units anticipated from Grande Côte from 2013.

Figure 2.33 Forecast Supply and Demand for Sulphate Ilmenite, Including New Projects, to 2027



Source: TZMI 2009

2.15.3 Chloride-Grade Feedstock Supply and Demand Forecasts

Chloride-grade TiO_2 feedstock represented 57% of the total feedstock market in 2008 but in 2008 the total global production of chloride-grade feedstock decreased by 2%. TZMI anticipates a progressive decrease in supply to 2015, impacted upon by the following:

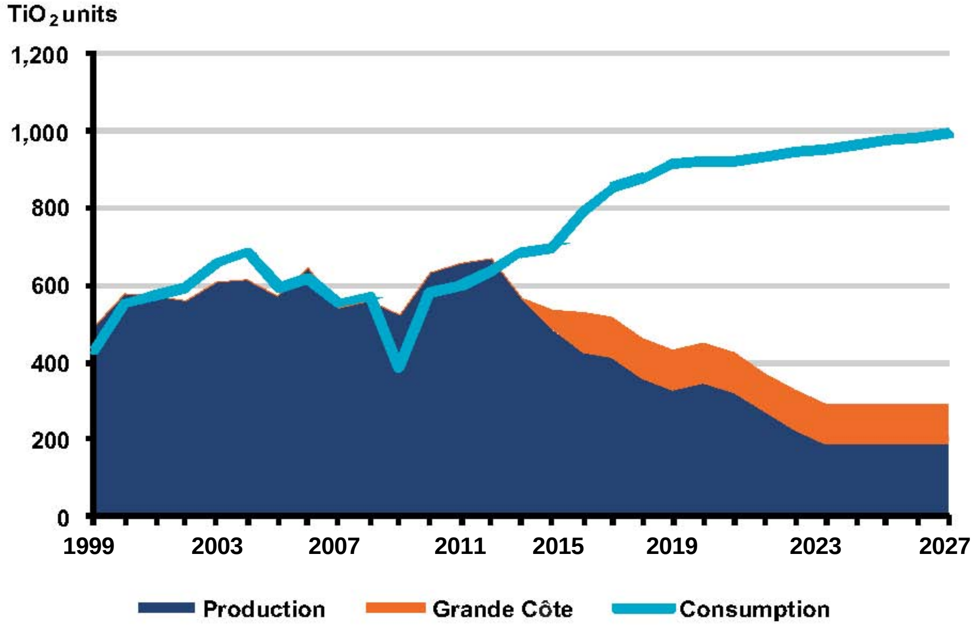
- Australian output will decrease from 2012 due to the closure of several mines, including Tiwest's North Mine by 2012 and Iluka's Eneabba by 2010 and reduction of its installed SR capacity by 50%.
- Iluka's newly commissioned Jacinth–Ambrosia deposit is fine grained and its suitability for SR use or direct chlorination is yet to be determined.
- Bemax Resources' chloride ilmenite supply is contracted to DuPont.
- US chloride ilmenite supply is diminishing as Iluka and DuPont's resources deplete to 2015.
- Ukrainian supply is expected to be exhausted by 2014.

Demand for chloride ilmenite is dominated by direct chlorination feed for DuPont pigment production and as feedstock for titanium sponge. Global demand is forecast by TZMI to grow at 12% per annum to 2015, impacted upon by:

- DuPont's new pigment plant in China, expected in 2015.
- The small volume but high growth of the titanium sponge sector, forecast at 13% per annum to 2015.
- Additional opportunities to use chloride ilmenite as feedstock to SR manufacture.

TZMI expects chloride ilmenite supply surplus to 2012 due to demand decreases from the GEC, increased output from Moma and Iluka's Eucla Basin and a build-up of SR inventory. Beyond 2012, depletion of resources also threatens supply. The forecast supply gap is shown in Figure 2.34, which includes supply from Grande Côte from 2013.

Figure 2.34 Forecast Supply and Demand for Chloride Ilmenite, Including Grande Côte, to 2027



Source: TZMI 2009

2.15.4 Rutile Feedstock Supply and Demand Forecasts

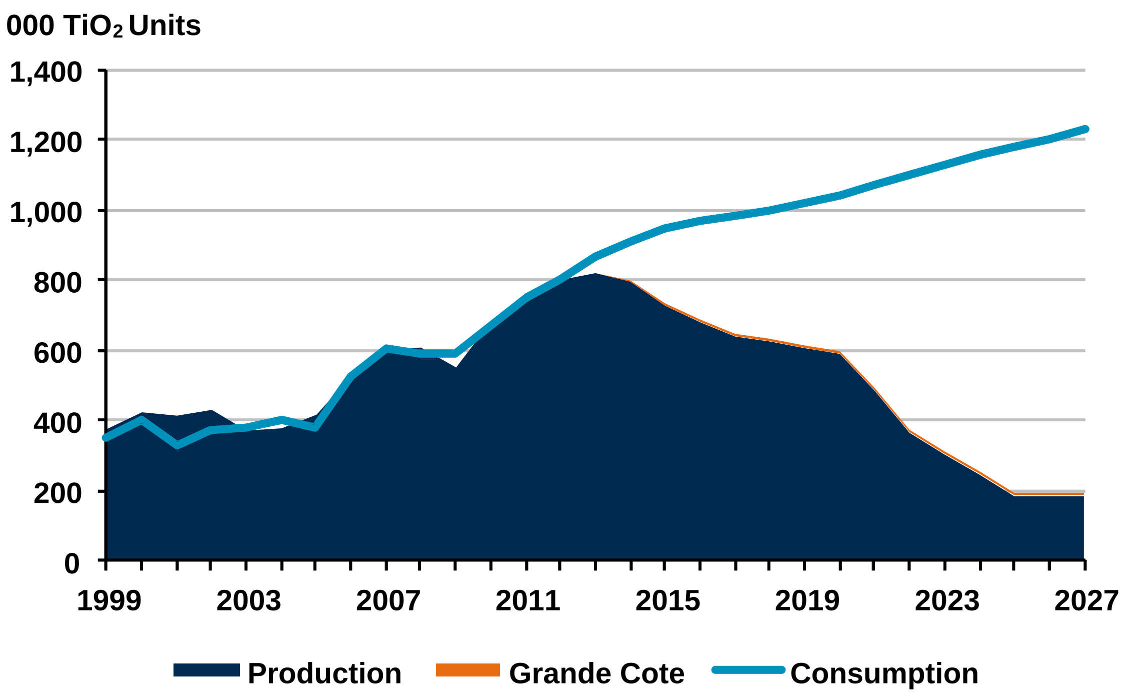
Global rutile production decreased by 10% in 2009 from 2008, attributed to lower grades from Iluka's Mid West and Bemax's Murray Basin and the capsizing of Sierra Leone's SRL dredge in 2008. A rebound in production is forecast for 2010 due to Iluka's Murray Basin Stage 2 operation, but by 2020 TZMI anticipates a progressive decrease in supply, impacted upon by:

- Expected decline in output from Iluka's Murray Basin from 2015.
- A doubling of Bemax's rutile output from 2010 with the commissioning of Snapper deposit, but declining grades at Gingko from 2014.
- The commissioning of RBM's tailings project from 2011.
- Closure of Exxaro's Hillendale mine by 2013.
- Potential that the SRL dredge may not be reinstated.
- Declining grades and increased mining economics at Vilohirsk beyond 2014.
- Absence of rutile supply from new projects.

Demand for rutile is dominated by pigment production and global rutile demand for this end use is forecast by TZMI to grow at 4.4% per annum. For other uses, such as welding electrodes, global rutile demand growth is forecast at 5%.

TZMI expects rutile supply deficits to 2020, unless new supply sources can be found and economics are favourable for their development. The output from Grande Côte has very limited impact on the global forecast and alternative feedstock may be used by consumers of rutile for pigment manufacture, such as UGS or SR. The forecast supply gap is shown in Figure 2.35, which includes supply from Grande Côte from 2013.

Figure 2.35 Forecast Supply and Demand for Rutile, Including Grande Côte, to 2027



Source: TZMI 2009

2.16 Titanium Feedstock Price Trends and Forecasts

2.16.1 Factors Influencing Titanium Feedstock Prices

The pricing of titanium feedstock products varies according to the level of impurities and the particle size distribution. Most titanium feedstock sold requires standard specifications. However, as there are no internationally defined quality parameters a range of quality products are marketed into the various end uses.

The price changes of feedstock products are not independent, with changes in one affecting others, and the price differential between grades can fluctuate widely.

The pricing and forecasting of pricing for titanium feedstock is considered complex due to a number of long- and short-term factors, such as:

- The actual and expected short-term supply/demand balances.
- The longer-term expectations of supply/demand balance, which establish long-term price contracts.
- The anticipated overall level of demand, with the TiO_2 pigment sector considered the largest consumer and having the largest influence on demand pricing.
- Supply challenges caused by rapid growth in demand, such as that from China.
- Oversupply when large suppliers are commissioned in an unregulated manner, or undersupply due to delays in commissioning new resources.
- Overall economic activity, which influences demand and therefore price (e.g. the GEC and subsequent decrease in demand).
- Opportunistic pricing policies at times of supply uncertainty.
- Exchange rate fluctuations.
- Wide variations in the TiO_2 grade of feedstock.
- Packaging and volume of shipments, with smaller or bagged lots attracting a significant premium.
- Freight rates variations.
- The availability of scrap or other substitution products.

2.16.2 Long-term Trends in Titanium Feedstock Prices

2.16.2.1 Sulphate Ilmenite and Chloride Ilmenite Long-term Price Trends

According to TZMI, from 1975 to 1986, the price for 60% TiO_2 ilmenite was in gradual decline. However, since 1988 this has reversed and a gradual increase of 1.4% per annum observed. Figure 2.36 and Figure 2.37 illustrate the Australian chloride and sulphate ilmenite prices from 1975 to 2006.

There were three peaks in sulphate ilmenite price over the last 15 years, attributed to:

- The gradual decline in quality of sulphate ilmenite as resources, particularly in Australia, diminished and grades dropped.
- Consistency of product quality due to the variable nature of ore bodies.
- The entry of new producers in Norway and Asia introduced competition.
- Tight market supply.

Historically, the prices for chloride ilmenite were lower than sulphite ilmenite despite the greater TiO_2 content. This was attributed to a narrow market for chloride ilmenite:

- As a blended feedstock for SR production.
- Only DuPont is able to use it directly in the pigment production.

Recently, 60% TiO_2 chloride ilmenite products have reached premiums above 54% to 56% TiO_2 sulphate ilmenite products reflecting the tighter supply and improved quality mix.

Figure 2.36 Australian Chloride Ilmenite Prices, Australian Export, 1975–2006

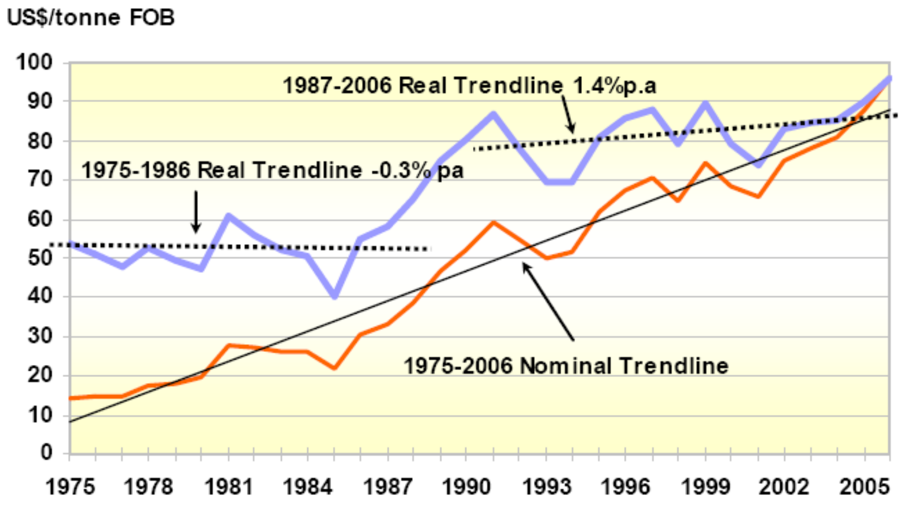


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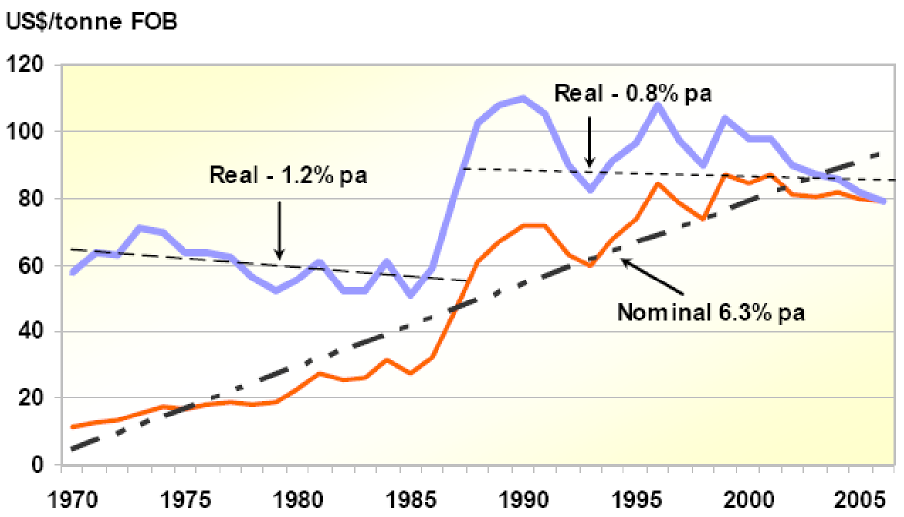
Figure 2.37 Australian Sulphate Ilmenite Prices, 1975–2006



Ref: 3714

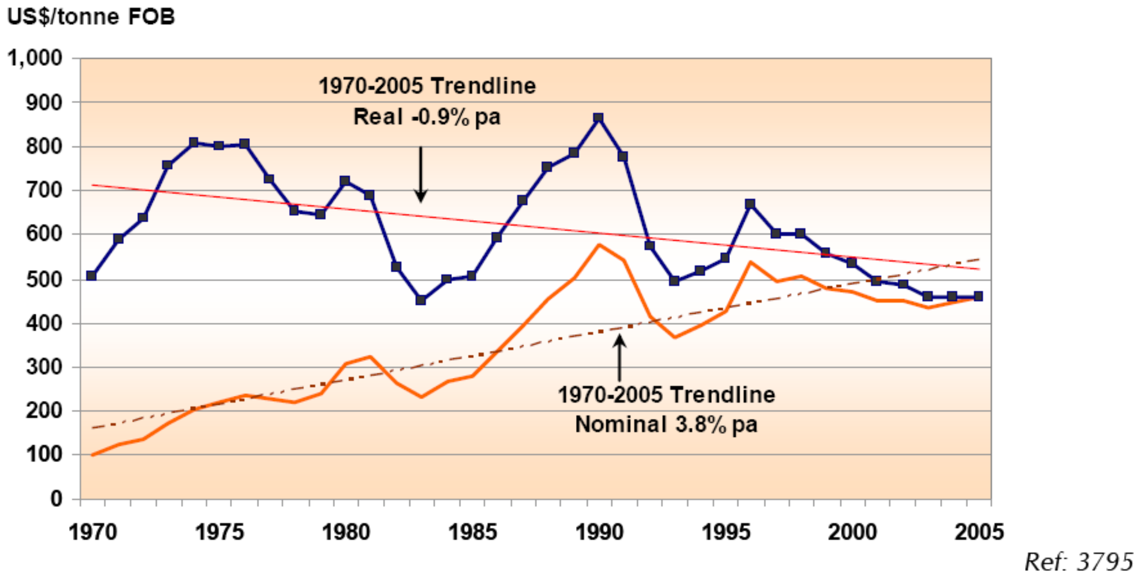
Source: TZMI 2009

2.16.2.2 Rutile, Synthetic Rutile and UGS Long-term Price Trends

According to TZMI, since 1970 the overall price for rutile has declined by 0.9% per annum, in real terms. However, throughout this period the rutile price has experienced a number of high to low cycles, which mirror those experienced in the pigment sector, such as troughs in 1978, 1983, 1993 and 2000 (Figure 2.38).

From 2003, pigment producers created a more competitive market, which placed downwards pressure on prices. As such rutile prices have stabilised as it now encounters competition from UGS and SR and is considered a niche product.

Figure 2.38 Bulk FOB Australian Export Rutile Prices, 1970–2005



Source: TZMI 2009

2.16.2.3 Leucoxene Long-Term Price Trends

TZMI does not prepare price histories of leucoxene because the quantities traded internationally have been low and there are a multitude of grades that are often undisclosed. This makes interpretation of statistical data difficult.

2.17 Titanium Feedstock Price Forecasts to 2027

2.17.1 Overview

According to TZMI, despite a current drop in demand for feedstock, the prices have and will continue to increase from 2010 as a result of supply uncertainties due to production cut-backs, closures and delays in commissioning new projects. TZMI's average, bulk forecast prices for titanium feedstock are shown in Table 2.16.

Table 2.16 TZMI Forecast Average Titanium Prices

Product	**US$ Real 2009 Prices (FOB/t)**			
TZMI average $ FOB	**2013f**	**2014f**	**2015f**	**Post 2015**
Sulfate ilmenite	114	113	113	125
Chloride ilmenite	114	120	131	145
Bulk rutile	605	614	619	635

By the end of 2010 a scenario of market surpluses and consumer inventory is anticipated, which may lower prices for some consumers. However, tiered prices are anticipated due to conditions of some longer-term contracts.

Increases in feedstock prices are also going to be required for some producers to remain economically viable due to operating cost pressures and strengthening domestic currencies, in turn maintaining sustainable supply levels.

2.17.2 Sulphate Ilmenite Price Forecasts to 2027

According to TZMI, the average prices of sulphate ilmenite of all grades in 2009 were between US$60 to US$160/t FOB, depending on TiO_2 content, impurity levels, proximity-related freight savings and contractual arrangements.

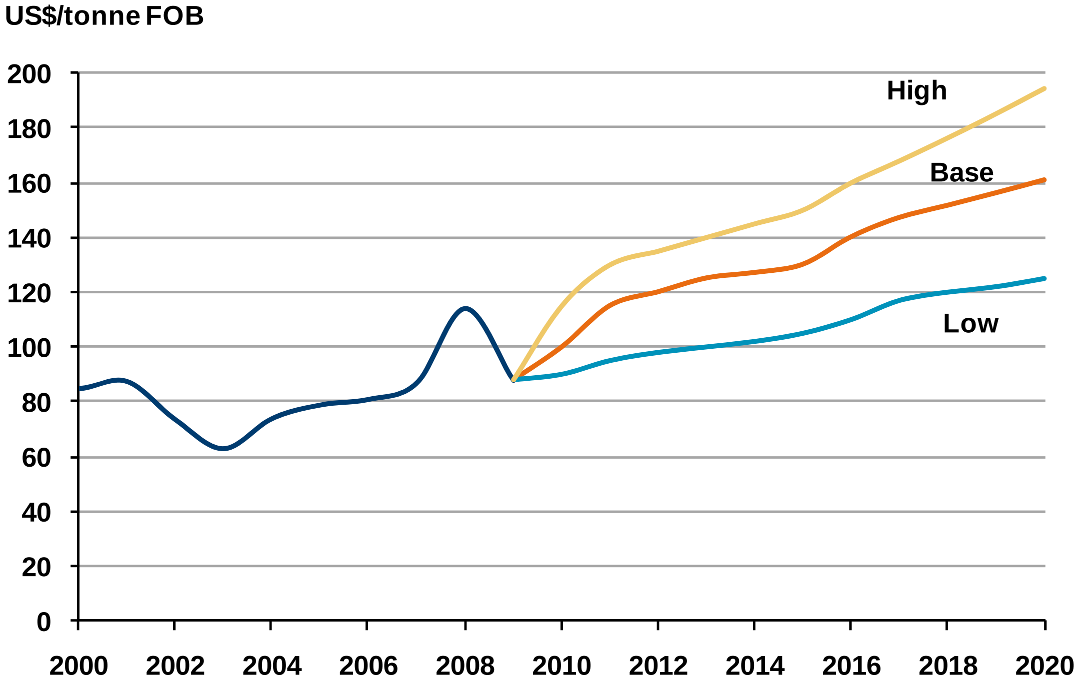
In 2008, prices ranged according to grade between US$87 to US$150/t FOB. Spot market prices were as high as US$200/t cost insurance and freight (CIF). High prices are attributed to:

- Strong domestic production in China, with imports required to meet demand.
- The market in China is predominantly a spot market, uninhibited by contracts that limit annual price moves, enabling quick response to market trends. Hence, in the last half of 2008 Chinese consumption decreased in response to demand reduction, resulting in some producer stockpiling and price drops.

The Chinese market is considered indicative of sulphate ilmenite price trends, and domestic spot prices have been on the increase since late 2009, to around US$88 to US$115/t FOB into 2010.

Sulphate ilmenite demand is largely driven by demand in the TiO_2 pigment sector. Given the forecast of increased pigment demand and tighter feedstock supply, an increase in the global average price for sulphate ilmenite is expected, shown in Figure 2.39.

Figure 2.39 Annual Average Global Sulphate Ilmenite Price Forecasts to 2020 (Nominal)



Source: TZMI 2009

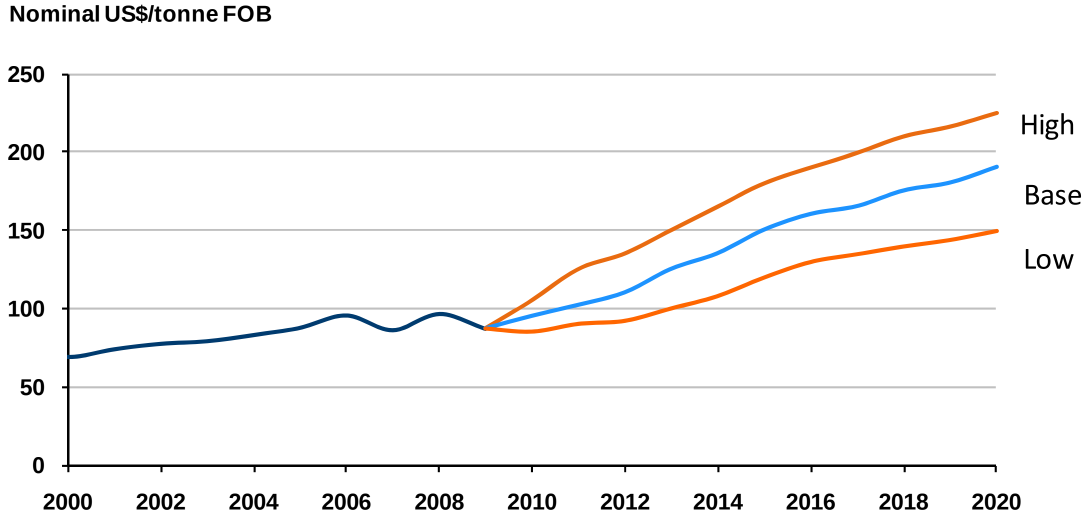
2.17.3 Chloride Ilmenite Price Forecasts to 2027

According to TZMI, the 2007 average price was US$86/t FOB. In 2008, this increased 7% to US$97/t FOB. Some price variations were observed due to tiered pricing, variations in product qualities and contractual positions.

Chloride ilmenite is not influenced by growing Chinese demand from the pigment sector as they predominantly use the sulphate process. A small number of large consumers in Western countries dominate consumption of chloride ilmenite for pigment use, under long-term contract with annual price moves and low competition.

For chloride-grade ilmenite, nominal prices are expected to increase only moderately due to tight supply and fixed contractual arrangements. TZMI estimated price forecasts for 2010 are for an average global price of US$95/t FOB. A short-term tiered pricing regime is expected due to the co-existence of older long-term contracts with newer ones at higher prices. Once the older contracts expire, the global average price will reflect the higher prices and is expected to continue to increase given forecast market tight supply with increasing demand, shown in Figure 2.40.

Figure 2.40 Annual Average Global Chloride Ilmenite Prices to 2020



Source: TZMI 2009

2.17.4 Rutile, Synthetic Rutile and UGS Price Forecasts to 2027

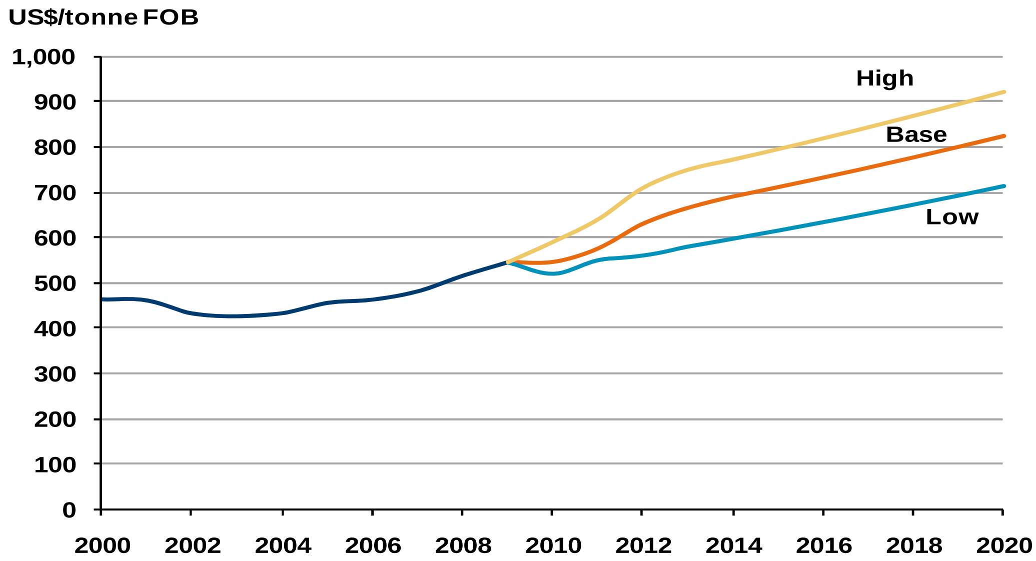
The market for rutile was tight in 2008 due to unplanned events at a number of mines forcing reduced supply. As such, the average price for bulk rutile grew 8% to US$545/t FOB in 2009. Consumers paid an average premium on bagged rutile of US$155/t FOB, higher in some Asian markets.

The average global price for synthetic rutile increased 4% to US$436/t FOB in 2008. Small volumes of high-grade TiO_2 SR from India shipped to Japan and Singapore attained average prices of up to US$700/t FOB.

The average price of UGS increased to US$518/t FOB in 2008.

According to TZMI, natural rutile is considered a niche product in a range of unrelated markets so has reflected spot market conditions rather than larger volume, longer term contract prices. In TZMI's view, a number of contractual commitments were established in the market prior to the GEC, so tiered pricing for bulk rutile will be observed in the short term and 2010 prices expected to be similar to 2009. Forecast tight supply and producer cost pressures will require ongoing global price increases to sustain feedstock supply. TZMI forecast bulk rutile prices to 2020 are shown in Figure 2.41.

Figure 2.41 Forecast Bulk Rutile Prices to 2020



Source: TZMI 2009

2.17.5 Leucoxene Price Forecasts to 2027

TZMI typically benchmarks leucoxene products against rutile, given the similar TiO_2 content and the absence of a consistent price series for leucoxene. DuPont is the only consumer for bulk leucoxene. There is a more diverse customer base for welding electrode use, but the product is sold predominantly in small lots. TZMI estimates a long-term real price for the 90% TiO_2 Grande Côte leucoxene product equal to that of rutile, at US$635/t FOB for bagged sales into the welding electrode market, or US$535/t FOB for bulk sales.

2.18 MDL Zircon Marketing Strategy

MDL's marketing objective with ilmenite is to develop long-term contracts to secure the position of this high-volume/low-value product. Typically these are agreed under contract of three to five years with evergreen intent thereafter.

MDL's strategy with the smaller tonnages of higher value rutile and leucoxene is to optimise the sales mix. This will be enabled by the sale of GCP products into a range of niche markets, establishing price competition as consumers will have varying capacities to pay and appetites for more tonnage.

Shipments will be by bulk shipments for ilmenite and small lot sales by container shipments in the case of rutile and leucoxene.

2.18.1 GCP Market Window

A number of factors are considered to be advantageous to the GCP, creating a favourable market window for ilmenite, rutile and leucoxene:

- High product quality:
  - Good chemistry, which has particular relevance in niche markets. For example, high Cr_2O_3 levels are no impediment for the sale of GCP chloride ilmenite for SR production in Western Australia, as chloride slag feedstock or directly in chloride pigment manufacture.
  - At 0.16% Cr_2O_3, GCP sulphate ilmenite compares favourably with other ilmenite, such as that of CRL and Bemax ilmenite produced in the Murray Basin. CRL in particular has had a long history of stable business into China by way of selling in blends to the Chinese sulphate route industry.
  - Good sizing, which has particular relevance in niche markets. For example, the relatively fine grain size of the product makes the GCP rutile a premium product for the flux core wire segment of the welding electrode sector. Rutile may also be suitable for titanium sponge manufacture.
  - GCP leucoxene will be marketed as welding-grade rutile, comparable to products from Richards Bay.
- Access to a range of global markets:
  - A strategic proximity advantage to those headquartered in Europe and North America.
  - Access to spot markets in growing regions, such as India and China, especially for lower-grade product.
- Bulk shipment advantages for ilmenite:
  - Shipments can be organised in weekly or fortnightly deliveries, whereas the timing and quantity of deliveries from more distant suppliers is dependent on the availability of space.
  - With bulk shipments, while having to buy a much larger cargo of 35,000 to 40,000 t, the buyer can enter the freight market and fix a vessel based on prevailing market conditions. In times when shipments are available, freight rates can be competitive.
- Faster container shipments from Dakar to Europe for rutile and leucoxene:
  - Container shipments can be organised in weekly or fortnightly deliveries spread evenly over the year. The timing and quantity of deliveries by way of bulk shipment from more distant suppliers takes a long time to organise and is dependent on availability.
  - Just-in-time inventories can be serviced, as extra tonnage can be supplied quickly for consumers who experience unexpected new business or to protect against an unexpected stock shortage. For example, shipping times to Western Europe from Dakar are 10 days compared to 31 from Australia or 25 from South Africa.
  - Inventory reductions for consumers. Container shipments can operate in regular shipments of 100 t to 200 t. Storage and handling needs and inventory levels are therefore lower, which is advantageous to consumers under internal pressure to keep inventories down.

- Cheaper freight rates for container shipments for rutile and leucoxene:
  - Freight charges for containers range from 3% to 10% of the CIF price over major shipping routes, whereas bulk shipment freight costs from Australia have been up to US$60/t higher.
  - Container shipment rates are held valid for six or 12 months, whereas bulk shipments can be negotiated on a vessel-by-vessel basis.
  - Freight cost will be cheaper compared to other major producers as they are driven by operating costs, corresponding to the length of the voyage. Dakar offers a long-term benefit to Europe with 25 days less steaming time.
- Port advantages for container shipments from Dakar:
  - Bulk shipment facilities, including warehousing and bulk loading facilities already exist and are underutilised at the Port of Dakar.
  - GCP offers new export business to Senegal to fill containers that are currently returned after import, empty. This is expected to enable negotiation of a good freight rate on containers that were otherwise shipped empty.
- Market attraction of the GCP:
  - The GCP is a mine of international significance with a long mine life “in excess” of 20 years. The GCP will be producing about 575,000 tpa of ilmenite, which is a highly significant production on a world scale.
  - The GCP will be entering the market at a time of forecast, emerging market supply deficits, coinciding with the closure of a number of domestic operations in the GCP’s nearby markets in the USA and Ukraine, which will result in deficits in sulphate ilmenite, chloride ilmenite, leucoxene and rutile from 2013.
  - While there are other mineral sands mines under development, potential exists for further price increases because of slower than expected development, hence TZMI forecasts a tight supply/demand balance to 2020.
- Price negotiation advantages:
  - Many buyers have a preference to widen the supply base and decrease the influence over supply from a few key producers.
  - The negotiation process for titanium feedstock has no formal reference points, such as the London Metal Exchange in the case of non-ferrous metals, and a forecast of tight supply can be advantageous for spot prices.

2.18.2 MDL’s Price Premium Strategy

TZMI’s forecast prices are for average prices for bulk shipments.

For GCP rutile, MDL believes that the commercial benefits outlined will position them to negotiate price premiums of approximately US$200/t over the TZMI forecast prices. This is based on the tighter supply forecast and an established history of price premiums in excess of US$150/t into the welding industry with premiums recently reaching US$300/t.

For leucoxene, MDL expects a US$100/t discount from the GCP rutile price. Niche marketing with shipments via bulk-in-container will also be advantageous for generating price premiums for rutile and leucoxene.

For ilmenite, TZMI has calculated a price for all ilmenite sold by the GCP after factoring in a price discount of US$15 to US$20/t from the global average bulk price. This price differential reflects the relatively high Cr_2O_3 content for sales to the sulphate route industry in China.

Importantly, the market forecast of increasing supply shortage for ilmenite, along with increased demand from 2013, driven by China, is fortuitous for the GCP, which has a planned market entry at that time. Table 2.17 summarises the annual price anticipated for GCP titanium feedstock.

Table 2.17 Annual Forecast Price for GCP Titanium Feedstock

Product	US$ Real 2009 Prices (FOB/t)			
TZMI bulk average $ FOB	**2013f**	**2014f**	**2015f**	**Post 2015**
Sulfate ilmenite	114	113	113	125
Chloride ilmenite	114	120	131	145
Bulk rutile	605	614	619	635
GCP project evaluation $ FOB				
GCP average ilmenite	105	110	120	125
GCP average rutile	805	815	820	835
GCP average leucoxene	705	715	720	735

2.18.3 MDL Zircon Marketing Development and Contracts

For ilmenite, it is customary for the chemical plants to undergo detailed technical evaluation of future supplies under strict confidentiality agreements, with the actual start-up of business normally commencing after a small trial parcel has been delivered for final technical clearance.

The tighter market conditions are forecast for 2013, so the timing is not yet ideal for discussion about new ilmenite supply. MDL believes market development work for ilmenite sales into large chemical plants will accelerate when the forecast tightness in the market becomes apparent. This is particularly so in respect to buyers in China, which is the fastest growing pigment market in the world and one that acts swiftly when market conditions shows signs of tightness. China is also shifting into chloride route technology in order to produce higher-grade pigments aimed at displacing business currently supplied by imported pigment. In the meantime, GCP ilmenite is being evaluated with customers in a number of market areas, not just China.

For rutile and leucoxene, the GCP entering the market in 2013 is fortuitous because of the forecast tightening in the overall market and, more importantly, because of the closure of a significant existing operation. TZMI forecast that the 60-year-old Ukrainian mine, producing 60,000 tpa of rutile, will cease mining operations in 2014. The GCP's combined rutile and leucoxene production of about 17,000 tpa will provide a close proximity replacement for this.

The Grande Côte is targeting the welding industry because very good price premiums are available in that market, which is not the case for alternative sales into the pigment industry and, to a lesser extent, into the titanium sponge industry. In addition, given the forecast for rutile of growing supply tightness, demand for rutile will increase. Other markets for rutile such as the TiO_2 pigment and TiO_2 slag industries have the flexibility to source alternative supplies from SR, titanium slag and chloride route ilmenite. However, the welding industry is dependent on rutile and leucoxene, possibly only being able to switch to lower-grade leucoxene feedstock. This is beneficial for the GCP in terms of sales and increased prices.

The welding industry features a number of smaller consumers and, as is customary for the welding industry, sales contracts will be progressed with customers closer to the time of entering production. This process normally involves a first small lot shipment for customer approval prior to the commencement of ongoing business with prices normally set annually.

2.18.4 Structure of Contracts for Titanium Feedstock

The terms and conditions of sale of the GCP sulphate and chloride ilmenite, rutile and leucoxene will be formalised under contract arrangements in a similar manner to that of zircon as outlined in Section 2.8.4.

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SECTION 3

Geology, Mineralisation and Resources

Copy 16

AMC CONSULTANTS

CONTENTS

TABLES

FIGURES

3 GEOLOGY, MINERALISATION AND RESOURCES

3.1 Exploration History

The exploration history of the Grande Côte Project (GCP) has been summarised from "Technical Report for Mineral Deposits Limited" P. R. Stephenson, May 2007.

The GCP is located on a coastal mobile dune system starting about 80 km north-east of Dakar and extending northward for more than 100 km. The mineralised dune system averages 2 km in width. The project area is 445.7 km^2 and the main heavy mineral (HM) deposits identified to date are Diogo, Mboro, Fass Boye and Lompoul. Other deposits have been partially explored within the Exploration Permit and there is potential to identify additional deposits beyond the limits of present drilling.

The deposits were first recognised in 1945, but it was not until they were acquired by EI du Pont de Nemours and Company Inc (DuPont) in 1989 that systematic exploration was undertaken.

DuPont conducted a substantial drilling campaign over 50 km of strike length, resulting in a significant mineral resource. However, it relinquished its tenements in 1992, apparently due to the relatively low grade of the ilmenite in comparison to its alternative sources at that time. The results from DuPont's work were lodged with the Department of Mines and Geology in Dakar. No further exploration took place on the deposits until MDL Senegal acquired its Exploration Permit in 2004.

MDL Senegal was granted its Exploration Permit in October 2004 having recognised the potential for developing the HM resource based on its zircon content alone. Initial resource estimates undertaken by MDL were based on the previous DuPont drilling data.

Exploration has been undertaken by DuPont and MDL by drilling lines of vertical holes using both reverse circulation (RC) and hand auger techniques. DuPont drilled 535 RC holes for 10,210.5 m and 7,893 hand auger holes for 28,852.2 m for a combined total of 39,062.7 m. From 2005 to 16 April 2010, MDL had completed 7,750 RC holes for 150,665 m and 4,569 hand auger holes for 45,203 m for a combined total of 195,868 m.

RC holes are able to penetrate below the water table whereas hand auger holes stop at the water table. The only material difference between DuPont's and MDL's drilling procedures has been that DuPont used water for sample flushing of RC holes whereas MDL uses air. DuPont's drilling was undertaken on a 400 m north-south by 80 m east-west grid. In 2007, MDL completed infill drilling program over a 20 km strike length covering the Fass Boye and Diogo deposits. Infill drilling was spaced 200 m north-south and 40 m east-west. In 2008 and 2009, MDL completed an infill drilling program focusing on the Mboro deposit in the south.

Both DuPont and MDL have collected samples at 1 m intervals down-hole and their sample treatment processes have been consistent with good industry practice in the mineral sands industry.

DuPont measured HM content using the "Magstream" process, a technique that uses ferro-fluids and magnetic and centrifugal forces to produce precise split points over a range of specific gravities. DuPont implemented industry-standard quality assurance/quality control (QA/QC) procedures and undertook rigorous checking of the Magstream results to confirm the reliability of the method. MDL measured HM content using lithium sodium tri-polytungstate (LST), a non-toxic, water-soluble heavy liquid that is now in common use in the mineral sands industry. MDL has also implemented industry standard QA/QC procedures.

MDL has validated the DuPont data by referring to all original drill logs, sample sheets, assay sheets and most plans, and checking them for internal and plotting consistency and correctness. A number of key location points from the DuPont drilling grid were preserved in concrete by DuPont and relocated by MDL, enabling the DuPont grid to be reconfigured into the Universal Transverse Mercator (UTM) grid by a registered surveyor.

In 2007, MDL compared its RC and hand auger drilling results with each other and with the results of new bulk samples obtained from shafts. The comparison showed that both RC and auger holes show a comparative closeness in heavy mineral grades compared to the shaft samples. These results showed that both types of drilling can be used for sample collection for analysis and that the analytical results can be used in resource and reserve estimation. It also found that auger samples taken above the water table have a closer correlation to the shaft bulk samples and would be the preferred method of sampling.

Future infill drilling will focus on the northern area of the deposits where previous drilling by DuPont has identified high-grade concentration of both zircon and ilmenite. There is also potential for additional deposits beyond the limits of present drilling, both to the south-west and north-east for a total strike length drilled of 70 km.

3.2 Geology

The following descriptions are summarised from P. R. Stephenson's Technical Report for Mineral Deposits Limited, May 2007, and publicly released information from MDL's website http://www.mineraldeposits.com.au.

3.3 Regional Geology

The extensive Senegal Mauritanian Basin covers most of Senegal and is composed of Mid-Jurassic to Recent, poorly cemented marine sands, marls, limestones and shales overlain by continental lacustrine and marine sediments.

The Grande Côte Project (GCP) area is situated within the Senegal-Mauritanian Basin in north-west Senegal, specifically within the belt of coastal dunes that lie along the current shoreline. The dunes are Recent in age (Holocene, 4,000 to 2,000 years before present), are mobile or semi-fixed, pale yellow in colour and overlie older Late Quaternary white marine sands. The dunes range between 5 m and 35 m in height and the mineralised zones, which are essentially flat-lying, average around 15 m in thickness.

The main deposits for the GCP include: Mboro, Lompoul, Diogo and Fass Boye and extend over a length of about 50 km along the northern coastline of Grande Côte of Senegal. There is potential for additional deposits beyond the limits of present drilling, both to the south-west and north-east for a total strike length drilled of 70 km.

3.4 Local Geology

The Recent light yellow, mobile dunes overlie older Late Quaternary white marine sands that were deposited during a time when lagoons, bars, spits and deltas formed along the coast together with the development of minor peat in lagoons and estuaries. The interface between these two layers is generally a 0.5 m humic horizon. Both the light yellow dunes and the underlying white marine sands contain HMs, principally ilmenite with accessory zircon, rutile and leucoxene. Zircon is the main commodity of interest.

The mobile dunal system is typically asymmetric, rising from about 10 m immediately inland from the fore-dune area to an average of 20 m before terminating at a high and steep-faced inland dune. Heights are variable and may reach more than 35 m. The average height of the topography in the dunal area is 13.3 m. The average width of the dune field is 2 km and reaches up to 4.5 km inland. The dunes and the sand mass in general appear to increase in size and height north-eastward from Mboro to Lompoul.

The underlying white marine sands are generally 30 m to 40 m thick and contain thinly bedded HM concentrations reworked as lag deposits in the mobile dunes (strandlines).

The water table generally occurs at about 4 m reduced level (RL).

An extensive older back dune system of north-east trending Aeolian red or orange coloured sands (rouges) was formed during an Ogolien age (20,000 to 11,000 years before present) regression when the desert sands of Mauritania spread to this region. The mobile dunes may also be a reworked part of these back dunes. Drilling data indicates the mobile dunes intermittently overlie the back dune sands in the more inland parts of the deposits.

Based on work by the Geological Survey and DuPont, a model of the mineral sand deposits was constructed that suggests three Aeolian phases, with the greatest amount of HM in the oldest phase, which is now the most inland part of the mobile dune system.

3.4.1 Water Table

Within the GCP area there are numerous artisanal wells, pits and 326 piezometers. Testing of the piezometers show the water level varies between 1.3 m to 6.4 m RL as at September 2009 for an average RL of 3.7 m. Reading of some water levels began in 2006 and the water levels appear to be falling in some piezometers over time. The water level is lower towards the coast line (west).

Data from a Bureau de Recherches Géologiques et Minières (BRGM) 1983 peat study, hydrological report gives a mean annual variation in the depth of the water table of 0.27 m. The variation is reported to increase inland.

3.4.2 Peat Deposits

The base of the light yellow coloured mobile dunes is commonly marked by a humic horizon approximately 0.5 m thick, with white, quartz-rich marine sands beneath.

MDL's observation of the profile in hand dug wells and pits is that the peat persists away from the major swales as a humic layer averaging 0.5 m thick and this layer is considered to extend beneath the mobile dunes. Much thicker (±10 m) deposits of peat may occur, but these deposits are not widespread.

Beneath the humic layer (and peat), localised accumulations of fine-grained iron oxide-rich friable sandy clays representing ancient swamps are occasionally present. The ratio of the "swampy areas" to clean white beach sands is difficult to ascertain, but considered to be very small.

3.5 Deposit Types

The mineralisation of the project area comprises a linear series of Aeolian sand dunes (Figure 3.1) containing a HM assemblage (~2.0% HM) concentrated by wind action.

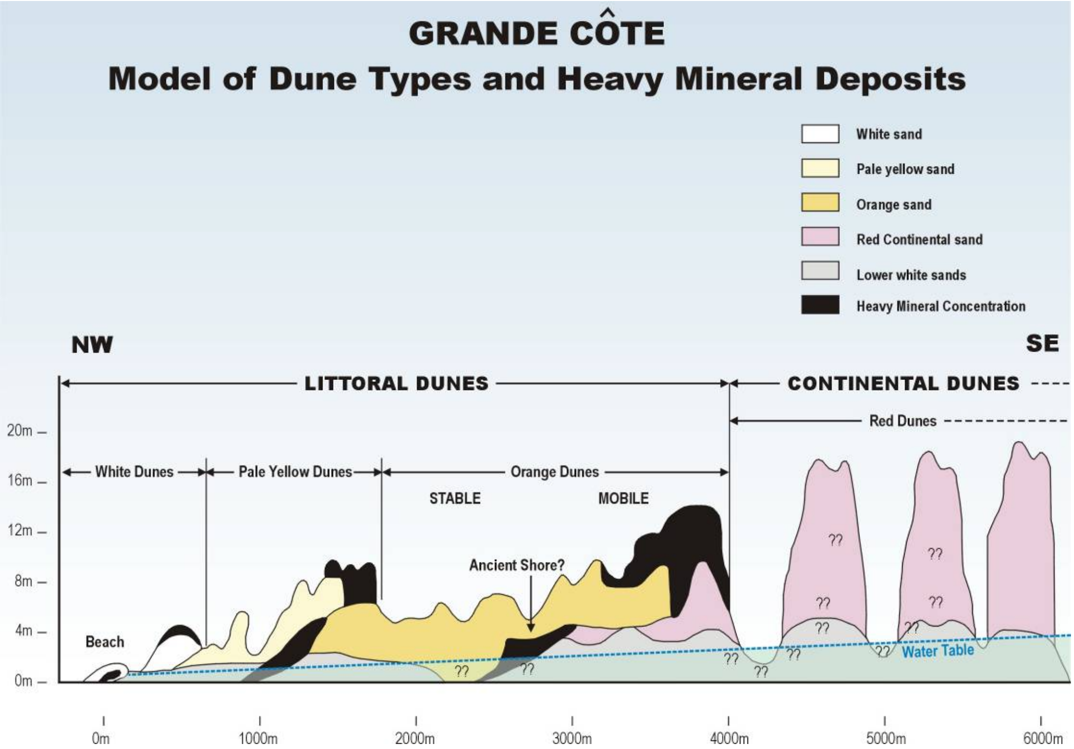
The Aeolian or mobile dunes overlie a substratum of former beach sands representing a recessive littoral environment. These sands also contain HM (~0.5% HM) but in some cases, apparently thin strandline concentrations of >10% HM are indicated by deeper drilling. The natural water table occurs close to the interface between the mobile dunes and the white sand substratum.

The floating dredging and wet recovery plant require a clearance depth of 6 m. Therefore the resource deposit model includes both mobile dune and littoral sand together with occasional peaty materials preferentially located at the dune-littoral sand interface.

Figure 3.1 Photography of Sand Dunes

Figure 3.2 is a diagrammatic cross-section through the deposits (note: horizontal scale 100 times vertical scale, a common practice in the mineral sands industry).

Figure 3.2 Diagrammatic Cross-Section through Grand Côte Deposits



3.6 Mineralogy

The four main deposits for the Grande Côte Project from south to north are: Mboro, Lompoul, Diogo and Fass Boye and extend over a length of about 50 km along the northern coastline.

Analyses of composite samples indicate that the content of valuable heavy minerals within the HM is in the ranges of 7% to 19% for zircon, 1% to 3% for rutile, 2% to 7% for leucoxene and 56% to 75% for ilmenite.

Traditionally the grain counting method was used to determine mineral assemblages in the deposits. From 2006 MDL has utilised the Mineral Liberation Analyser (MLA) technology to gather data on grain size distribution and mineral abundance and associations in each of the deposits. MLA utilises an automated scanning electron microscope and an energy dispersive X-ray microanalysis system. More recently MDL has used X-ray fluorescence (XRF) methods for the determination of zircon percentage and other mineral percentages.

Table 3.1 presents mineralogical data for Mboro, Fass Boye, Diogo, Lompoul South and Lompoul North based on MLA results (source: JK Tech reports April 2005 and June 2005).

Table 3.1 Mineralogical Data based on MLA Results

Mineral	Mboro (% of sand)	Fass Boye (% of sand)	Diogo (% of sand)	Lompoul South (% of sand)	Lompoul North (% of sand)
Ilmenite	0.3	0.7	2.5	0.9	0.5
Alt. Ilmenite	0.2	1.2	-	1.5	1.2
Leucoxene	0.1	0.2	0.2	0.3	0.2
Rutile	0.0	0.0	0.1	0.1	0.1
Zircon	0.1	0.2	0.2	0.2	0.3
Garnet	0.0	0.0	-	0.1	0.1
Quartz	98.6	97.0	96.2	96.3	96.9

Note: Amounts shown are percentages of sand.

MLA analyses have also reported cumulative weight/per cent P80 values for product zircon ranging from 86 micron to 100 micron.

During 2006 to 2008 MDL conducted extensive mineralogical analyses of the Fass Boye and Diogo deposits as part of its mineral resource update for those areas. The following results are summarised from the AMC May 2007 report "Mineral Sand Resource Estimate Grande Côte Zircon Project Fass Boye - Diogo Area MDL".

Grain counting was carried out in 2006 on HM fractions from a 110 t metallurgical testwork bulk sample from Diogo (split into 80 t and 30 t bulk samples). The results from the two bulk samples were comparative, with higher grades in the larger sample, as to be expected. Overall the HM content, especially zircon (18.8% and 15.7% respectively) was much higher than the grades from previous work. The grain counting gave the results as shown in Table 3.2.

Table 3.2 Mineralogical Data, Bulk Samples

Mineral	80t Bulk Sample (% of HM)	30t Bulk Sample (% of HM)
Ilmenite	56.0	62.4
Alt. ilmenite	11.0	9.5
Lucoxene	2.0	2.2
Rutile	1.2	2.3
Chromite	0.0	0.2
Zircon	18.8	15.7
Monazite	1.0	1.2
Garnet	0.2	0.2
Quartz	0.4	0.2
Trash	9.4	6.2

Note: Amounts shown are percentages of HM.

In 2008, MDL sent two 40 t samples from shafts dug in the Grand Côte deposit to Downer EDI Mining - Mineral Technologies (DEDI) to quantify the mineral recovery that could be achieved in the plant circuit. The results show much lower zircon grades and much higher ilmenite grades than the previous grain counting work in 2006. The other mineral compositions are reasonably comparative with previous work. The mineral composition from MLA analysis for both samples is shown in Figure 3.3.

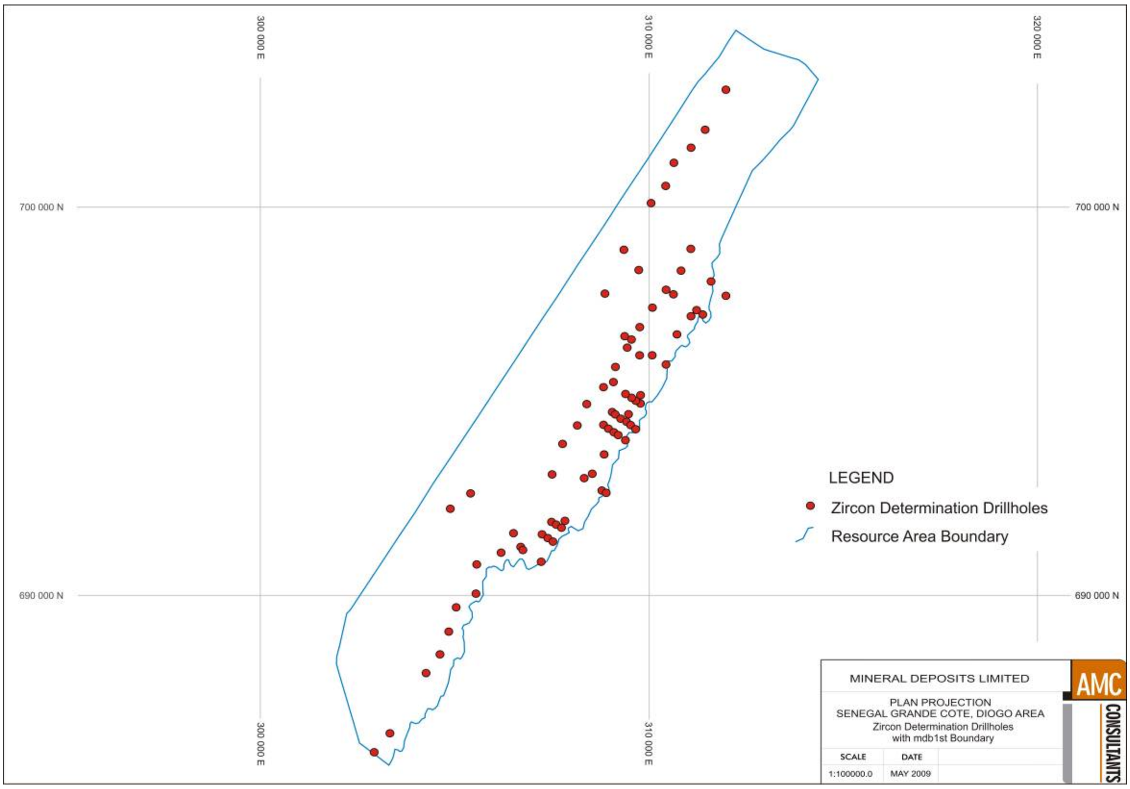
Table 3.3 Mineralogical Composition of 40 t Bulk Samples of HM

Mineral	Sample A (%w/w)	Sample B (%w/w)
Ilmenite	74.0	74.4
Zircon	11.0	10.6
Lucoxene	3.4	3.2
Rutile	2.1	2.8
Silicates	6.8	6.4
Andalusite/kyanite	0.78	1.03
Staurolite	1.1	1.28
Fe Oxides	0.15	0.12
Chromite	0.23	0.15
Titanite	0.01	0.01
Spinel	0.07	–
Others	0.36	0.03

MDL also prepared seven series of samples from composited heavy mineral samples taken from drillholes across drill lines for analysis. Assaying used the Mineral Liberation Analyser (MLA) and X-ray fluorescence (XRF) methods for the determination of zircon percentage and other mineral percentages, during the period 2006 to 2008.

Samples were selected from drillholes located along the whole length of the area being evaluated at that time (Diogo-Fass Boye) as shown in Figure 3.3.

Figure 3.3 Location of Drillholes used in the MLA Analyses



A listing of MLA and XRF series of analyses is shown in Table 3.4.

Table 3.4 MLA and XRF Series of Analyses during the Period 2006 to 2008

Laboratory	Method	Date	Laboratory Job Number	Number of Analyses
Ultra Trace	XRF and MLA	April 2006	U080660	3
Ultra Trace	XRF	October 2006	U91977	50
Ultra Trace	XRF	November 2006	U88770	27
Ultra Trace	XRF	October 2007	U111555	142
ALS Mineralogy	XBSE	November 2007	I102	2
ALS Mineralogy	XBSE	March 2008	I145	1
ALS Mineralogy	XBSE	July 2008	I0167	1

Note: XBSE is the MLA Extended Liberation Analysis technique.

The results by ALS using the MLA method are shown in Table 3.5.

Table 3.5 Results of ALS Composited Samples Using MLA Analysis

Mineral	AGL I102 (E9744) (%w/w)	AGL I102 (E9745) (%w/w)	AGL I145 (%w/w)	AGL I1067 (%w/w)
Rutile	2.35	2.72	2.81	2.10
Leucoxene	3.14	3.04	3.22	3.44
Ilmenite	75.89	74.20	74.40	74.03
Ilmenorutile	–	–	–	0.00
Zircon	10.31	10.78	10.58	10.96
Andalusite/Kyanite	0.54	0.57	1.03	0.78
Staurolite	1.26	1.27	1.28	1.05
Titanite			0.01	0.01
Silicates	5.94	6.70	6.37	6.82
Fe Oxides	0.10	0.16	0.12	0.15
Chromite			0.15	0.23
Spinel	0.15	0.15	0.00	0.07
Apatite	0.01	0.00	0.00	0.00
Monazite	0.03	0.02	0.00	0.03
Others	0.28	0.38	0.03	0.35

The results of the mineralogical analysis of three samples using the MLA method, based on drill line sample composites, for the April 2006 (U80600) test are shown in Table 3.6. The average result of the three series of samples tested using XRF is 10.19% zircon (U80600). The results of 219 samples tested by Ultra Trace to calculate the zircon percentage using drill line sample composites are shown in Table 3.7.

Table 3.6 Results of Ultra Trace Composited Samples Using MLA analysis

Mineral	Drillholes DGR0083-093	Drillholes DGR0126-132)	Drillholes DGR0194-202)	Average
Ilmenite %	63.36	62.11	60.80	62.09
Rutile %	1.90	2.00	1.92	1.93
Leucoxene %	15.09	16.99	16.78	16.29
Zircon %	10.48	8.65	8.34	9.16

Table 3.7 Results of Ultra Trace Composited Samples using XRF Analysis

Mineral	U88770	U91977	U111555
Zircon %	9.78	9.90	9.59

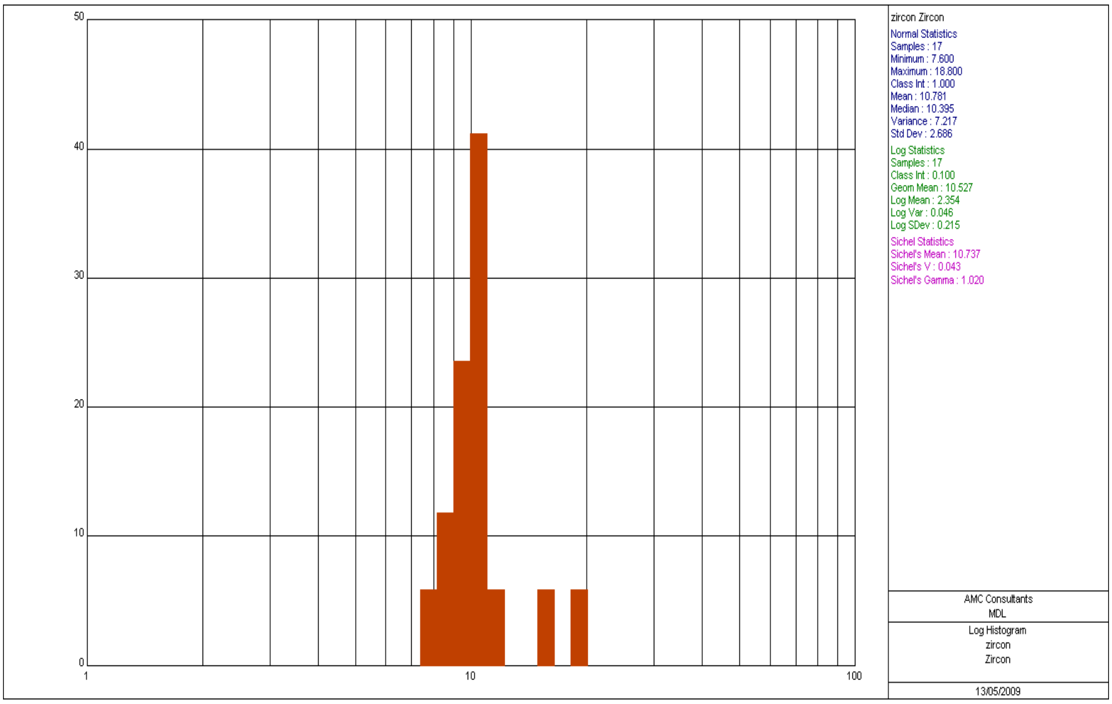
Further MLA analysis of the three samples referred to in Table 3.6 was conducted to classify the major titanium bearing minerals by industry standard based on the TiO_2 content. The results are as follows:

- Rutile = +94% TiO_2.
- Leucoxene = +70% to 94% TiO_2.

- Ilmenite = +4% to 70% TiO_2.

The main conclusion from the mineralogical work conducted on the Fass Boye and Diogo deposits from 2006 to 2008 is that the different sample sizes, locations and methods make the estimation of the average mineralogy throughout the deposit difficult. Bearing this in mind, an unweighted histogram of the zircon percentages (Figure 3.4) shows consistent results with an unweighted mean of 9.98 (after the removal of the grain count results). When the high results from the less accurate grain count analyses are removed, the MLA results give a zircon grade range from 8.34% to 11.0% with an unweighted average of 10.6% of the HM, which is comparable to the various MLA and XRF results. Rutile percentages are consistent and range from 2.1% to 2.8% with an unweighted average of 2.5% of the HM. Ilmenite percentages range from 74.0% to 75.9% with an unweighted average of 74.6% of the HM. Leucoxene percentages range from 3.0% to 3.4% with an unweighted average of 3.2% of the HM.

Figure 3.4 Histogram of Unweighted Zircon Average Grades



3.7 Drilling and Sampling

3.7.1 MDL Drilling

MDL uses two types of drilling: air core RC and hand auger. All holes are vertical. Samples are collected at 1 m intervals from both RC and hand auger drilling. To the end of April 2010, MDL had completed 7,750 RC holes for 150,665 m and 4,569 hand auger holes for 45,203 m for a combined total of 195,868 m.

3.7.2 MDL RC Drilling and Sampling Procedure

MDL uses in-house RC (aircore) drill rigs mounted on Bombardier Muskeg tracked carriers (Figure 3.5). Drilling rods are 3 m in length and based on AQWL size diamond drill rods (44.6 mm diameter) fitted with a proprietary inner tube. The Bombardier mounted drill rigs traverse the dune sands without difficulty along each line selected for drilling.

The rigs are set up for rapid drilling and there is provision to collect the complete sample with a basic cyclone separation by means of a swivel outlet feeding two alternate sample bags. Therefore there is no sample splitting on site. Theoretical sample weight is 1.8 kg/m. Each sample is weighed (field weight), and then a handful taken and manually panned to estimate a field value of HM content. All samples are geologically logged for colour, material, grain size, clays, humic content and slimes content. Depth of the standing water table is estimated. Additional piezometer drilling is undertaken at approximately one hole per drill line for regular water table measurements.

Drilling is undertaken on lines at 200 m spacing north-south and with holes at 40 m intervals east-west across much of deposits. Drillholes are designed to be completed at a depth of 8 m beneath the water table allowing overlap of information for a proposed 6 m deep dredge pond. Overall the average hole depth is 15 m.

Figure 3.5 Bombardier Track Mounted Drill Rig

3.7.3 MDL Hand Auger Drilling and Sampling Procedure

MDL uses conventional Dormer brand shell augers for infill drilling. The augers are Australian made and are recognised as the standard for mineral sands drilling. The type used is the 50 mm fine sand auger with 1.5 m-long extension aluminium coarse thread drill rods.

The sand is wetted to provide for a collar and the hand augering commenced. From experience, the auger shell will fill with two to three rotations for approximately 20 cm advance. The auger is then withdrawn from the hole and the sample poured/pushed directly into a labelled sample bag. A 75 mm PVC collar is placed by hand and the hole re-entered. This procedure is repeated until a 1 m representative sample is collected per sample bag. At completion of each metre sample, a small aliquot is panned and studied for the geological log.

Hand auger drilling is used for infill at 40 m intervals, but can only sample as deep as the water table.

3.7.4 Shaft Sampling

In 2007, MDL also took shaft samples to gather accurate geological information down the sand profile and to perform a comparative analysis of HM percentages from RC and auger drilling results. The shaft samples were generally taken at 0.20 m intervals. The shaft assays were composited to 1 m intervals for comparison with the RC and auger drilling.

The shaft sampling is considered to be superior to the RC and auger drillhole sampling because the exact location of the shaft and the samples taken from it is known. Also the actual geology is exposed for direct observation on the shaft walls.

3.7.5 DuPont Drilling

DuPont also used two types of drilling: water injection RC and hand auger. All holes were vertical, with samples being collected at 1 m intervals from both drilling methods. The hand auger drilling was conducted on a grid spacing of 400 m north-south by 80 m east-west, stopping at the water table (sometimes shallower if the hole was fairly deep). The RC drilling was not undertaken on a regular grid, but distributed to achieve a reasonable coverage of the dunes and of the zones beneath the water table.

3.7.6 DuPont RC Drilling and Sampling Procedure

DuPont's RC drilling was undertaken by Victor Drilling of Florida, USA, using a truck-mounted rig with large, specially treaded tyres to enable it to operate in sand dune conditions. The RC method used a high-pressure pump to force water down the inside of the inner rod and back up though the gap between the two rods, to raise the suspended cuttings that were recovered as a sample. The outer diameter of the outer rod was 1¾" or 44.5 mm.

3.7.7 DuPont Hand Auger Drilling and Sampling Procedure

DuPont's procedure was identical to MDLs procedure. DuPont tested the reliability of the sampling by randomly re-drilling a hole at or very near to the location of a previous hole. The difference between the geological description and the HM determination of the samples from the two holes was generally found statistically negligible.

The hand auger drilling was conducted on a grid spacing of 400 m north-south by 80 m east-west generally stopping at the water table (sometimes shallower if the hole was fairly deep).

3.8 Statistical Analysis of RC and Auger Drilling

In August 2007, AMC carried out a comparative analysis of heavy mineral percentage assays on samples taken from RC and auger drilling and compared these results with assay results from shaft bulk samples.

The findings of this study are contained in the AMC report, Comparative Analysis Of Mineral Sands Assays Between Bulk Samples from Shaft, RC and Auger Drilling, August 2007. The main conclusion from the study was the estimates of the heavy mineral grades from both types of drilling are comparable to the results of the control shaft samples. Both types of drilling can be used for obtaining samples for analysis that can be used in resource and/or reserve estimation.

The assay data from three shafts (Shafts 2, 3 and 4) were selected for the study using an arbitrary cut-off grade of 1.0% HM from the shafts. The corresponding sampling intervals (top and bottom) were then used to extract the assay results from both RC and auger drillholes. The extracted samples were averaged and used for the control charts.

The comparative study using control charts on the assays returned by the RC and auger drillholes on the one side and the shaft samples on the other showed that while individual drill sample assays differ from the shaft sample results the overall means of the drill samples do not depart significantly from the average grades returned by the samples from the shafts. This is to be expected as the shafts (2 m in diameter) provided bulk samples while the drillholes provided much smaller localised samples. The analysis has demonstrated that the drilling results lie within the acceptable 99% confidence band.

There is a tendency for the RC drill samples to underestimate the grade above the water table and to overestimate the grade below the water table. An RC sample taken above the water table has a closer correlation to the shaft than a sample taken from below the water table.

The auger drill samples yield results closer to the shaft samples. However, the auger drillholes generally terminated at the water table and therefore no comparison could be made with shaft samples below the water table.

Table 3.8 shows that the RC drillhole assays differ by 2% to 13%, averaging 7%, and the auger drillhole assays differ by 1% to 3%, averaging 2%, from the shaft samples. It should also be noted that when the zone with the highest difference in the RC drilling versus shaft results (Shaft 4) is removed, the overall average difference is reduced to 4.6%.

Table 3.8 Overall Weighted Average Grade Comparison of Shafts, RC and Auger Drillholes

Shaft	Depth (m)	Location	Shaft Average HM%	RC Drillholes		Auger Drillholes		Difference (%)	
				HM%	No. Holes	HM%	No. Holes	RC	Auger
2	2-8	Central	4.43	4.23	14	4.33	10	5	2
2	2-10	Northwest	4.16	3.88	11	4.05	6	7	3
2	2-10	Southeast	4.16	3.60	11	3.77	5	13	9
Average/Total			4.25	3.93	36	4.12	21	8	3
3	0-11	–	1.69	1.66	42	1.71	21	2	1
Average/Total			1.69	1.66	42	1.71	21	2	1
4	06	–	2.34	2.04	34	2.30	21	13	2
Average/Total			2.34	2.04	34	2.30	21	13	2
Weighted Average/Total			2.73	2.51	112	2.71	63	9	2

The individual variability of the sampling points is a function of the smaller size of the RC and auger samples when compared with the shaft samples and also may be due to the nature of the deposit where depositional interleaving of heavy minerals is common.

The study shows that average grades estimated from the auger drilling results are closer to the average grades of the shaft samples than the average grades estimated from the RC drilling results. It implies that auger drilling would be the preferred drilling method to assess the grade down to the water table.

3.9 Statistical analysis of DuPont and MDL Drilling

In May 2009, AMC conducted a study to assess the influence the DuPont drilling and MDL drilling was having on the resource estimate. The results from this study are detailed in the AMC memorandum “105080 MDL and DuPont Drilling - Resource Model Comparison”, May 2009.

Statistical analysis of the two drillhole databases found differences in HM grades between the DuPont and MDL drillhole databases. Overall, the MDL HM grades are lower than the DuPont HM grades, most likely a result of the earlier holes (DuPont) being widely sampled and possibly preferentially sampling areas of higher grade. See Table 3.9 for results for composited DuPont and MDL drillhole data. Figure 3.6 shows the log probability plot of HM% for the DuPont and MDL drillhole data.

Table 3.9 Sample Statistics for the Composited DuPont and MDL Drillhole Data (as at May 2009)

Dataset	No. Holes	No. Samples	%HM Maximum	%HM Minimum	%HM Mean
DuPont	1,833	15,014	14.77	0	1.51
MDL	7,358	109,843	14.89	0	1.18

Figure 3.6 Log Probability Plot of %HM - DuPont and MDL Drillholes

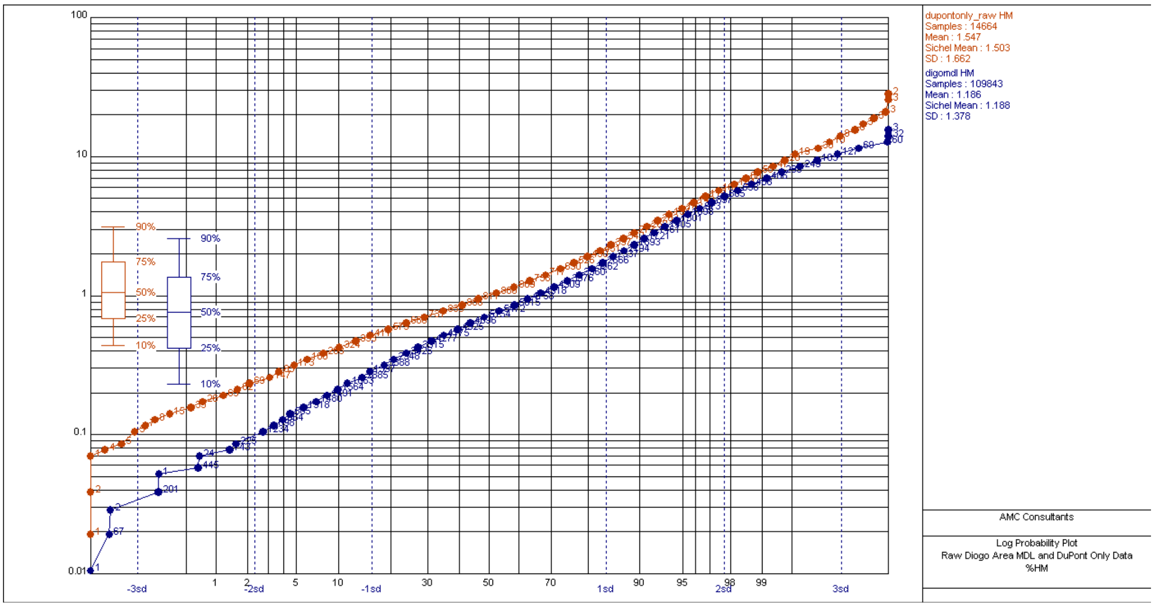


Figure 3.7, Figure 3.8 and Figure 3.9 show the log histogram of HM% for the total DuPont and MDL drillhole database, the HM% for DuPont and MDL auger drillhole database and the HM% for DuPont and MDL RC drillhole database respectively.

Figure 3.7 shows there is reasonable correlation between the distributions, despite the MDL drilling having a lower mean HM% grade. The increase in the mean grade for the DuPont drilling may be due to it preferentially sampling areas of higher grade.

Figure 3.7 Log Histogram of %HM DuPont and MDL Drillholes

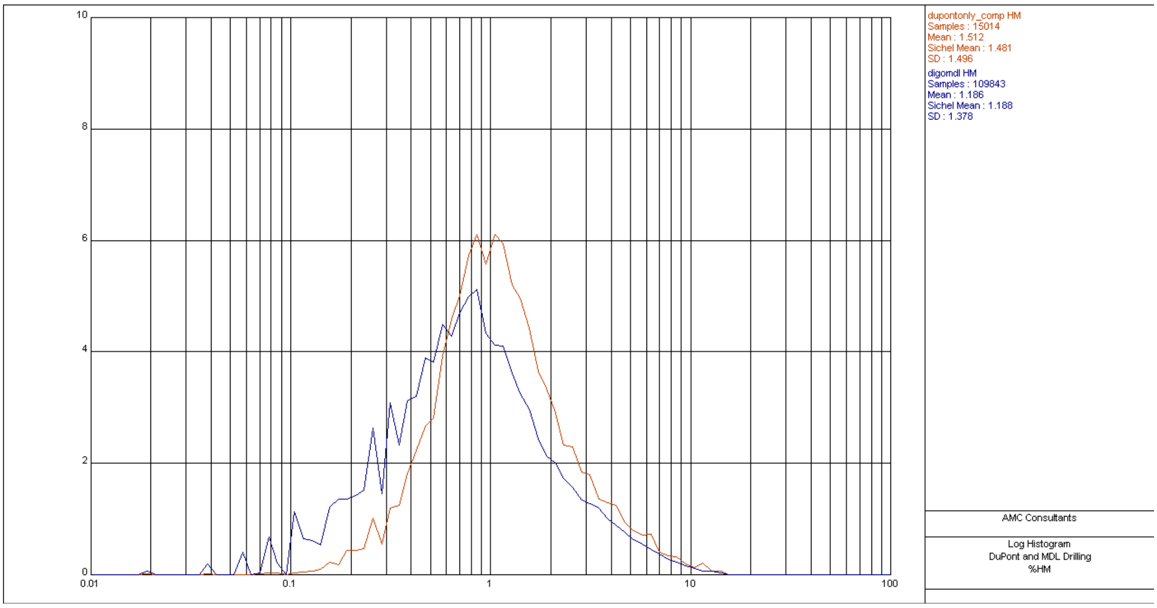


Figure 3.8 shows very good correlation between the MDL and DuPont auger holes. This supports the previous comments that drilling and sampling methods used by MDL and DuPont were identical, and suggests that the hand augering achieves better sample recoveries and a more representative sample, as overall the HM% grades are higher than the RC drilling results.

Figure 3.9 shows that the MDL RC drilling has lower HM% grade than the DuPont drilling. MDL use air core RC method, while DuPont used water injected RC method. It has been suggested that the RC drill samples have a tendency to underestimate the grade above the water table and to overestimate the grade below the water table. The reason why the MDL RC holes are lower in grade than DuPont RC is unclear.

The different methods may be resulting in the grade differences.

Figure 3.8 Log Histogram of %HM DuPont and MDL Drillholes Hand Auger

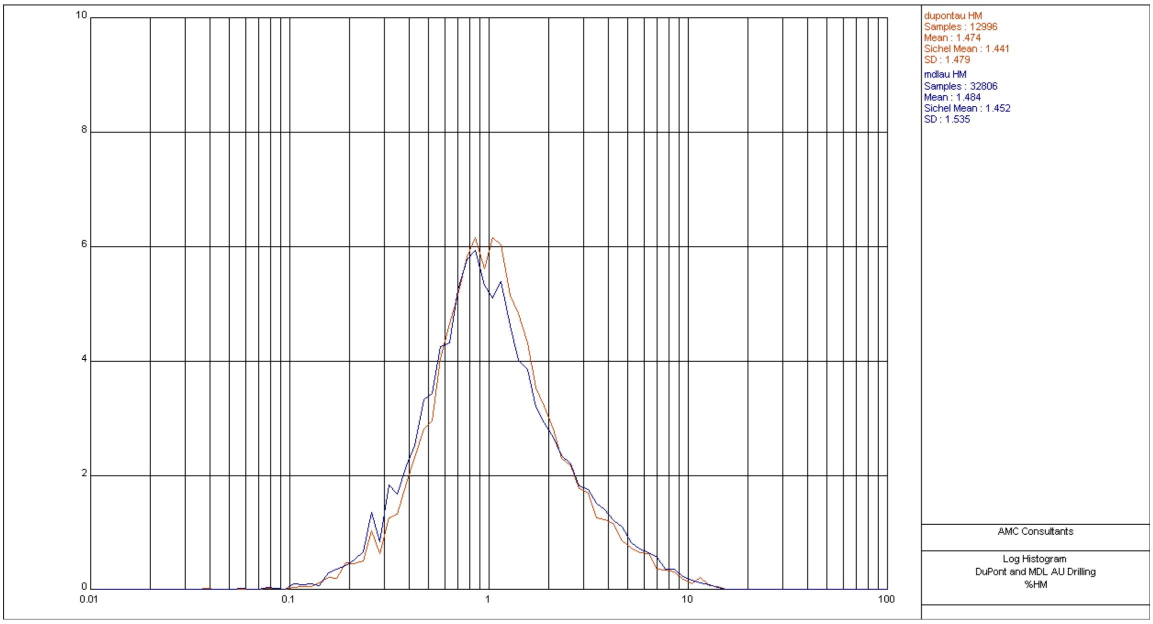
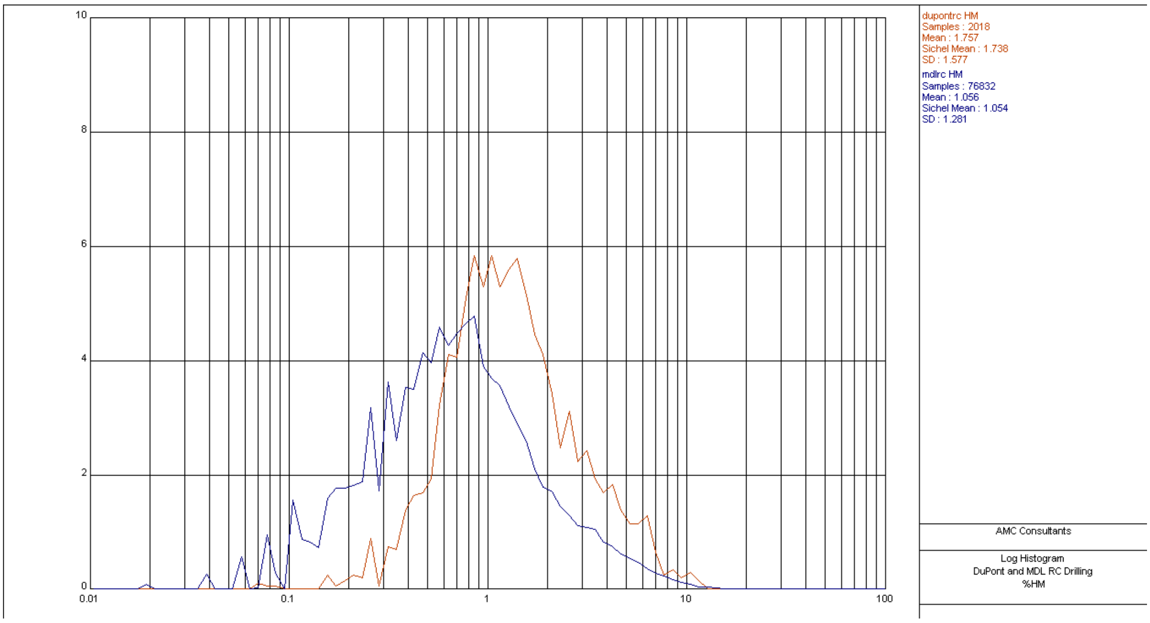


Figure 3.9 Log Histogram of %HM DuPont and MDL Drillholes RC



The difference in the average grades for the RC holes prompted the investigation into how much influence these differences were having on the block model grades. The block model estimated using DuPont drilling only resulted in higher total HM grade and tonnes, especially below the water table where only limited RC drilling (with possible overestimated grades) influences the block model. Other reasons for the increase in grade and tonnes using the DuPont RC drillholes only are mainly due to the limited data available for block grade estimation resulting in each hole having an influence on a large area of the deposit.

Figure 3.10 shows the block model estimated using DuPont RC data only.

MDL RC drillhole target depths were 8 m below the water table. This provided more data across the deposit and especially at depth. The block model estimated with all available data resulted overall in lower tonnes and HM grades. AMC is confident the combined data (MDL and DuPont) is resulting in a block model that more accurately represents the HM% grade distribution across the deposits as the MDL drilling is generally infill drilling supplying additional data a depth limiting the smearing of the higher grades higher up the sand dune.

Figure 3.11 shows the block model estimated using all RC data.

Figure 3.10 Resource above 6 m below Water Table - DuPont Only Drillholes

(Section 699604N)

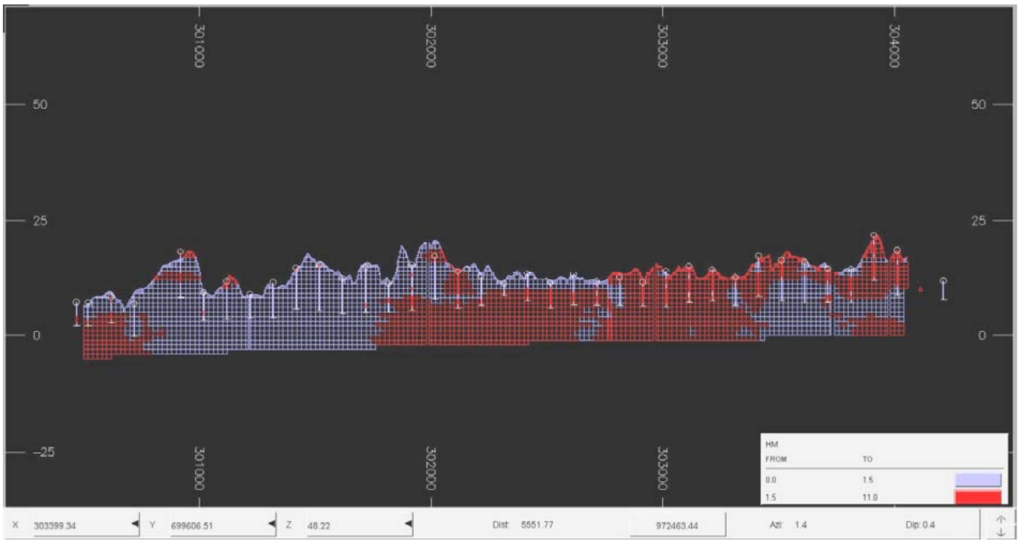
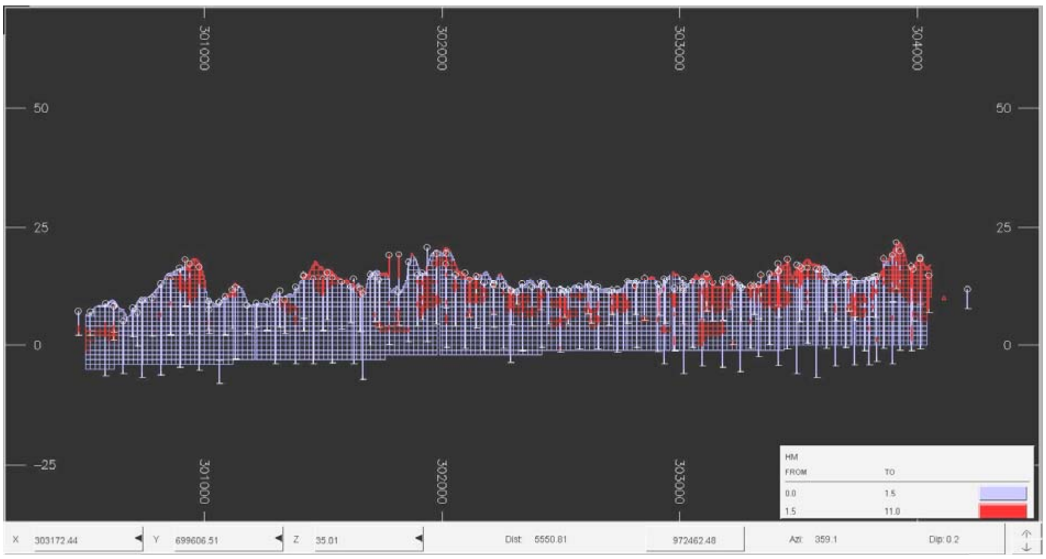


Figure 3.11 Resource above 6 m below Water Table - All Drillholes

(Section 699604N)



3.10 AMC Comments

In general, HM grades estimated from the RC and auger drilling results are comparable to the grades returned by the samples from the control shafts and therefore it follows that both types of drillhole data can be used for resource and/or reserve estimation.

The MDL and DuPont results for hand augering are comparable and appropriate to use in the resource estimates, as they provide the most accurate representative samples, due to good recoveries. The main disadvantage for this method is most auger samples terminate above the water table.

AMC has not found a definitive reason for the difference in the grade distribution of the DuPont and MDL RC drilling.

AMC is confident the resource estimation using the combined data (MDL RC and auger and DuPont RC and auger) is resulting in a block model that accurately represents the HM% grade distribution across the deposits.

3.11 Quality Assurance and Control

3.11.1 Introduction

AMC reviewed the quality assurance and quality control (QA/QC) protocol used by MDL. This section of the report includes for completeness excerpts from the report prepared by AMC Principal Geologist P.R. Stephenson, who qualifies as a Competent Person in terms of the JORC Code.

3.11.2 MDL's Sampling/Assaying QA/QC Procedures

MDL's on-site training and laboratory setup was supervised by consultant chemist Mr B.Woodward from Perth, Western Australia. Mr Woodward, who has over 30 year's laboratory experience, prepared a comprehensive laboratory manual giving clear instructions on procedures for the laboratory quality system.

Laboratory quality control measures include the use of prepared bulk standards for daily laboratory accuracy checks, daily checks of the specific gravity of the LST heavy media fluid, and assaying of a random duplicate from each drillhole by an Australian umpire laboratory. The umpire laboratory uses tetrabromoethane (TBE) for its heavy media separation. Electronic balance equipment is maintained by means of standard weights. Data entry is routinely checked by the laboratory supervisor.

QA/QC procedures include the use of internal laboratory standards made from Grande Côte mineralised sands as three bulks: low, medium and high grade. One standard is chosen at random for a daily check of laboratory accuracy. The laboratory supervisor collates and examines the results for the standards and prepares a comparative table with a Shewhart chart for examination of the consistency of results.

In November 2009, AMC was provided with all the known results for low-grade HM and medium-grade HM standards.

AMC generated a scatter plot of the standard results to determine the precision and accuracy of the laboratory. Figure 3.12 and Figure 3.13 show the standards checks for all low-grade HM and medium-grade HM standard data to November 2009.

The standard HM grade for the medium-grade batch is 2.055% with 0.087% standard deviation. The standard HM grade for the low-grade batch is 1.065% with 0.075% standard deviation.

The number of low-grade HM% standard samples total 1,722. Greater than 85% of the standards fell within two standard deviations of the mean (1,551 samples out of 1,722). This suggests the laboratory is performing well. The number of medium-grade HM% standard samples total 1,425. Greater than 90% of the standards fell within two standard deviations of the mean (1,372 samples out of 1,425). This suggests the laboratory is performing well.

Figure 3.12 Scatter Plot for Low-grade HM% Standard Checks, April 2010

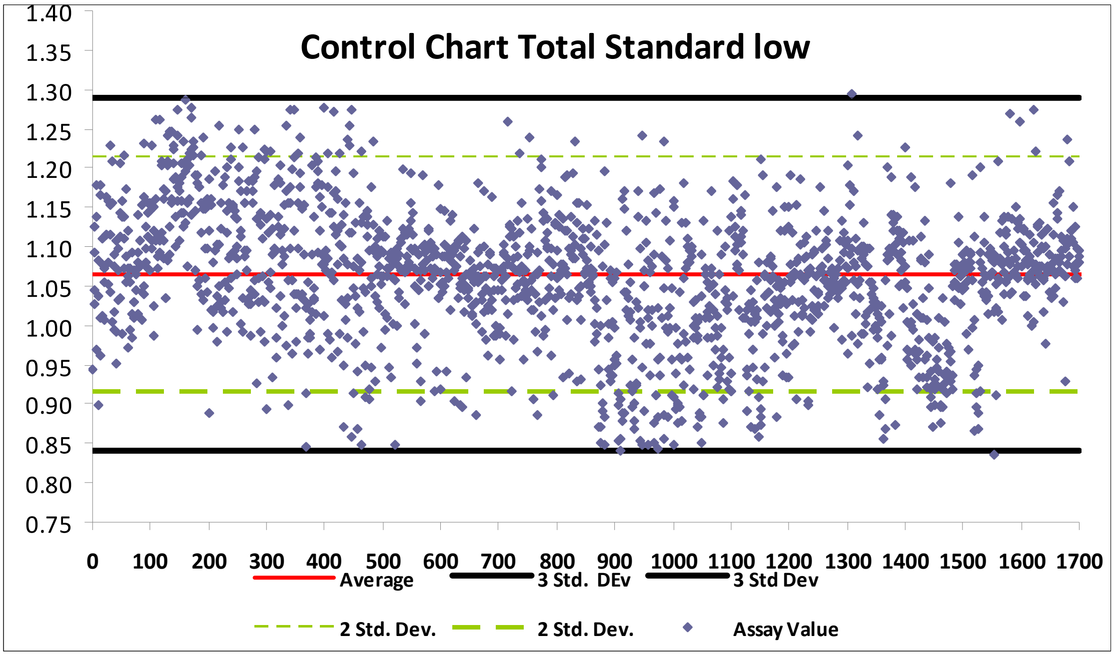
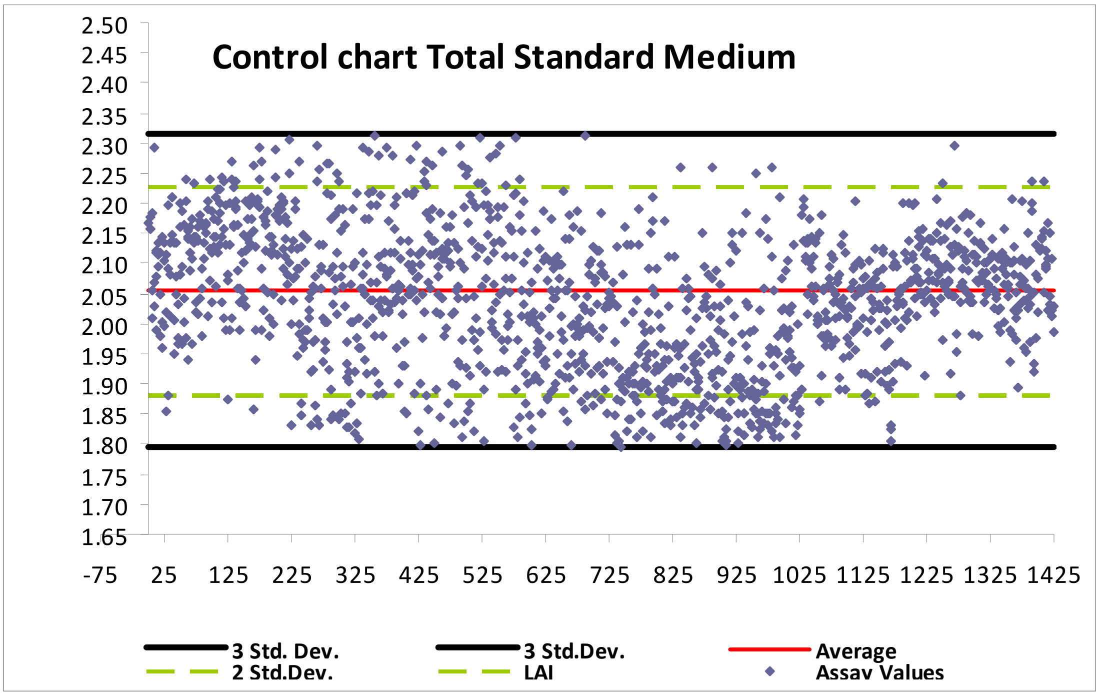


Figure 3.13 Scatter Plot for Medium-grade HM% Standard Checks, April 2010



Umpire sample duplicates are taken nominally at the ratio of 1:20, but often at a greater frequency, being one random sample per drillhole. The outside laboratory work is time consuming in that it requires a licence to export the samples from Senegal to Australia and then sterilisation of the samples at entry to Australia by Australian Customs Service.

Currently there are 2,590 umpire sample duplicates. The correlation graph (Figure 3.14) indicates the original MDL sample data (Tivaouane laboratory) may have a high-grade bias. The mean grade for the original assays above 2 HM% is higher than the duplicate assays. The HM Repeatability Plot Deviation (RPD) plot (Figure 3.15), show only 47% of the pairs with <10% RPD (recommended 80%) which also shows the data is biased and it is not precise. AMC recommends further investigation of the QA/QC data, based on these poor results. No batch or date information was provided at the time of the AMC review of the duplicates.

Figure 3.14 Correlation Plot MDL Results (Tivaouane) versus Outside Laboratory Checks (Diamond Recovery Services Limited)

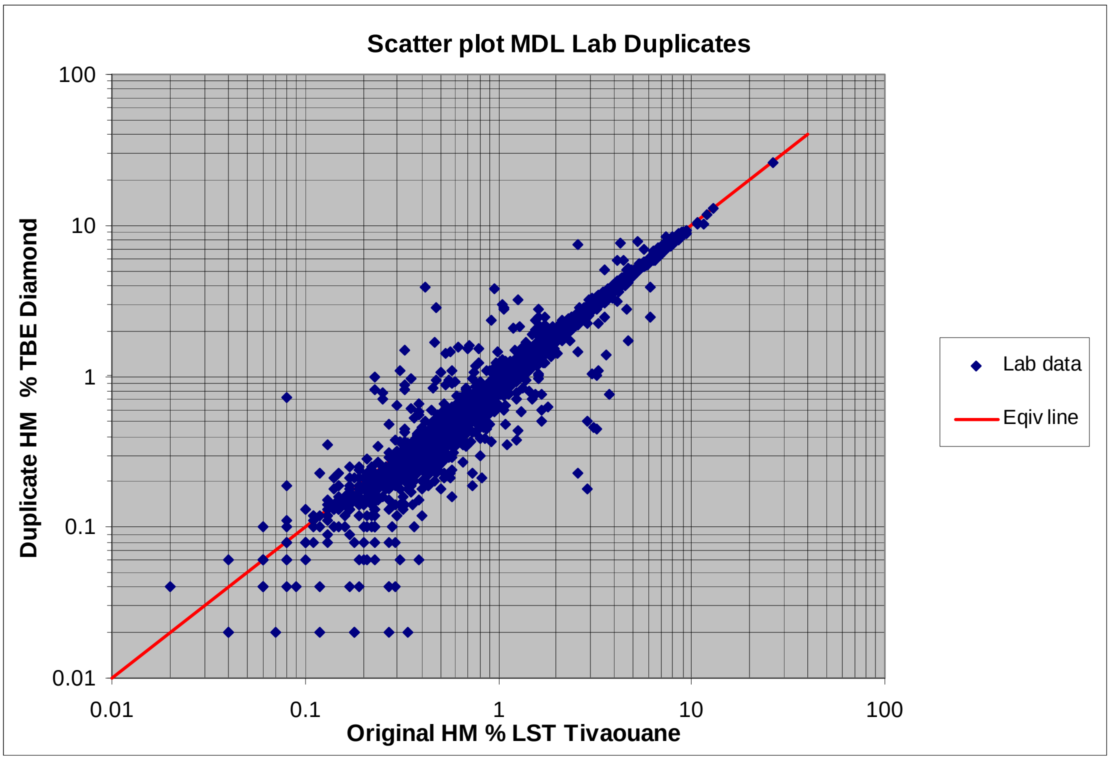
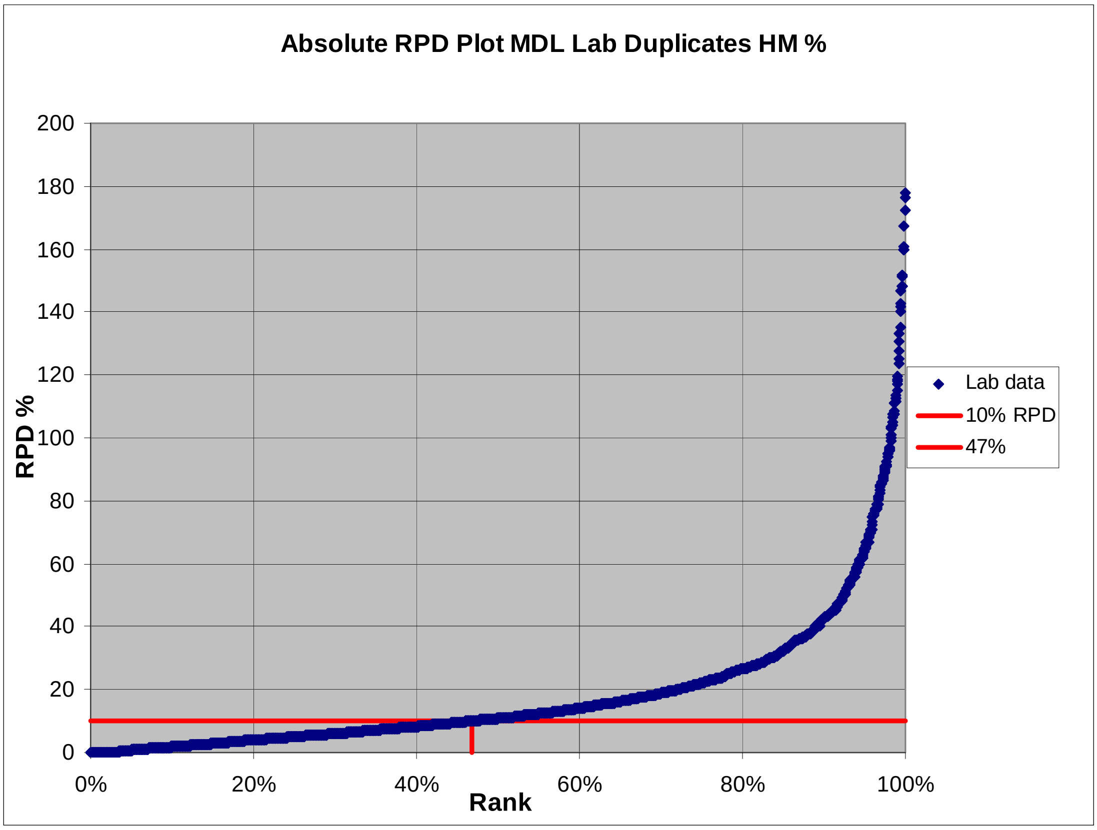


Figure 3.15 Absolute RPD Plot for HM% Laboratory Duplicate Samples from MDL



3.11.3 DuPont's Sampling/Assaying QA/QC Procedures

DuPont undertook rigorous comparative analysis of Magstream results with HM% results using the heavy liquid TBE. Samples were randomly selected and divided into two representative fractions. One fraction was separated using Magstream at a specific gravity (SG) split point equivalent to 2.96 g/ml; and the other fraction was separated by sink-float procedures using TBE at a SG of 2.96 at 20ºC. Results displayed excellent comparability, as shown in Table 3.10.

Table 3.10 DuPont, Comparison between Magstream and TBE Results

	Magstream	Heavy Liquid (TBE)
Average HM%	2.64	2.64
Variance	0.75	0.8
Standard Deviation	0.86	0.89
Relative Std. Dev.	0.326	0.337

3.11.4 Validation of DuPont Drillhole Database

The DuPont drillhole database was validated by MDL using both automated and manual procedures. The process was greatly assisted by having access to the original DuPont drill logs, survey records, sample sheets, assay sheets and plans. All DuPont assay record sheets were scanned and are available in digital form. Geological logs have yet to be scanned.

Validation of the DuPont database included:

- Automatic testing of hole-spacing consistency for adjacent line-hole numbers resulting in the location of a number of coordinate data entry errors. These were corrected using original hard copy data.
- Assay from/to sequences and HM% calculations from Magstream feed and product weights were checked and found to be mostly free from errors. Errors detected were corrected.
- Validation of the location of early RC holes drilled on an irregular pattern was difficult. Some location errors were found and corrected; however, there are instances where collar RLs of RC holes appear incompatible with those of proximal hand auger holes. Field checking is resolving these differences wherever possible.
- A number of key points from the DuPont grid were located and preserved in concrete and relocated by MDL (Figure 3.16). Registered surveyor BetPlus located these tie points enabling the DuPont grid to be reconfigured in the UTM grid.

All reasonable efforts have been made by MDL to validate the DuPont exploration data and AMC believes the data is of a suitable standard.

Figure 3.16 Concrete Location Marker

3.11.5 AMC Comments

In 2007, P. R. Stephenson stated in his report that he had examined QA/QC data at MDL's Tivaouane laboratory and is satisfied that the procedures are being implemented to good industry standards and that the results demonstrate that MDL's HM determinations are reliable and an appropriate basis for mineral resource estimation and project development. On the basis of the documented results for DuPont's QA/QC procedures, he is also satisfied that the DuPont HM determinations are reliable and an appropriate basis for mineral resource estimation and project development.

However, the results from the QA/QC analysis conducted by AMC in 2009 suggest there may be a bias with either the MDL Tivaouane laboratory overstating the HM grades or the check laboratory understating the HM grades. Further investigation is recommended to assess the impact this bias may have on future mineral resource estimates. It is considered that the bias will not have a material impact on the current resource and reserve estimates.

3.12 Bulk Density

This bulk density data has been previously reviewed in an AMC report by P. R. Stephenson in 2007. Bulk density data from that report is listed in Table 3.11. MDL's bulk density data has a limited range of variability from 1.67 t/m^3 to 1.80 t/m^3, with an average 1.75 t/m^3.

Table 3.11 MDL Bulk Density Measurements to end March 2007

Sample No	Dry Weight (g)	Volume (litre)	Bulk Density (g/ml = t/m^3)
DGBD001	1274.50	0.737	1.73
DGBD002	1293.08	0.737	1.75
DGBD003	1228.62	0.737	1.67
DGBD004	1295.48	0.737	1.76
DGBD005	1313.52	0.737	1.78
DGBD006	1325.84	0.737	1.80
DGBD007	1314.78	0.737	1.78
DGBD008	1271.84	0.737	1.73
DGBD009	1306.14	0.737	1.77
DGBD010	1319.46	0.737	1.79
DGBD011	1267.38	0.737	1.72
DGBD012	1295.64	0.737	1.76
DGBD013	1274.86	0.737	1.73
DGBD014	1317.04	0.737	1.79
DGBD015	1236.46	0.737	1.68
DGBD016	1309.52	0.737	1.78
DGBD017	1323.00	0.737	1.80
DGBD018	1277.68	0.737	1.73
DGBD019	1245.40	0.737	1.69
DGBD020	1273.72	0.737	1.73
DGBD021	1313.58	0.737	1.78
DGBD022	1288.68	0.737	1.75
DGBD023	1232.86	0.737	1.67
DGBD024	1279.06	0.737	1.74
DGBD025	1272.60	0.737	1.73
DGBD026	1312.26	0.737	1.78
Average			**1.75**

MDL requested a conservative density of 1.7 t/m^3 to be used throughout the deposit, for resource and reserve estimation.

3.13 Mineral Resource Estimate

3.13.1 Introduction

A mineral resource was estimated for the Diogo, Mboro, Fass Boye and Lompoul areas of the deposit. Combined MDL and DuPont RC and auger drilling was used in the estimate. The topographic surface was based on accurate surveyed data and the depth of the water table on 337 piezometer holes.

A block model was used to define the resource volume and HM grades were estimated into each parent block using ordinary kriging (OK).

The resource estimate has been reported assuming the deposit will be mined by dredging where the total thickness of the sand will be mined to 6 m below the water table. For reporting the total sand accumulated to 6 m below the water table, above a cut-off of 1.25% HM, has been classified as Measured, Indicated and Inferred based on the drillhole spacing and available information on the watertable level.

3.13.2 Geological Model

The area consists of mobile dunal sand system, typically asymmetric, rising from about 10 m immediately inland from the fore-dune area to an average of 20 m before terminating at a high and steep-faced inland dune. Heights are variable and may reach more than 35 m. The average height of the topography in the dunal area is 13.3 m. The average width of the dune field is 2 km and reaches up to 4.5 km inland. The dunes and the sand mass in general appear to increase in size and height north-eastward from Mboro to Lompoul.

3.13.3 Drillhole Database

Details of the drillhole sample data using in the resource estimate are listed in Table 3.12. Drillhole collars that were more than 3 m above or below the topographic wireframe surface were considered to have errors in their collar position and were therefore removed from the dataset before estimation. The drillholes removed are listed in Table 3.13.

Table 3.12 Drillhole Data used in April 2010 Resource Estimate

Type	DuPont			MDL			Total		
	No. Holes	Metres Drilled	Ave. Hole Length	No. Holes	Metres Drilled	Ave. Hole Length	No. Holes	Metres Drilled	Ave. Hole Length
RC	535	10,211	19.1	7,750	150,665	19.6	8,285	160,876	19.6
Auger	7,893	28,852	3.7	4,569	45,203	9.9	12,462	74,055	5.9
Total	8,428	39,063		12,319	195,868		20747	234,931	

Table 3.13 Drillholes Removed due to Errors with the Collar Position

AUFP0507	AUFP5911	AULP0211	AULP2307	DKRC0007	RCFR108	RCLR213
AUFP0511	AUFP5915	AULP0213	AULP2433	DKRC0009	RCFR109	RCLR228
AUFP0604	AUFP6003	AULP0217	AULP2730	DKRC0010	RCFR110	RCLR231
AUFP0605	AUFP6005	AULP0300	AULP2733	DKRC0011	RCFR111	RCLR232
AUFP0609	AUFP6006	AULP0301	AULP2734	LPRC0307	RCFR112	RCLR233
AUFP0610	AUFP6036	AULP0302	AULP2808	LPRC0466	RCFR115	RCLR238
AUFP0707	AUFP6106	AULP0303	AULP2826	LPRC0504	RCFR117	RCLR248
AUFP0709	AUFP6109	AULP0304	AULP3012	RCFR002	RCFR123	RCMR009
AUFP0711	AUFP6130	AULP0305	AULP3026	RCFR003	RCFR136	RCMR017
AUFP0802	AUFP6211	AULP0308	AULP3034	RCFR004	RCLR020	RCMR025
AUFP0808	AUFP6212	AULP0309	AULP3103	RCFR008	RCLR021	RCMR027
AUFP0901	AUFP6302	AULP0317	AULP3116	RCFR009	RCLR023	
AUFP0905	AUFP6317	AULP0401	AULP3202	RCFR010	RCLR026	
AUFP0906	AUFP6413	AULP0405	AULP3210	RCFR012	RCLR032	
AUFP0907	AUFP6525	AULP0406	AULP3236	RCFR013	RCLR033	
AUFP1006	AUFP6526	AULP0408	AULP3241	RCFR015	RCLR038	
AUFP1007	AUFP6616	AULP0409	AULP3314	RCFR017	RCLR040	
AUFP1009	AUFP6711	AULP0422	AULP3502	RCFR019	RCLR041	
AUFP1020	AUFP6713	AULP0501	AULP3602	RCFR020	RCLR042	
AUFP1104	AUFP6800	AULP0503	AULP3610	RCFR023	RCLR043	
AUFP1111	AUFP6816	AULP0504	AUMP3935	RCFR024	RCLR044	
AUFP1203	AUFP6818	AULP0505	AUMP4113	RCFR025	RCLR045	
AUFP1814	AUFP6825	AULP0509	AUMP4119	RCFR026	RCLR046	
AUFP2002	AUFP6902	AULP0518	AUMP4138	RCFR027	RCLR047	
AUFP2106	AUFP6904	AULP0607	AUMP4421	RCFR028	RCLR048	
AUFP2108	AUFP6908	AULP0703	AUMP4439	RCFR029	RCLR049	
AUFP2109	AUFP6910	AULP0705	AUMP4502	RCFR031	RCLR050	
AUFP2129	AUFP6917	AULP0738	AUMP4523	RCFR033	RCLR051	
AUFP2130	AUJP0105	AULP0801	AUMP4615	RCFR035	RCLR052	
AUFP2206	AUJP0203	AULP0808	AUMP4819	RCFR036	RCLR058	
AUFP2209	AUJP0303	AULP0908	AUMP5141	RCFR037	RCLR061	
AUFP2309	AUJP0312	AULP0931	AUMP5147	RCFR049	RCLR062	

AUFP2311	AUJP0400	AULP1008	AUMP5148	RCFR050	RCLR063	
AUFP2336	AUJP0411	AULP1024	DGAU0242	RCFR053	RCLR064	
AUFP2406	AUJP0509	AULP1028	DGAU0367	RCFR059	RCLR065	
AUFP2417	AUJP0513	AULP1037	DGAU1436	RCFR064	RCLR067	
AUFP2422	AUJP7135	AULP1038	DGRC0172	RCFR065	RCLR079	
AUFP2424	AUJP7200	AULP1109	DGRC0260	RCFR066	RCLR080	
AUFP2508	AUKP0302	AULP1636	DGRC0445	RCFR069	RCLR081	
AUFP2610	AUKP8025	AULP1637	DGRC0458	RCFR078	RCLR082	
AUFP2613	AULP0104	AULP1728	DGRC0460	RCFR079	RCLR084	
AUFP2614	AULP0106	AULP1826	DGRC0501	RCFR080	RCLR089	
AUFP2629	AULP0109	AULP1834	DGRC0622	RCFR082	RCLR091	
AUFP2634	AULP0110	AULP2002	DGRC0882	RCFR083	RCLR094	
AUFP2826	AULP0111	AULP2014	DGRC2235	RCFR084	RCLR099	
AUFP2831	AULP0114	AULP2111	DKRC0001	RCFR087	RCLR110	
AUFP2929	AULP0136	AULP2205	DKRC0003	RCFR094	RCLR119	
AUFP3000	AULP0205	AULP2207	DKRC0004	RCFR096	RCLR130	
AUFP3222	AULP0206	AULP2233	DKRC0005	RCFR099	RCLR136	
AUFP3300	AULP0208	AULP2304	DKRC0006	RCFR103	RCLR187	

3.13.4 Geological Modelling (3D Shape Generation)

It was not considered necessary to subdivide the sand for resource estimation based on the different sand units following a review of the results of dividing the sand into the upper unit (yellow sand) and lower unit (white sand).

The deposit was divided in the north direction into three domains for modelling to allow for minor changes in the mineralisation (Figure 3.17).

3.13.5 Coordinate Units

All coordinate units used in this report are in metres. Two coordinate systems are mentioned in the report. The dataset was provided to AMC in Universal Transverse Mercator, Northern Hemisphere Projection, Zone 28, WGS84 Datum.

For modelling AMC subtracted one million from the north coordinate, contained in dataset to prevent errors due to rounding of large numbers. All data was also rotated by -35° around the Z plane, so that it was orthogonal to the coordinate system. Coordinates in the RL direction (Z plane) were not changed. Details of the rotation are contained in Table 3.14.

Figure 3.17 Plan Showing Domain Boundaries

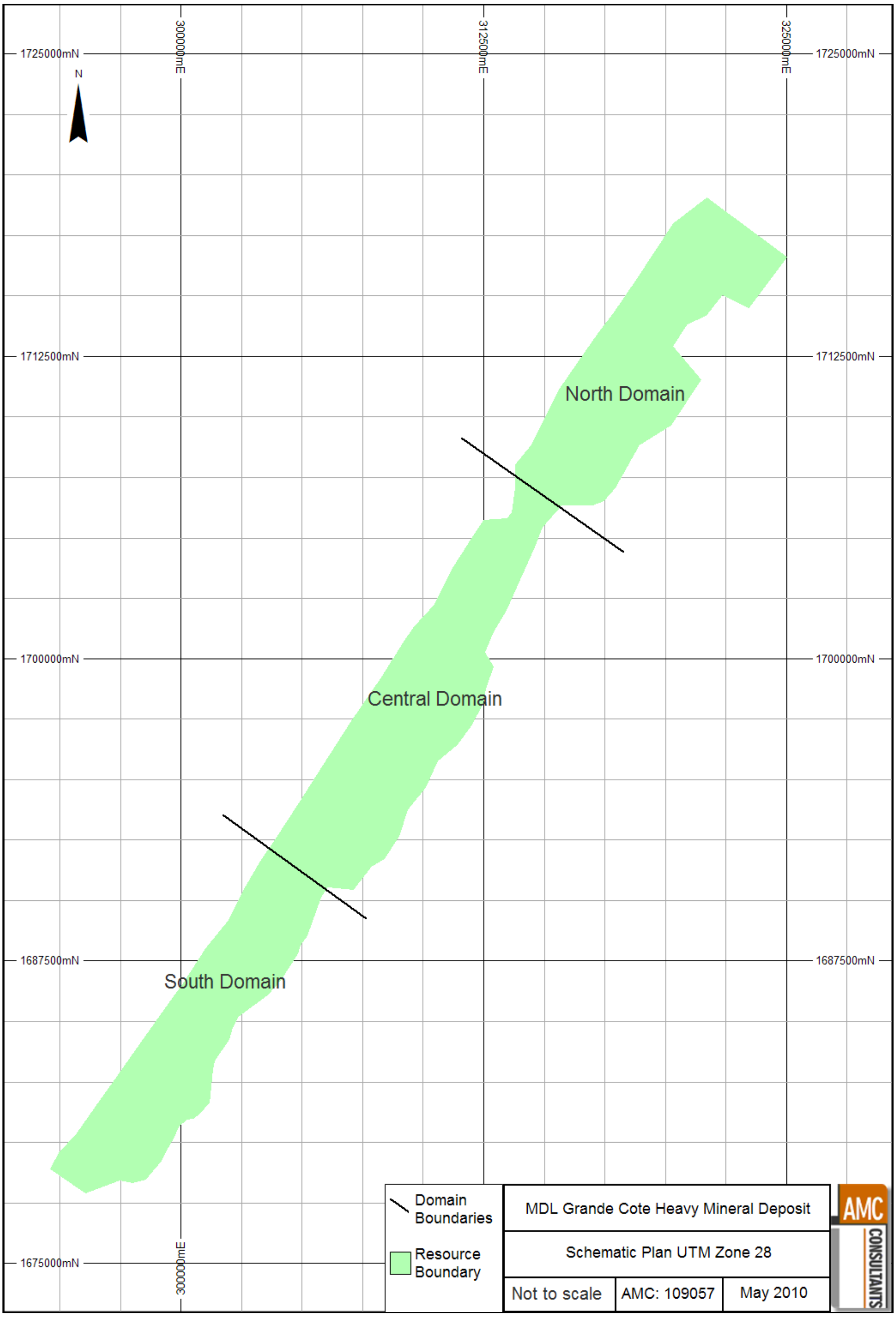


Table 3.14 Rotation Summary

Rotation	–35° Azimuth
Original X coordinate	310339.8
Original Y coordinate	1697683
Rotated X coordinate	296831.3
Rotated Y coordinate	703160.3

3.13.6 Topography

A detailed digital terrain model was produced by MAPS Geosystems of Dubai - a division of Fugro. This DTM was based on detailed aerial photography of the entire Exploration Permit area, flown by MAPS in early 2008.

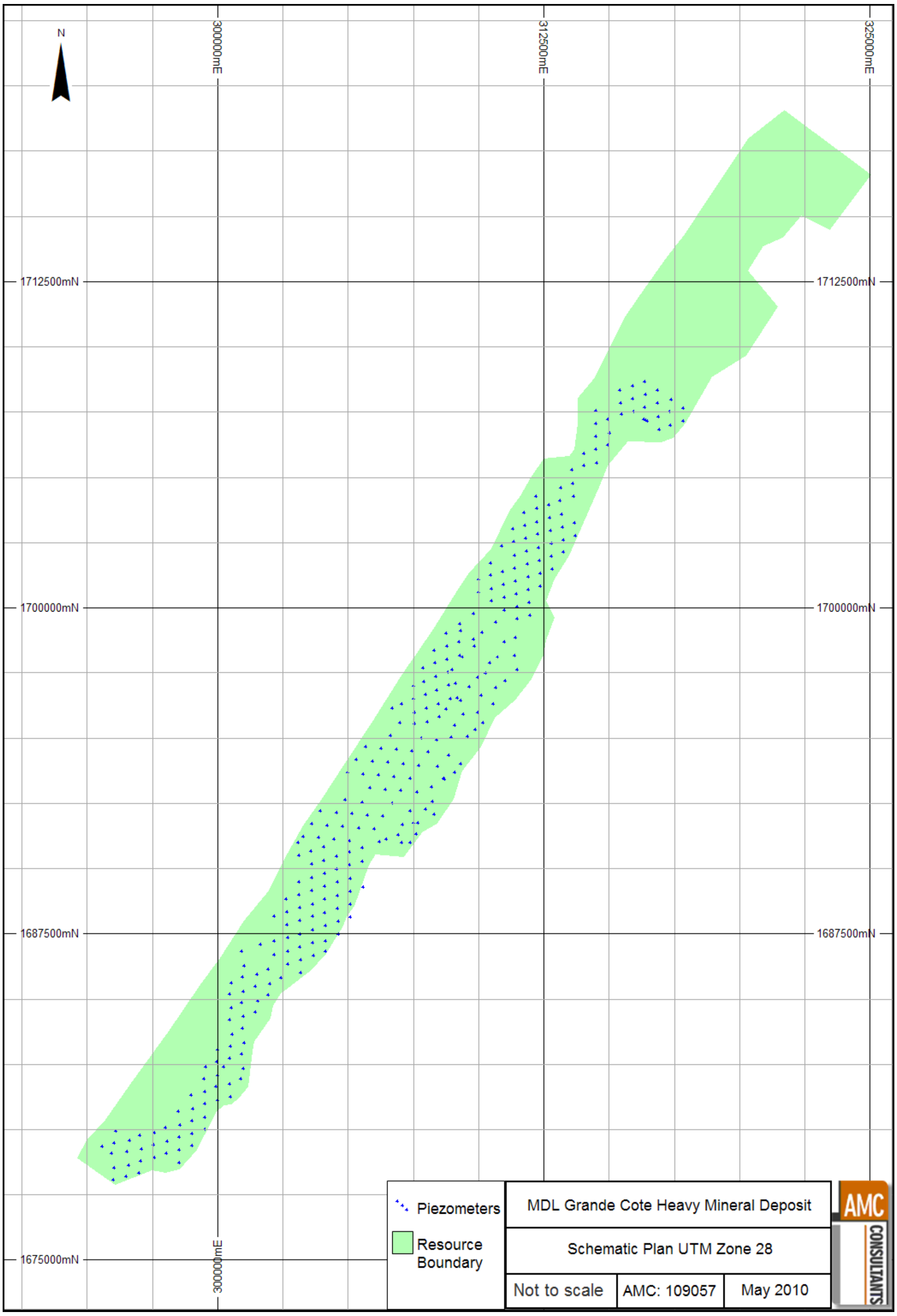
Colour aerial photography was undertaken at a scale of 1:12,000 (approx) with GPS location based on surveyed ground control points. MAPS utilised a refined automated procedure for the measurement of automated terrain models using Autometric's SoftPlotter software, by which a very dense grid of points is measured and then, using distance and correlation coefficient weighting, sub-sampled to the required grid spacing. The large redundancy of measurements and conditional filtering allowed a high accuracy to be achieved. Scanning of the aerial photography with a resolution of 15 microns created a grid of points with a grid spacing of 20 m. The data was also processed to form contour lines at 2 m intervals.

3.13.7 Water Table

The water table used to report resources is a based on a wireframe surface modelled on the average of 326 piezometer readings for the year from 31 March 2009 to 31 March 2010. The piezometer locations are shown in Figure 3.18. There are no piezometer readings north of 1,708,600 mN UTM Zone 28 (715,650 mN in the translated coordinate system). For this northern area, the cross-section of the water table at approximately 715,000 mN was projected northward and a surface was modeled using the projected data.

Two drillholes, DIRC0169 and DGRC2569, are associated with piezometer readings that are outside the trend observed in the adjacent data. They were considered to be outliers and were removed from the dataset before generating the wireframe surface.

Figure 3.18 Plan Showing Piezometer Locations



3.13.8 Raw Assay Statistics

The HM grade statistics for the raw drillhole 1 m samples are shown in Table 3.15.

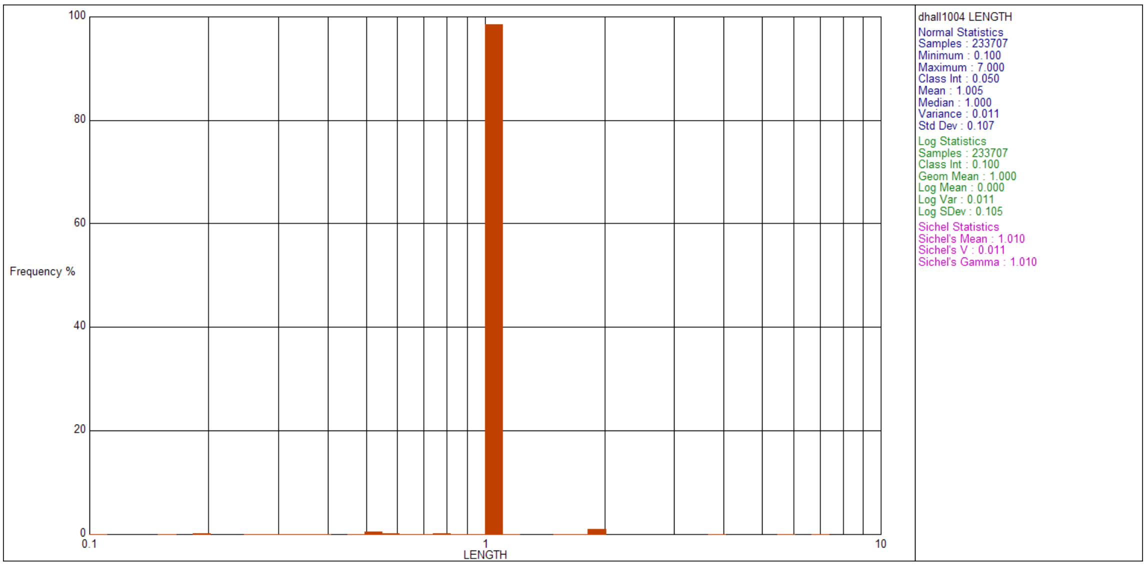
Table 3.15 HM Grade Statistics for the raw Drillhole Data (1 m samples)

No. of Samples	Minimum	Maximum	Mean	Median	Std. Dev.	Coefficient of Variation
233,178	0	42.15	1.2	0.7	1.5	1.2

3.13.9 Sample Compositing

Sample compositing was not conducted as more than 98% of the drillhole intervals were sampled on 1 m intervals the size of the blocks in the vertical direction used to model the deposit (Figure 3.19).

Figure 3.19 Log Histogram of Sample Lengths for all Drillholes used in the Resource Estimate



3.14 Correlations

MDL requested AMC to conduct a resource estimate for total HM grade only, and therefore it was not necessary to investigate any grade correlations.

Plotting northings against HM% indicates that there are two natural breaks in the HM grades located at 713,200 mN and 694,700 mN (Figure 3.20). These northings were used to divide the dataset into the northern, central and southern domains during resource estimation. No other domains were indicated from the scatter plots of eastings versus HM grade (Figure 3.21) or RL versus HM grade (Figure 3.22). The scatter plot of HM grade versus depth indicates that most of the higher grades are encountered near the surface (Figure 3.23).

Figure 3.20 Scatter Plot of Northing versus HM%

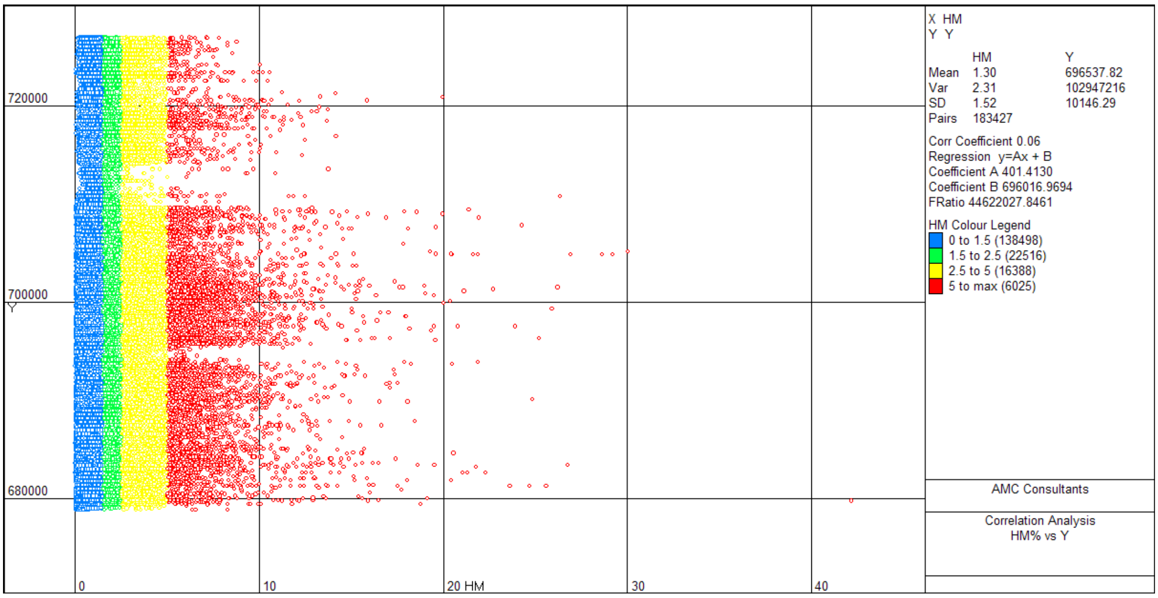


Figure 3.21 Scatter Plot of Easting versus HM%

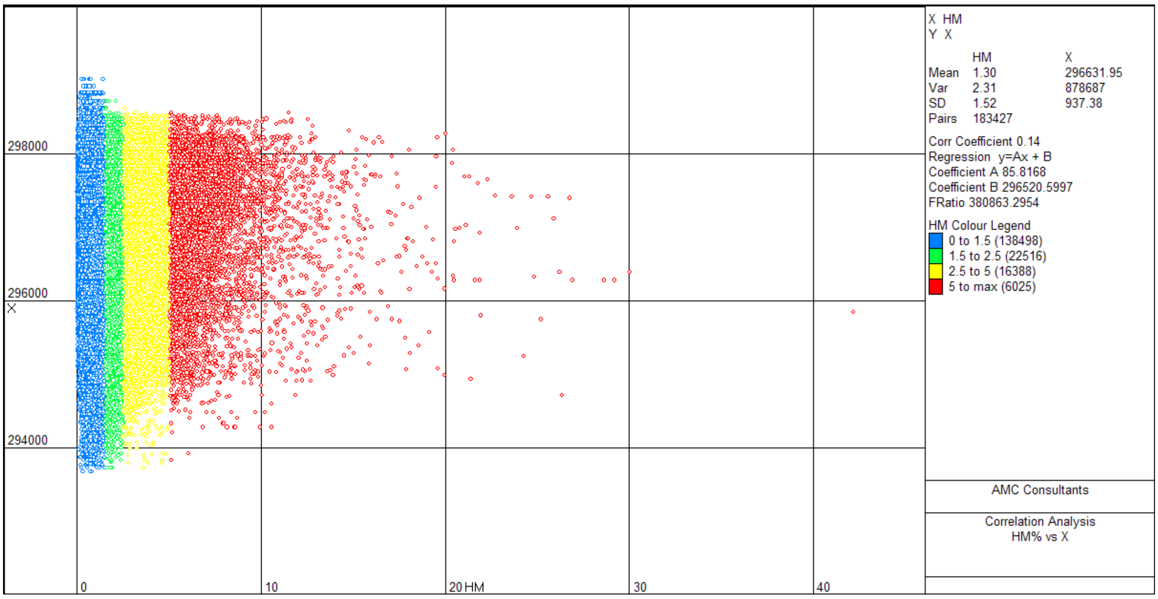


Figure 3.22 Scatter Plot of RL versus HM%

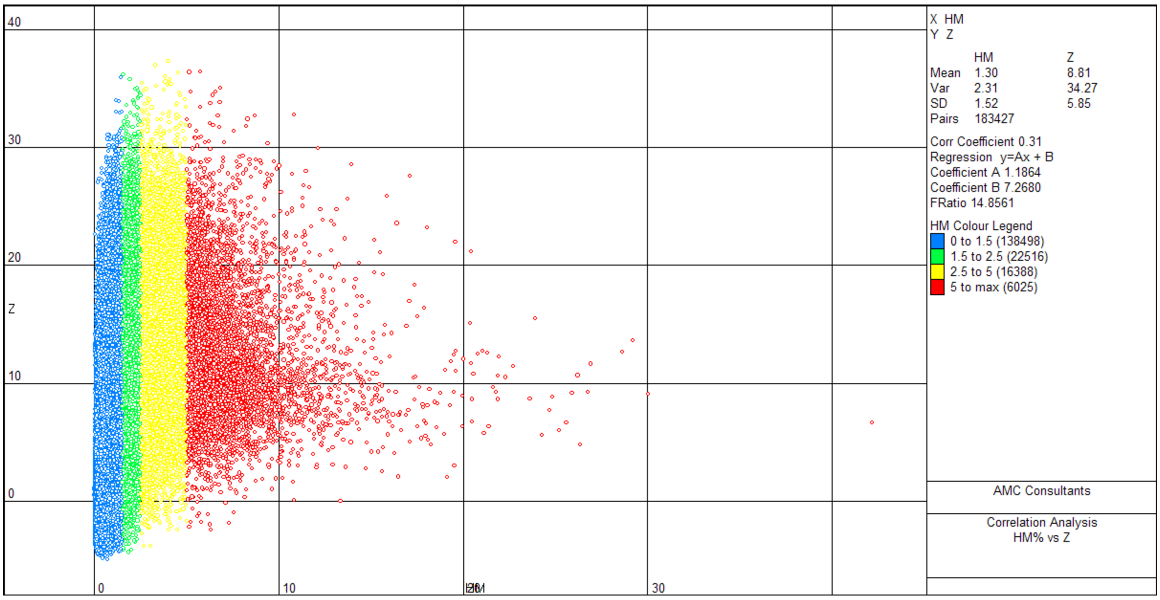
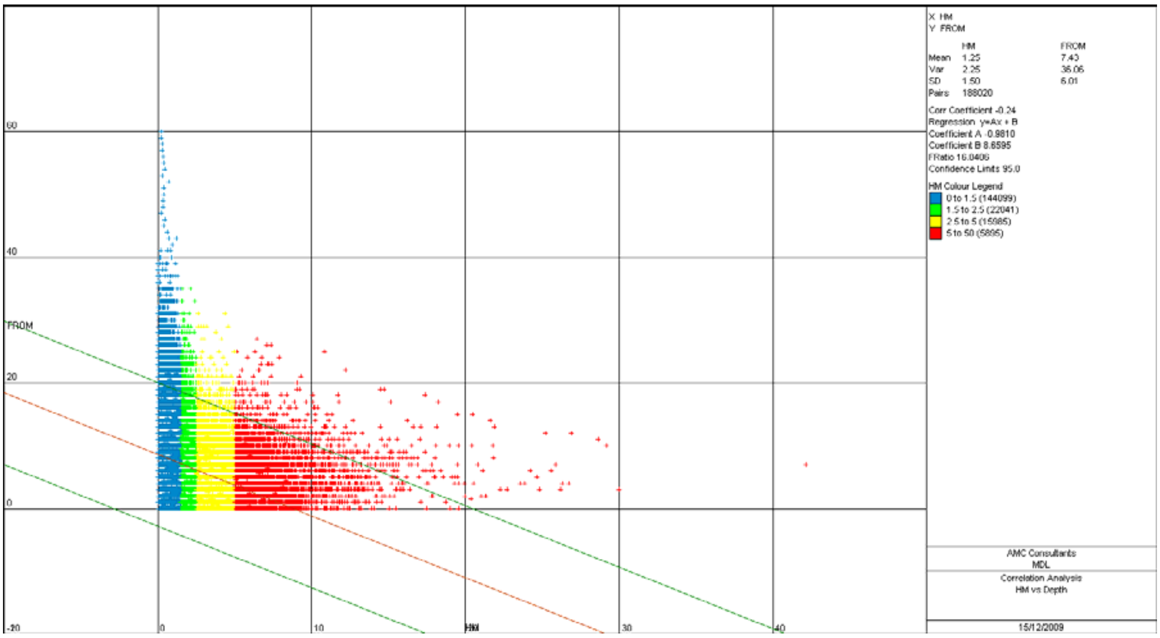


Figure 3.23 Scatter Plot of HM Grade versus Sample depth



3.14.1 Top Cutting

The log histogram and log probability plots of HM% in the northern domain (Figure 3.24) indicate that no top cut is necessary for this domain. The log histogram and log probability plots of HM% in the central domain (Figure 3.25) indicate that a top cut at 20% HM is appropriate for this domain. The log histogram and log probability plots of HM% in the central domain (Figure 3.26) indicate that a top cut at 20% HM is appropriate for this domain.

Sample HM grade statistics before and after top cutting, in each domain, are summarised in Table 3.16.

Figure 3.24 Log Histogram of HM% in the Northern Domain

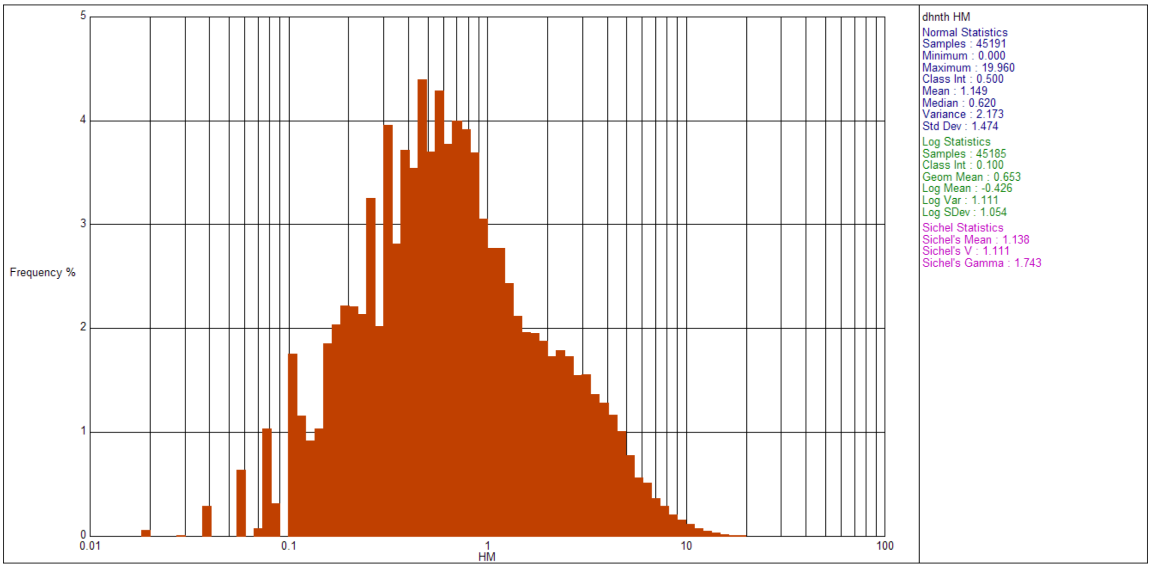


Figure 3.25 Log Histogram of HM% in the Central Domain (Before Top Cut)

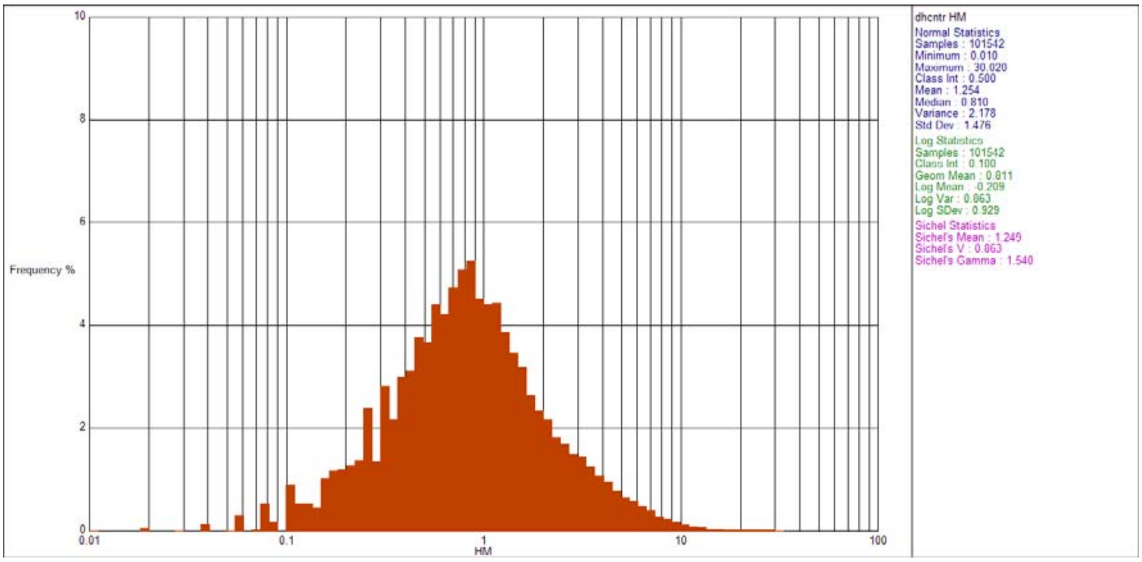


Figure 3.26 Log Histogram of HM% in the Southern Domain (Before Top Cut)

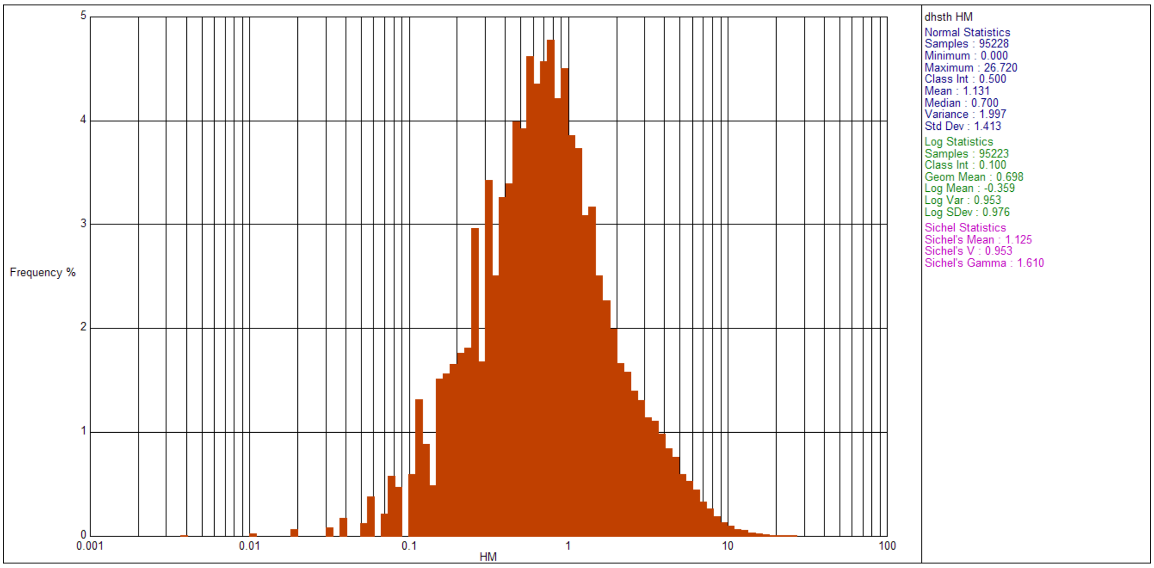


Table 3.16 HM Grade Statistics by Domain

Domain	Top Cut	Number	Minimum	Maximum	Mean	Median	Std Dev	Coeff Var
North	**None**	**45,191**	**0.0**	**20.0**	**1.1**	**0.6**	**1.5**	**1.3**
Central	No top cut	101,542	0.01	30.0	1.3	0.8	1.5	1.2
Central	**20% HM**	**101,542**	**0.01**	**20.0**	**1.3**	**0.8**	**1.5**	**1.2**
South	No top cut	95,228	0.0	26.7	1.1	0.7	1.4	1.3
South	**20% HM**	**95,228**	**0.0**	**20.0**	**1.1**	**0.7**	**1.4**	**1.2**

3.14.2 Geological Solids and Solid Validation

No geological solids were used in this resource estimate.

3.14.3 Variogram Analysis

Variogram analysis was conducted separately for each domain after top cutting the HM grades where necessary. Analysis was conducted using Isatis software. Experimental variograms with modelled as shown in Figure 3.27 to Figure 3.35. A summary of the variography parameters used in the resource estimate is presented in Table 3.17.

Figure 3.27 Vertical Variogram - Northern Domain

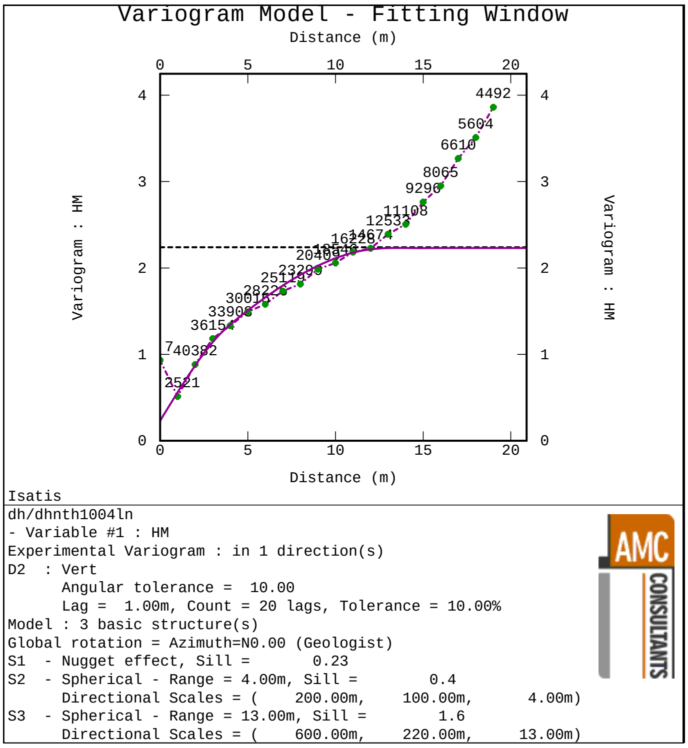


Figure 3.28 North-South Variogram - Northern Domain

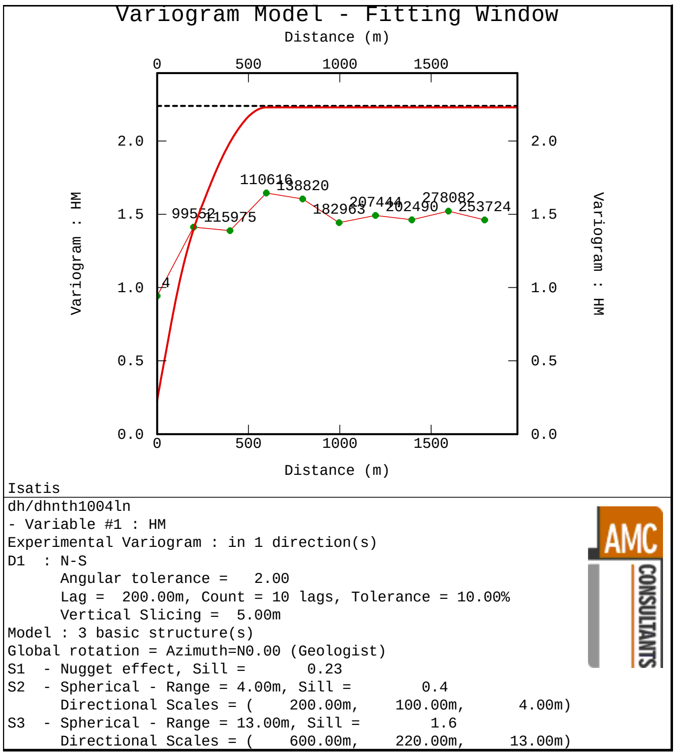
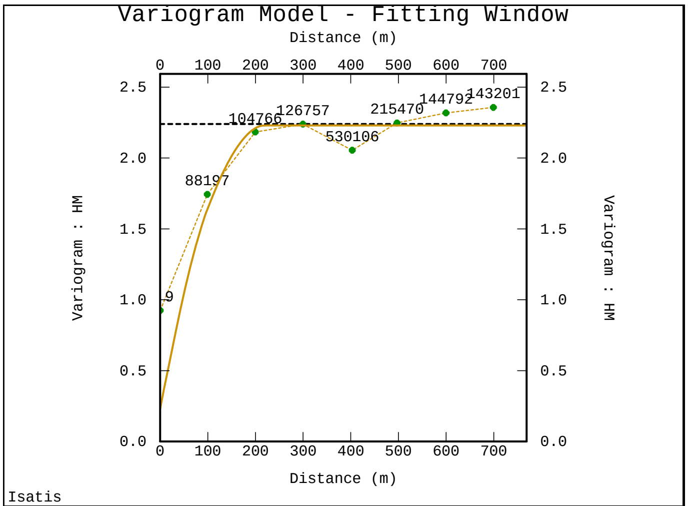
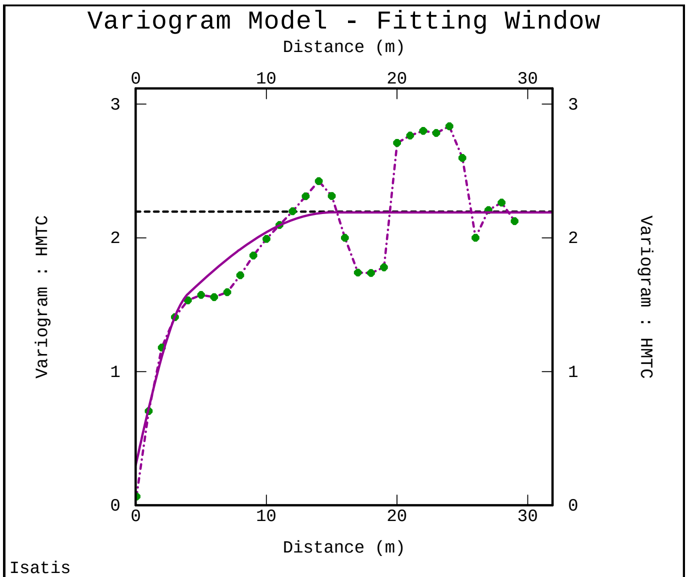


Figure 3.29 East-West Variogram - Northern Domain




```
dh/dhnth1004ln
- Variable #1 : HM
Experimental Variogram : in 1 direction(s)
D3   : E-W
       Angular tolerance =   5.00
       Lag =  100.00m, Count = 8 lags, Tolerance = 10.00%
Model : 3 basic structure(s)
Global rotation = Azimuth=N0.00 (Geologist)
S1   - Nugget effect, Sill =       0.23
S2   - Spherical - Range = 4.00m, Sill =        0.4
       Directional Scales = (    200.00m,    100.00m,       4.00m)
S3   - Spherical - Range = 13.00m, Sill =        1.6
       Directional Scales = (    600.00m,    220.00m,      13.00m)
```

Figure 3.30 Vertical Variogram – Central Domain




```
dh/dhcntrln
- Variable #1 : HMTC
Experimental Variogram : in 1 direction(s)
D2   : Vert
       Angular tolerance =  10.00
       Lag =  1.00m, Count = 30 lags, Tolerance = 10.00%
Model : 3 basic structure(s)
Global rotation = Azimuth=N0.00 (Geologist)
S1   - Nugget effect, Sill =         0.3
S2   - Spherical - Range = 4.00m, Sill =        0.89
S3   - Spherical - Range = 15.00m, Sill =          1
```

Figure 3.31 North-South Variogram - Central Domain

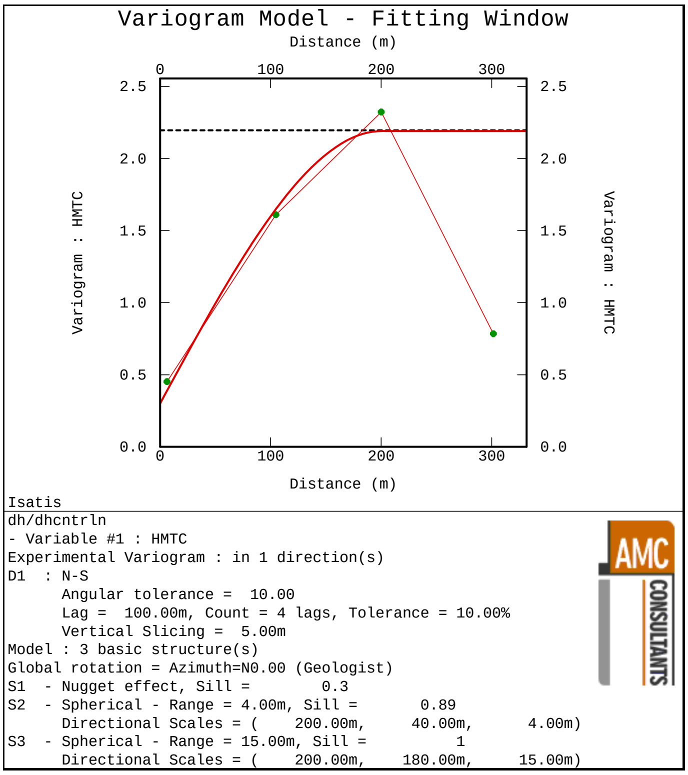


Figure 3.32 East-West Variogram - Central Domain

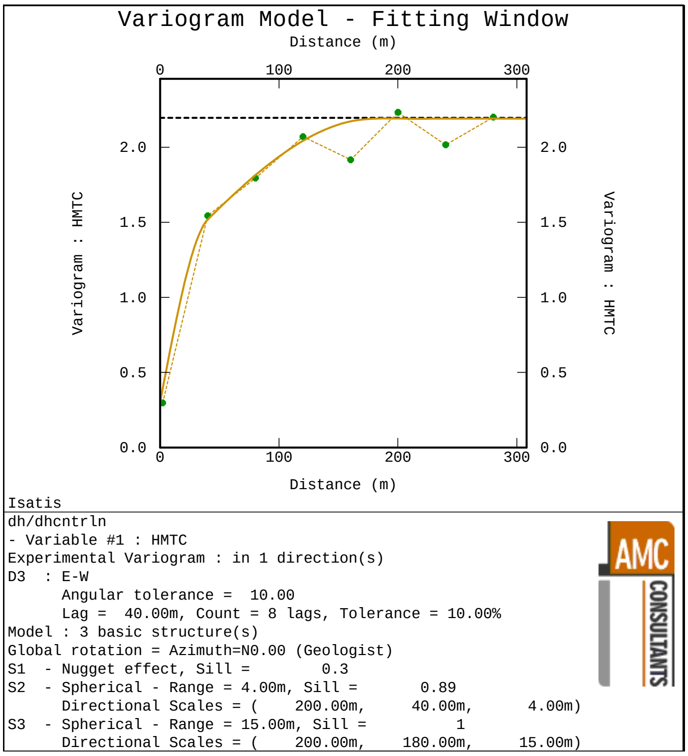


Figure 3.33 Vertical Variogram - Southern Domain

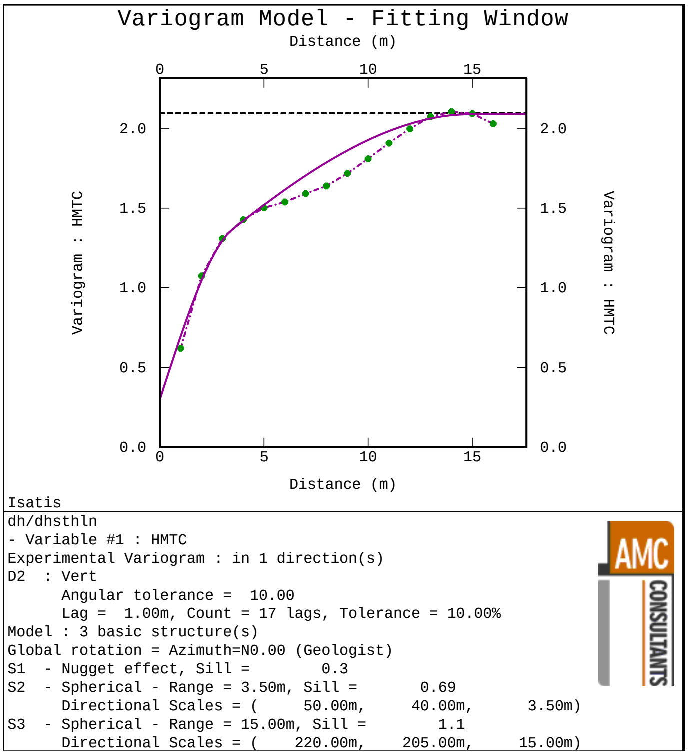


Figure 3.34 North-South Variogram - Southern Domain

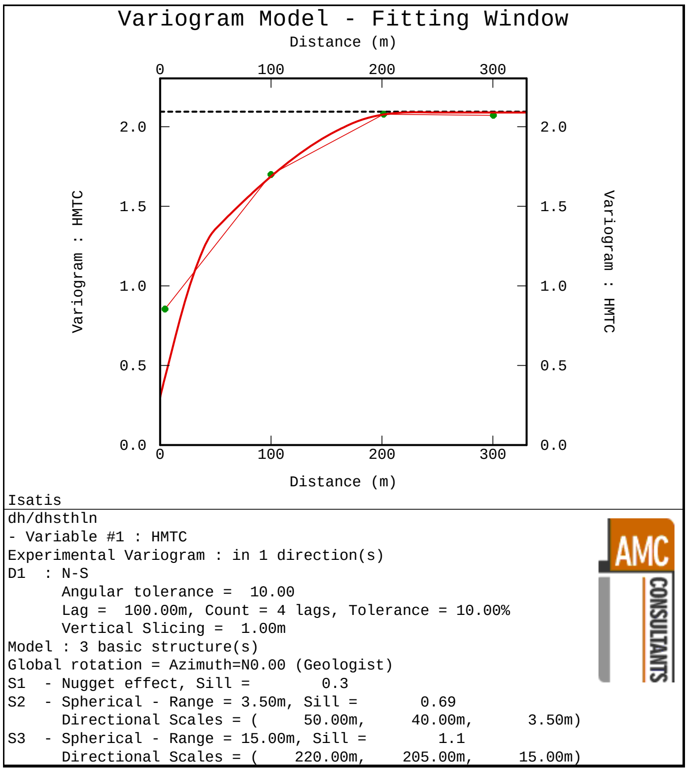


Figure 3.35 East-West Variogram - Southern Domain

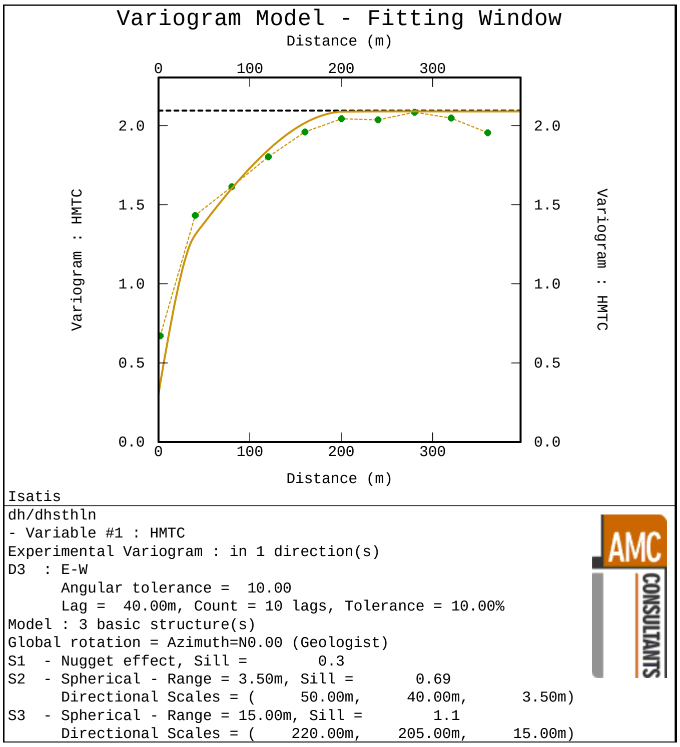


Table 3.17 Summary of Variography Parameters

Area	Nugget	Structure 1					Structure 2			
		Model type	Range East	Range North	Range Vertical	Sill	Range East	Range North	Range Vert	Sill
North	0.23	Spherical	100	200	4	0.4	220	600	13	1.6
Central	0.30	Spherical	40	200	4.0	0.89	180	200	15	1.0
South	0.30	Spherical	40	50	3.5	0.69	205	220	15	1.1

3.14.4 Kriging Neighbourhood Analysis

Kriging neighbourhood analysis is used to assess the impact on the estimate by changing key kriging parameters as a means of identifying the better parameters to use during estimation. The object of the analysis is to find optimum parameters that find a balance between minimising conditional bias, allowing realistic block selectivity and minimising the impact of negative weights.

Three different block sizes were investigated at the sample spacing of 40 mE x 200 mN x 1 m vertical, half the sample spacing at 20 mE x 100 mN x 1 m vertical, and quarter the sample spacing at 10 mE x 50 mN x 1 m vertical. Three different search neighbourhoods were investigated at 1.5 times the sample spacing, the range of the variogram and twice the range of the variogram. Nine different maximum number of samples were investigated at 4, 6, 8, 10, 12, 14, 16, 18, and 20. Each combination of these parameters resulted in 81 estimates. The slopes of the regression for the different cases are summarised in Figure 3.36, while the percentage of negative kriging weights for the different cases are summarised in Figure 3.37.

A block size that is one quarter of the sample spacing in the central domain tends to give better slopes than the other two cases that were investigated; however, the sample spacing in the northern domain is approximately 80 mE x 400 mN and so the 20 mE x 100 mN x 1 m vertical block size was selected for the block size.

Search neighbourhoods at 1.5 times to twice the sample spacing were selected for the final estimate after the estimation results from different cases were visually compared. It was found that, although searching to the range or twice the range of the variogram gave better slopes, there was too much smoothing of the estimates. Similarly, a maximum of 10 samples per estimate was chosen to minimise smoothing of the estimate, while still adequately reducing conditional bias.

The percentage of negative weights was negligible for all cases except for the smallest block size, with the maximum number of samples set to greater than approximately 16.

Figure 3.36 Slope of the Regression Results

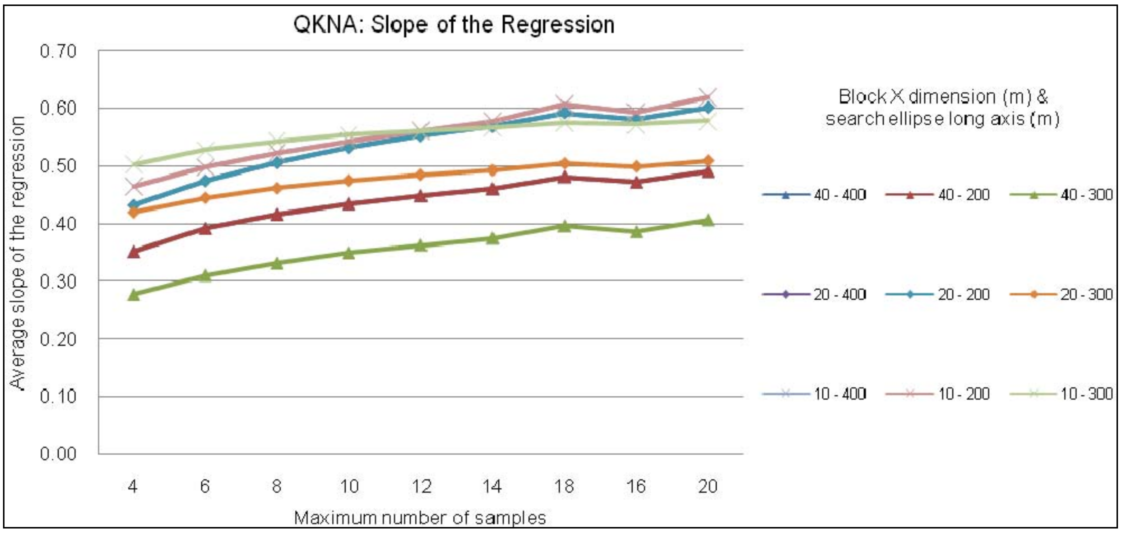
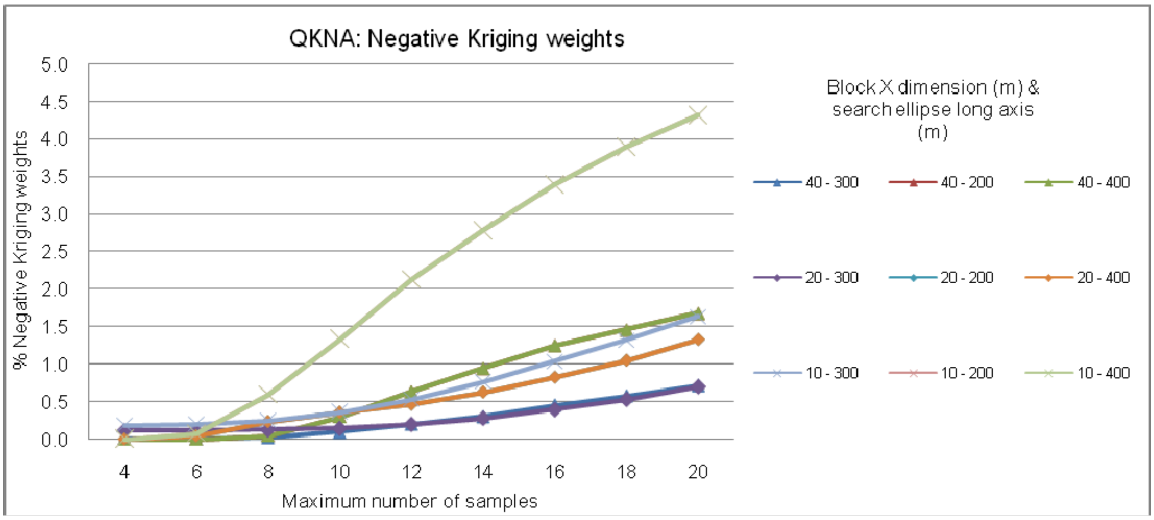


Figure 3.37 Negative Kriging Weights Results



3.14.5 Block Model

The resource estimate was conducted after rotating the dataset from its original coordinate system of Universal Transverse Mercator, Northern Hemisphere, Zone 28, WGS84 Datum by -35° azimuth to make it orthogonal to the coordinate system, and subtracting one million from the northings to increase the location precision.

Table 3.18 presents the block model origin after rotation back into the original coordinate system and the parent block sizes and number of blocks in each direction.

Grades were estimated into parent blocks with dimensions of 20 mE x 100 mN x 1 m vertical. These parent blocks were sub-celled in the north direction to 25 m and vertically to 0.5 m, to more accurately model the surface geometry of the deposit. Estimates were conducted in each domain after applying a top cut in the central and southern domains at 20% HM. The parameters used for the estimation of the block HM% grades are listed in Table 3.19. Grades were estimated using three passes with the search parameters progressively increasing with each pass. Blocks were left as absent HM% grade if they did not have grades estimated after the third pass.

An outer perimeter based on the area of drilling was used to define the area to be included in the resource estimate.

Table 3.18 Block Model Summary

	Easting	Northing	RL
Origin	293441.85	1679532.70	-30
Parent block size	20	100	1
Sub-cell	20	25	0.5
Number of blocks	308	500	80

Table 3.19 Estimation Parameters

Area	Search Pass	Range			Minimum Samples	Maximum Samples	Maximum Samples per Hole
		East	North	Vertical			
North	1	100	250	3	6	10	2
	2	150	375	4.5	6	10	2
	3	300	750	9	4	10	2
Central	1	100	250	3	6	10	3
	2	150	375	4.5	6	10	3
	3	300	750	9	4	10	3
South	1	60	250	3	6	10	3
	2	90	375	4.5	6	10	3
	3	180	750	9	4	10	3

3.14.6 Resource Classification

The resource classification was based on the drillhole spacing (Figure 3.38). The resource is classified as Measured where the drill spacing is approximately 40 m across strike and 80 m along strike. Outside these areas, the resource is classified as Indicated.

3.14.7 Resource Estimate

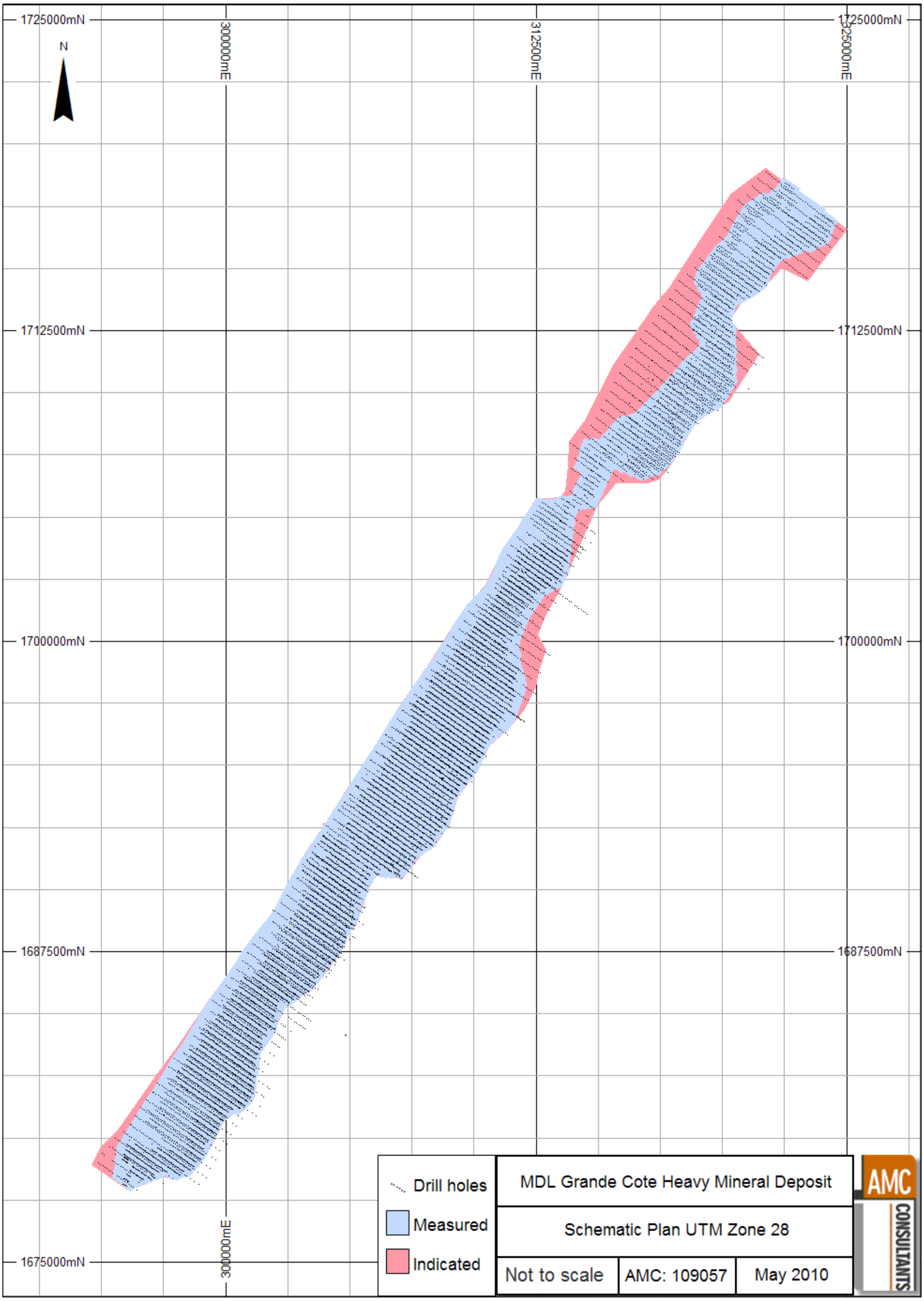
The Measured and Indicated Mineral Resources were estimated from the block model by accumulating the averaging grade in 20 mE x 25 mN columns of sand (based on grades estimated into 20 m x 100 m x 1 m blocks) above a surface that is 6 m below the modelled water table (based on the average piezometer readings from 31 March 2009 to 31 March 2010).

The Measured and Indicated Mineral Resource at a cut-off grade of 1.25% HM accumulated to 6 m below the water table is listed in Table 3.20.

Table 3.20 Resource Estimate above a Surface that is 6 m below the Water Table at 1.25% HM Cut-off Grade

Resource Category	Tonnage (M)	HM (%)
Measured	980	1.73
Indicated	50	1.72
Measured + Indicated	**1,030**	**1.73**

Figure 3.38 Resource Category Boundaries



The Measured and Indicated Mineral Resource at a cut-off grade of 1.25% HM accumulated to 6 m below the water table for the different areas of the deposit is listed in Table 3.21.

Table 3.21 Resource Estimate above a Surface that is 6 m below the Water Table, for the Different Areas of the Deposit, at 1.25% HM Cut-off Grade

Area	Resource Category	Tonnage (M)	HM (%)
Mboro	Measured	175	1.74
	Indicated	0.6	1.43
	Total	**175**	**1.74**
Fass Boye	Measured	124	1.70
	Indicated	0.2	1.52
	Total	**174**	**1.70**
Diogo	Measured	324	1.78
	Indicated	0.6	1.47
	Total	**325**	**1.78**
Diogo Extension	Measured	80	1.77
	Indicated	6	1.65
	Total	**86**	**1.76**
Lompoul	Measured	279	1.66
	Indicated	**39**	1.73
	Total	**318**	**1.67**
Total	Measured	980	1.73
	Indicated	50	1.72
	Measured + Indicated	**1,030**	**1.73**

3.14.8 Grade Tonnage Curves

The total resource at different cut-off grades is shown in Table 3.22.

Grade tonnage curves for the Measured and Indicated Mineral Resources at a range of HM% cut-off grades accumulated to 6 m below the water table are displayed in Figure 3.39 and Figure 3.40.

Table 3.22 Resource Estimate by HM Cut-off (Measured + Indicated)

Cut-off (% HM)	Tonnage (Bt)	HM (%)
0.25	4.37	1.0
0.50	4.14	1.1
0.75	2.90	1.2
1.00	1.72	1.5
1.25	1.03	1.7
1.50	0.61	2.0
1.75	0.36	2.2

Figure 3.39 Grade Tonnage Curve for the Measured Resource

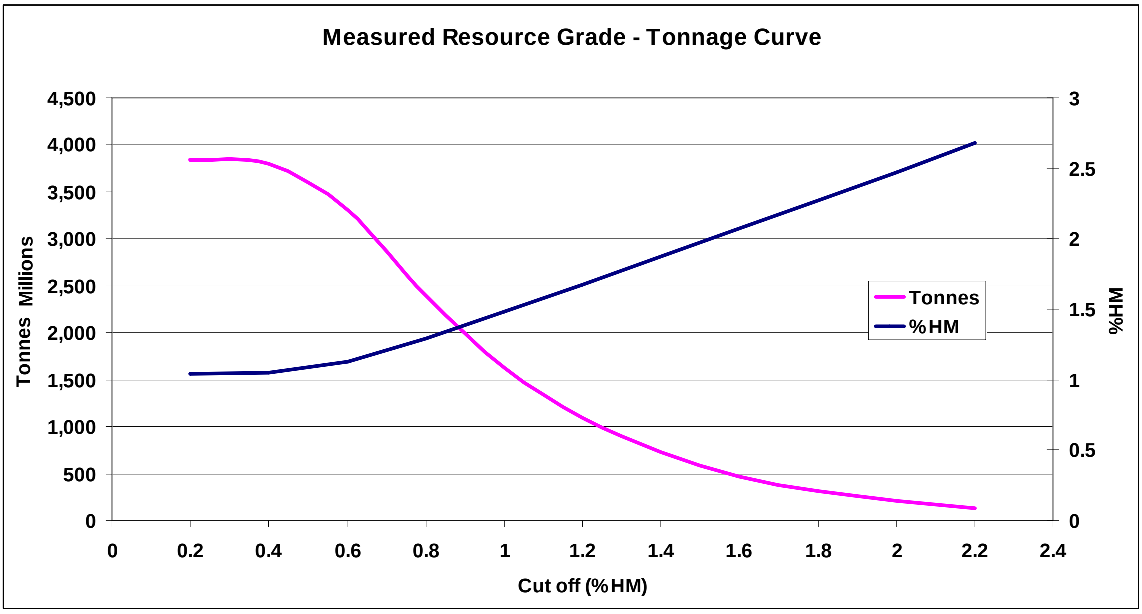
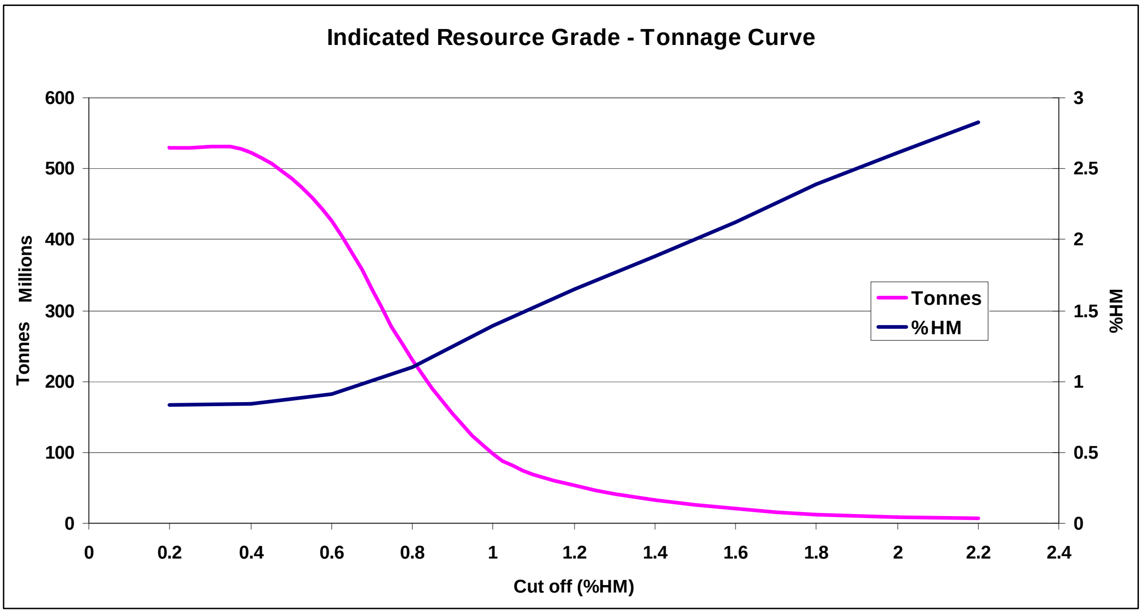


Figure 3.40 Grade Tonnage Curve for the Indicated Resource



3.14.9 Model Check

The block model was checked by:

- Comparing global statistics between drillhole data and the block model estimate.
- Visually comparing drillhole data and the block model grade estimates in cross-section.

- Comparing trends in the north direction between the drillhole data and the block model grade estimate using a swath plot.
- Comparing the current block model estimate with the previous block model estimate conducted by AMC.

The naive global statistics are similar with the estimated mean grade of 1.18% HM approximately 7% lower than the top cut mean grade of 1.27% HM.

The distributions are similar with the block model displaying less variance due to its larger support (Figure 3.41 and Figure 3.42).

Cross-sections display close agreement between the drillhole and the block model grades and demonstrate that limited smoothing has occurred (Figure 3.43 to Figure 3.45).

The swath plots display HM% grades in the drillholes and block model against northings at 20 m RL, 10 m RL, 0 m RL, -5 m RL, and -10 m RL (Figure 3.46 to Figure 3.50). These plots show good agreement between the drillholes and block model between 10 and 0 RL, with the drillholes displaying greater variability than the block model. At -5 RL the model underestimates the HM% grade displayed in the drillholes and at -10 RL the model overestimates the HM% grade displayed by the drillholes. This is a result of smoothing of the HM% grade, which decreases rapidly with depth. The crests of the sand dunes generally coincide with 20 m RL in the eastern half of the resource (Figure 3.43 to Figure 3.45), where the drillholes show that the HM% grade is relatively high and variable. These factors have lead to the block model generally underestimating the grade at this elevation due to smoothing of the HM% from lower elevations.

Plots of RL against HM% at various northings generally show close agreement between the drillholes and the block model from 15 m RL to -5 m RL (Figure 3.51 to Figure 3.57). Significant disparities occur above 15 m RL and below -5 m RL due to lack of drillhole data.

Figure 3.41 Log Histogram of HM% for Drillhole (Top Cut) and Block Model

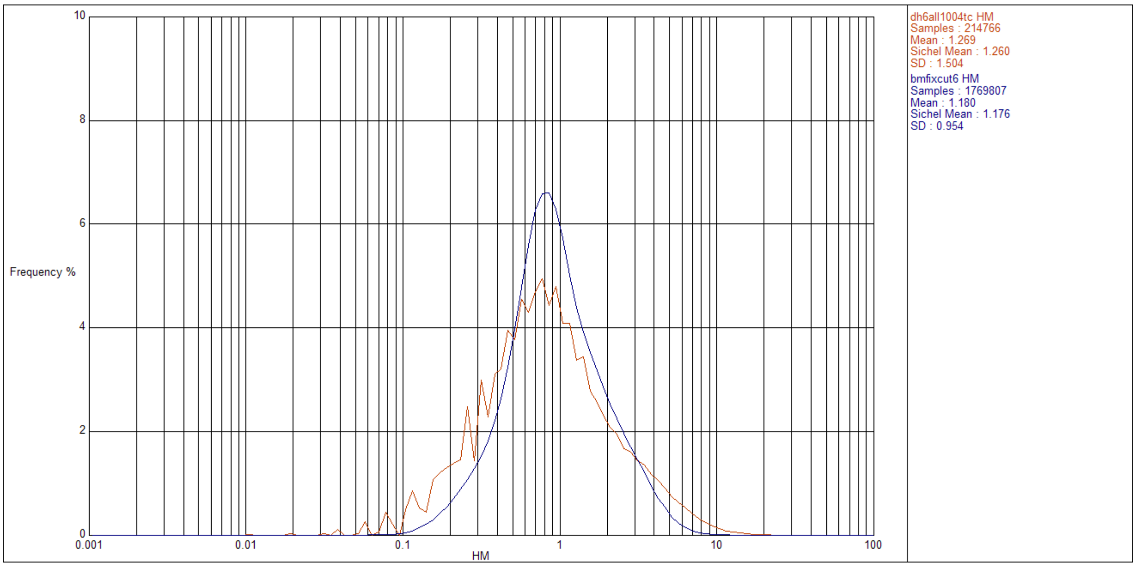


Figure 3.42 Log Probability Plot of HM% for Drillhole (Top Cut) and Block Model

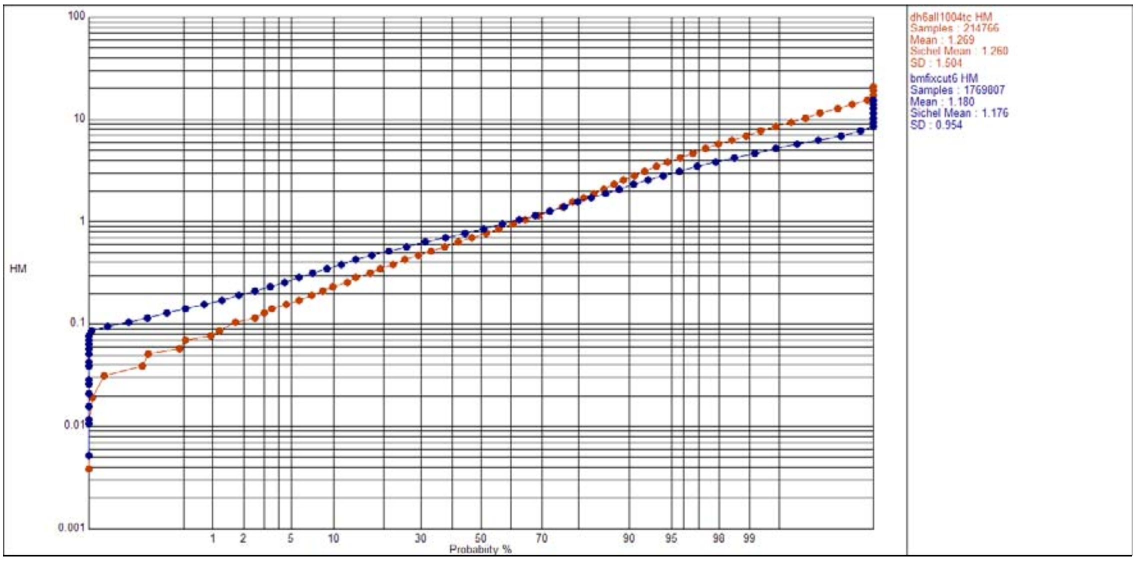
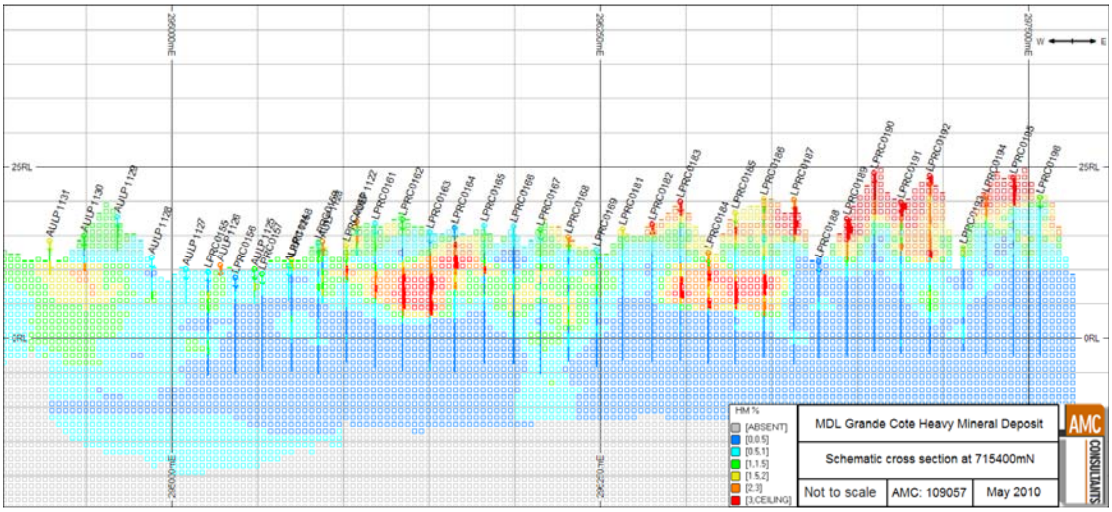
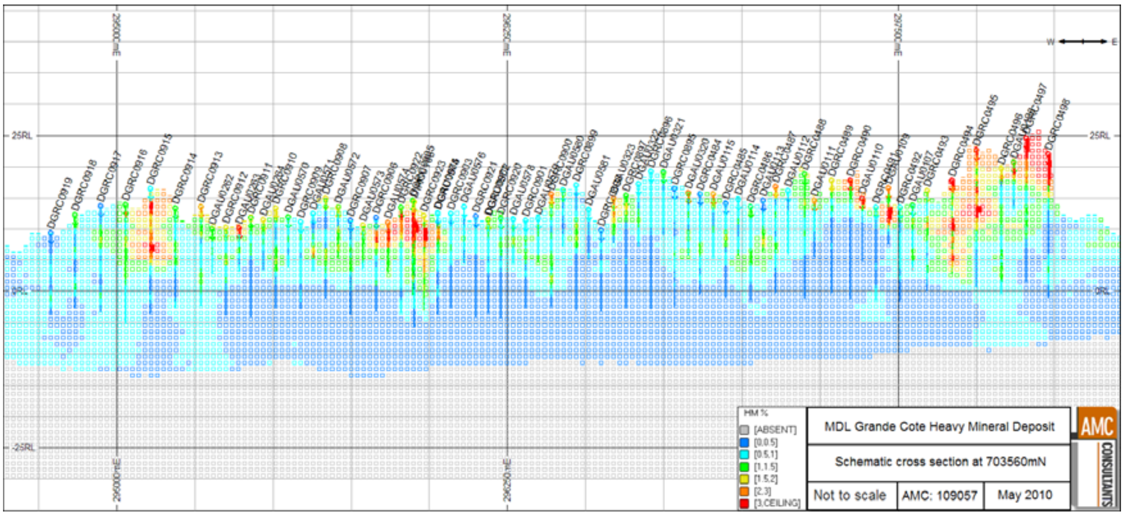


Figure 3.43 Cross-Section - Northern Domain Displaying Drillhole and Block Model HM Grades



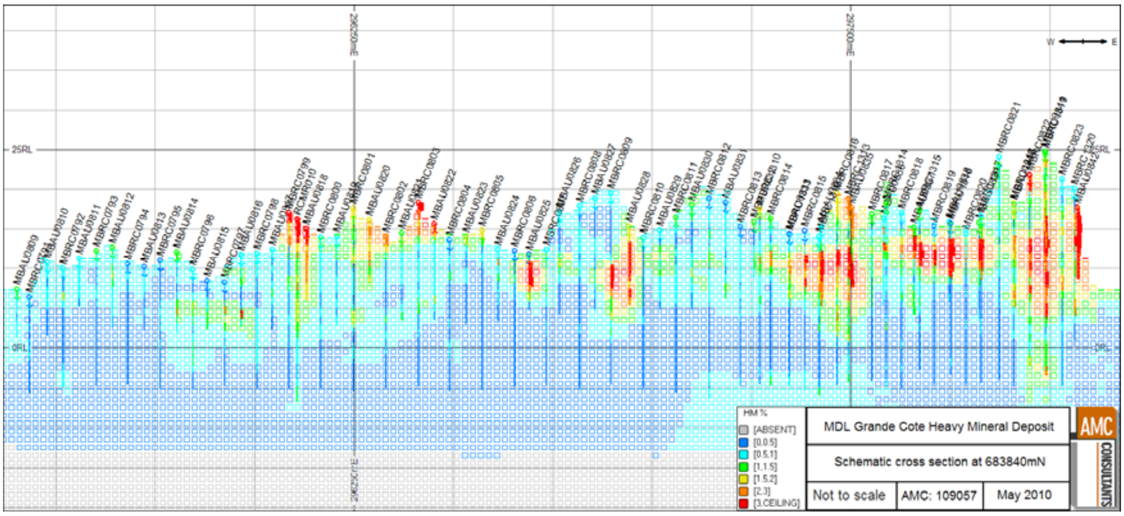
Note: 20x vertical exaggeration.

Figure 3.44 Cross-Section - Central Domain Displaying Drillhole and Block Model HM Grades



Note: 20x vertical exaggeration.

Figure 3.45 Cross-Section - Southern Domain Displaying Drillhole and Block Model HM Grades



Note: 20x vertical exaggeration.

Figure 3.46 North-South Swath Plot at 20 m RL

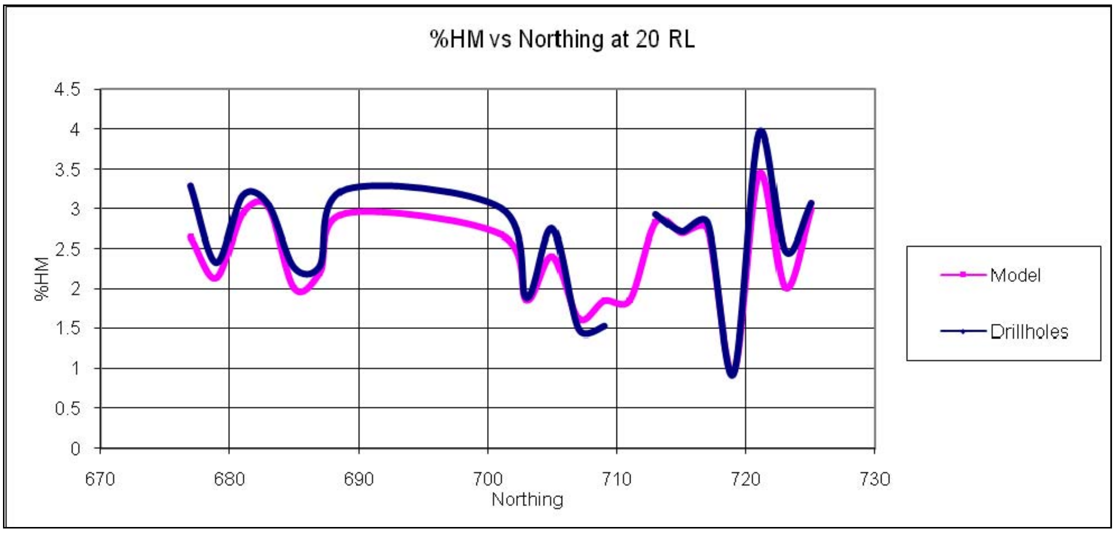


Figure 3.47 North-South Swath Plot at 10 m RL

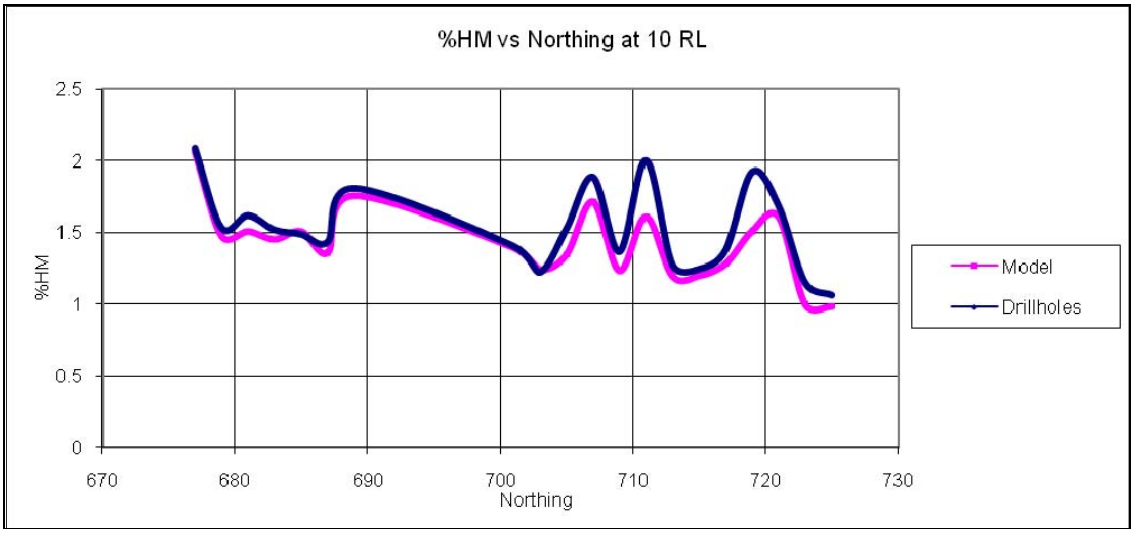


Figure 3.48 North-South Swath Plot at 0 m RL

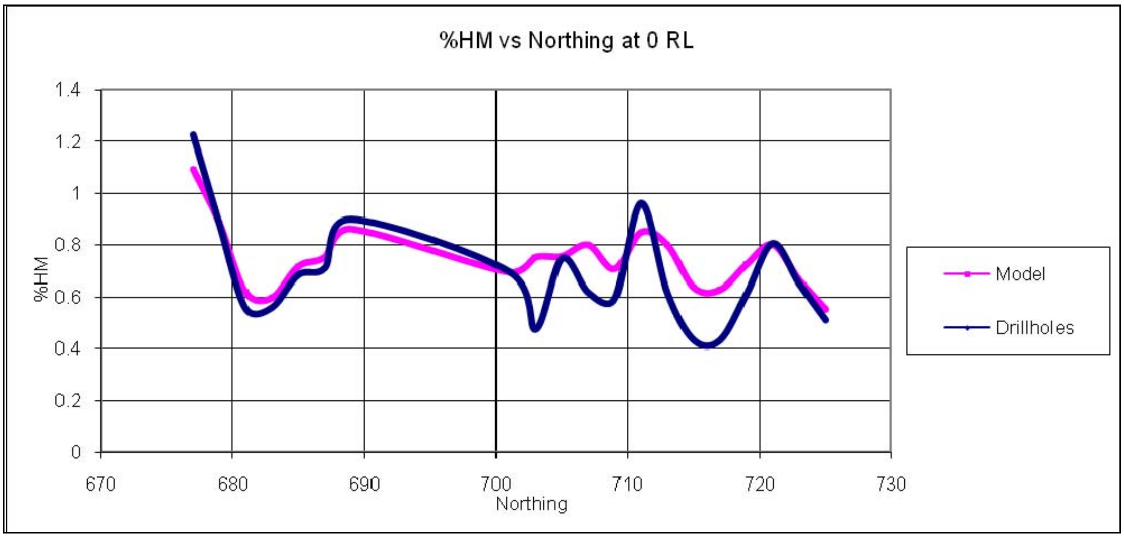


Figure 3.49 North-South Swath Plot at -5 m RL

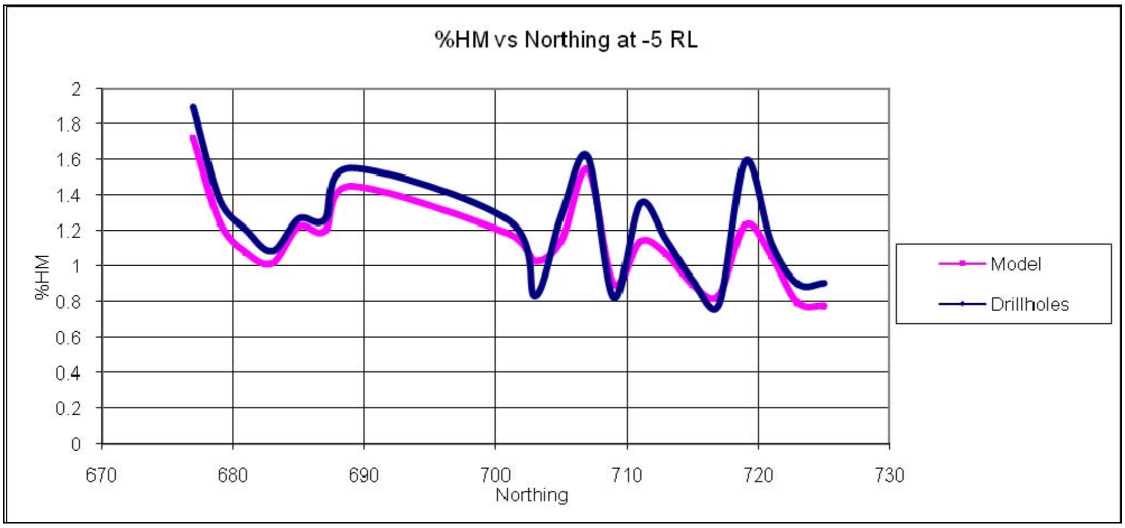


Figure 3.50 North-South Swath Plot at -10 m RL

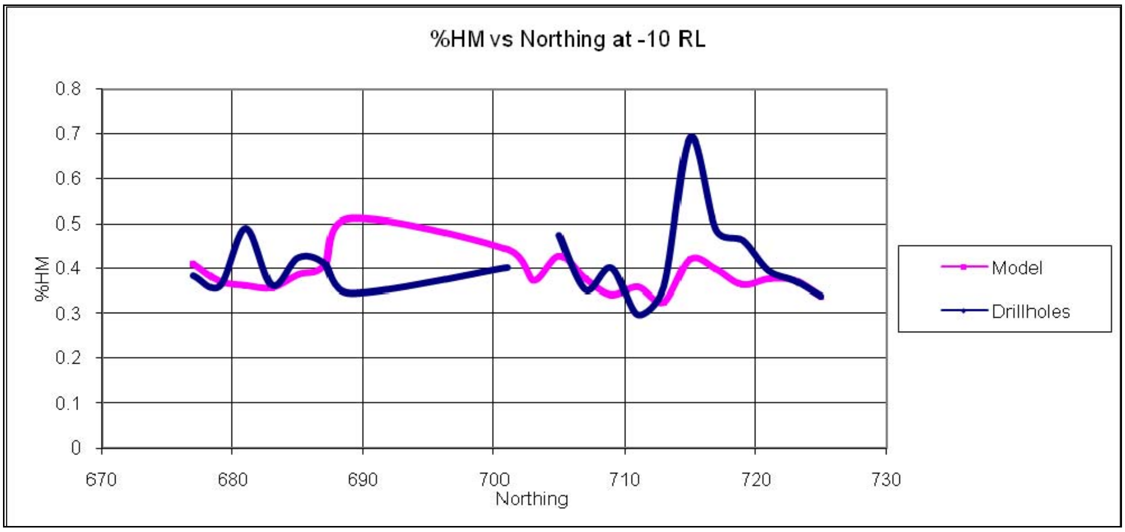


Figure 3.51 RL versus HM% at 677,000 mN

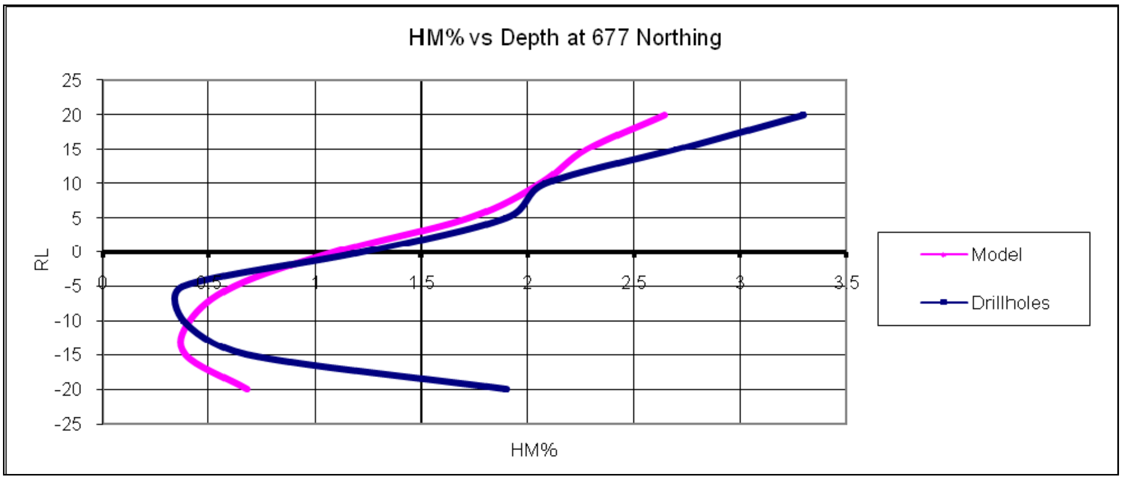


Figure 3.52 RL versus HM% at 683,000 mN

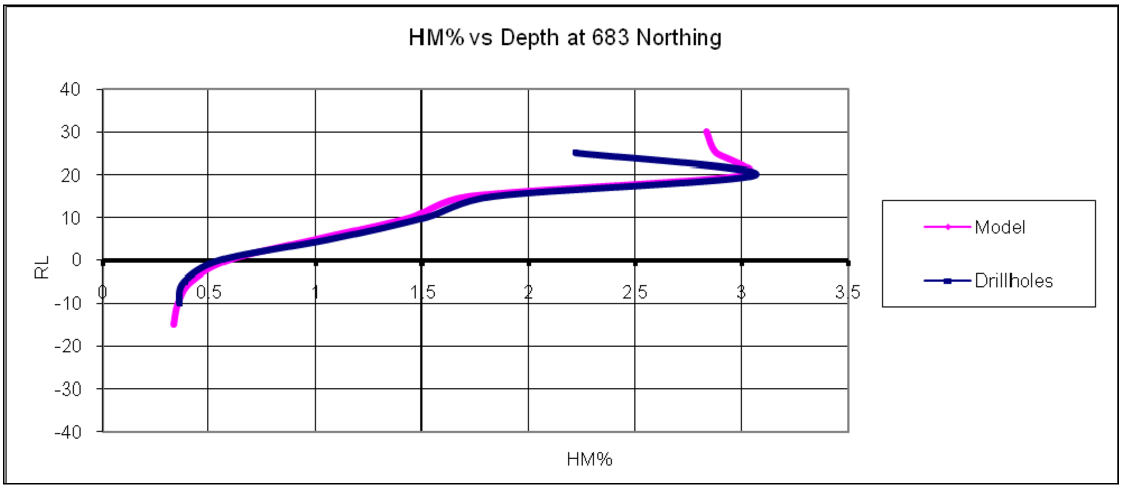


Figure 3.53 RL versus HM% at 713,000 mN

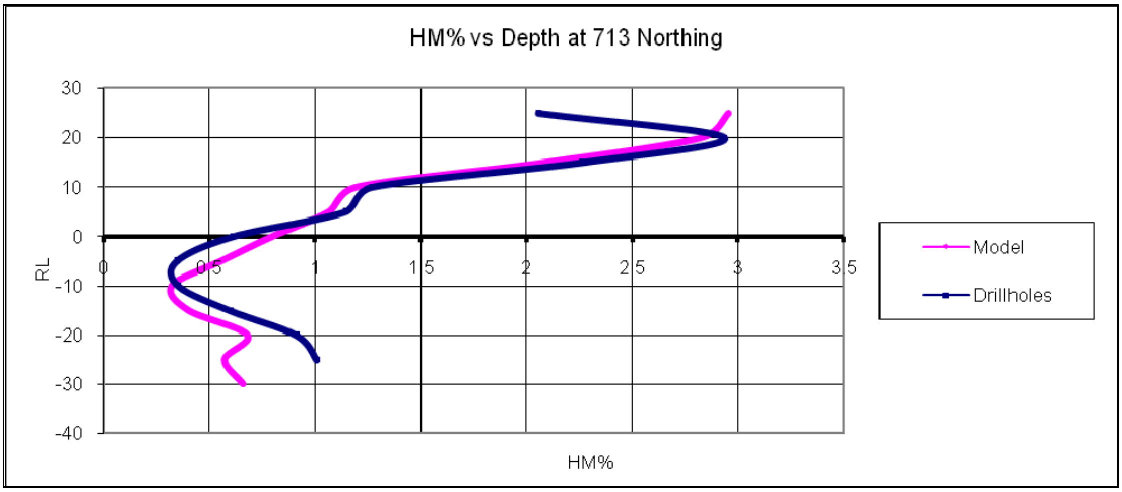


Figure 3.54 RL versus HM% at 715,000 mN

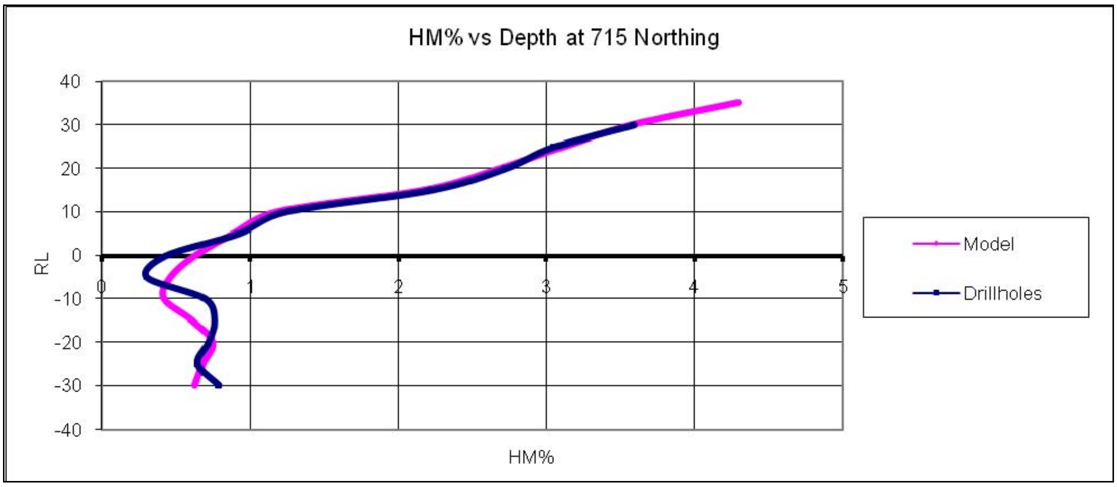


Figure 3.55 RL versus HM% at 719,000 mN

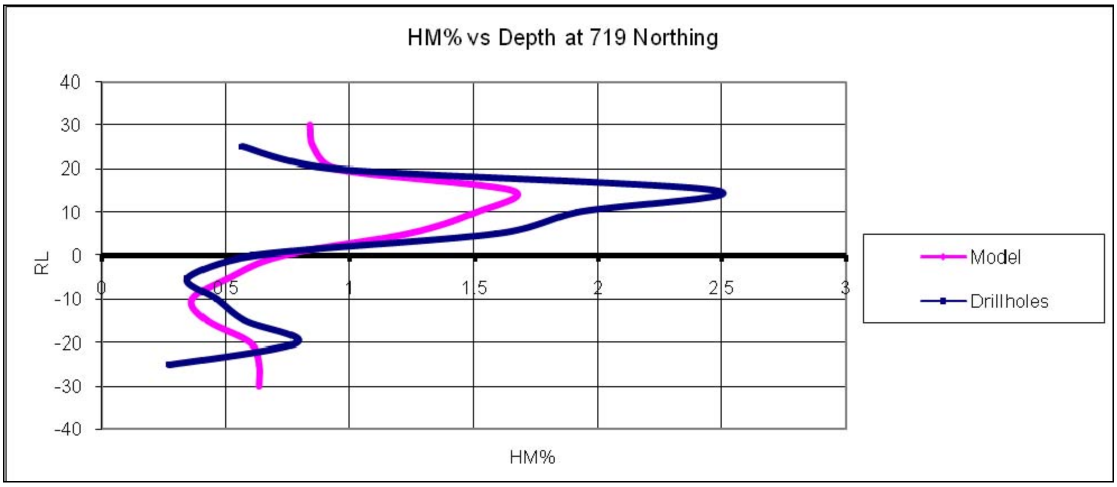


Figure 3.56 RL versus HM% at 721,000 mN

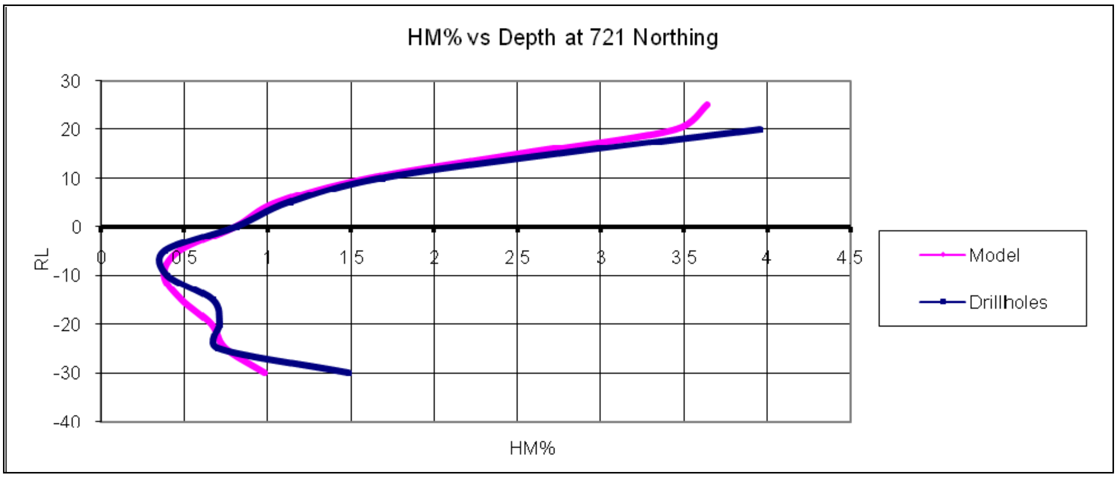
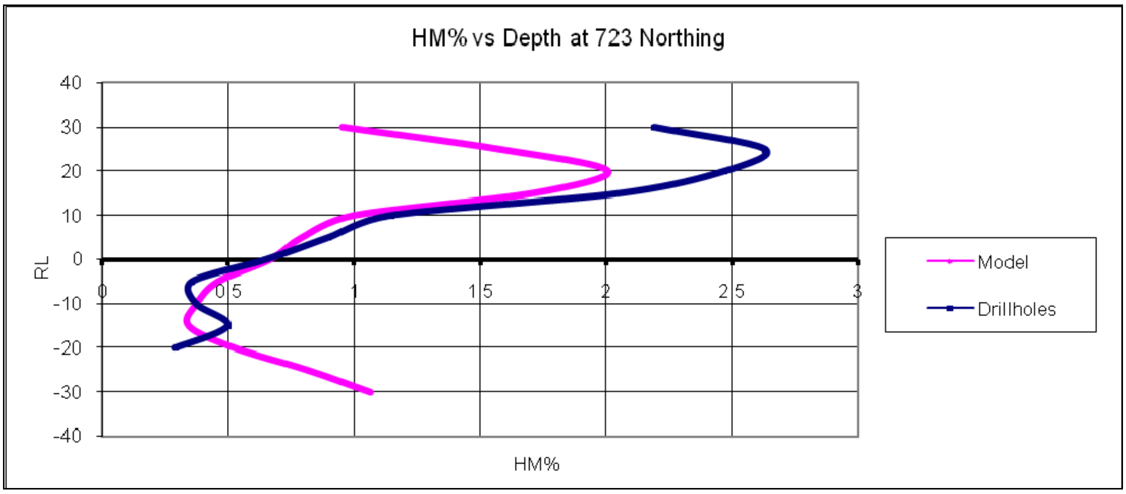


Figure 3.57 RL versus HM% at 723,000 mN



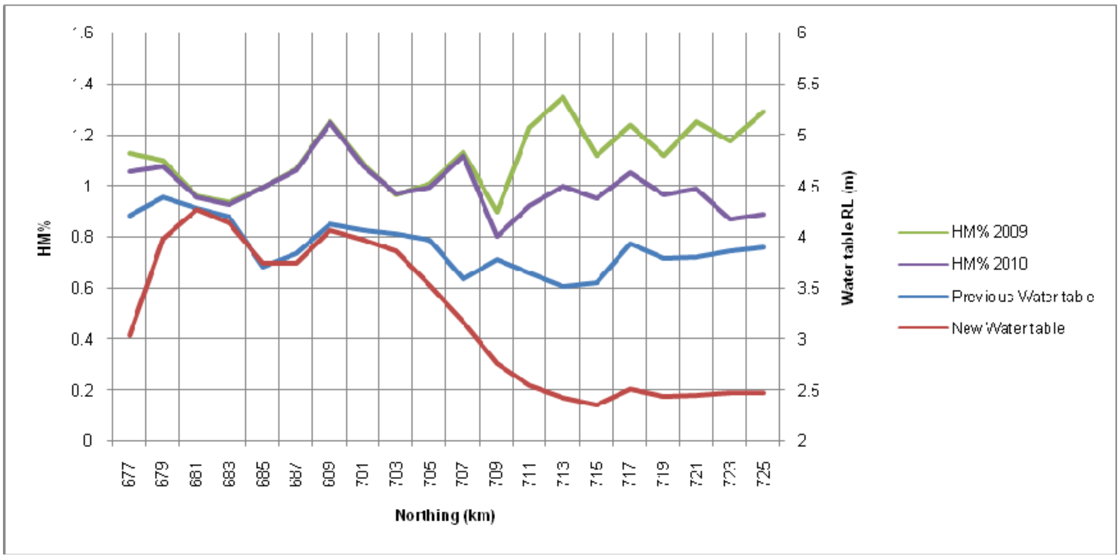
3.14.10 Comparison with Previous Estimates

AMC's previous estimate in 2009 is compared with the current estimate in Table 3.23. The drilling completed since the previous estimate has increased the confidence in the resource in the northern domain, which has resulted in an upgrade from the Inferred Resource classification in this area to Measured and Indicated. The increased drilling in the northern domain also resulted in a decrease in the estimated HM% grade, which has also resulted in decreased tonnage above the 1.25% HM cut-off. Additionally, new water table data has shown the depth of the water table in the northern domain is lower than previously estimated. This has also decreased the estimated grade, as the lower water table resulted in the inclusion of additional low-grade material at lower elevations during the accumulation process (Figure 3.58).

Table 3.23 Comparison of Current Estimate with 2009 Estimate above a Surface that is 6 m below the Water Table and a 1.25% HM Cut-off

Model	Resource Category	Tonnage (Mt)	HM (%)
2009	Measured	668	1.76
	Indicated	61	1.75
	Inferred	579	1.83
	Total	**1,308**	**1.79**
2010	Measured	980	1.73
	Indicated	50	1.77
	Total	**1,030**	**1.73**

Figure 3.58 HM% and Water Table for 2009 and 2010 Estimates by Northing



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SECTION 4
Mining

Copy 16

AMC CONSULTANTS

CONTENTS

TABLES

FIGURES

4 MINING

4.1 Overview

The Grande Côte resource consists of mineralised sand dunes of free-flowing sand with low slime levels (less than 1% clay). The minerals are naturally concentrated by wind action. Most of the heavy minerals (HM) occur in the upper leeward side (eastern side) of the dunes. The photograph shown in Figure 4.1 is typical of the mineralised sand dunes to be mined and the dark patches are the darker HM.

Figure 4.1 Typical Sand Dunes to be Mined

Analysis of piezometer measurements throughout the mining area indicates a stable water table on average 4 m beneath the swales (the base of the mobile dunes). The water table trends from 1 mRL (above sea level) on the western side (ocean side) to 8 mRL on the eastern side of the mobile dune system. Further details on the water table are in Section 8.

4.2 Mining Method Selection

A dredge mining operation was selected by GCO based on the following considerations:

- Ore body HM grade and the physical size of the dunes both lending themselves to high-volume dredging as opposed to traditional mechanical mining techniques.
- Drilling information indicating that all of the proposed mining areas consist of free-flowing sand with a minimal slimes (clay) content of less than 1%.
- The dunal system has a reasonably consistent water table.
- Comparable ore bodies in Australia have been successfully mined by dredging.
- Dredge mining is cost competitive, allows ready restoration of the mining areas and has a low impact on the environment.
- GCO, through its parent company MDL, has more than 60 years experience dredging similar dunal heavy mineral deposits.

4.3 Mining Method Description

Mining will be carried out by dredging a continuous canal (dredge path) through the dunal orebody. The dredge will float in an artificial pond accompanied by a floating spiral concentrator (WCP). The pond will advance as material in front is mined and tailings are discharged behind.

Vegetation will be cleared in advance of the dredge pond. Any topsoil removed in advance of mining will be stockpiled in areas adjacent to the dredge path for later use in rehabilitation. The pond will vary in width from 130 m to 270 m (nominally 240 m) and will be approximately 250 m long.

The dredge will be fitted with a suction-cutter head which will deliver sand and water to the WCP. Mining will occur below the pond level at the cutter head. The cutter head will traverse the face from one side of the pond to the other, benching the face in subsequent passes if necessary. Material located above the pond level will rill down the face as mining progresses. The dredge will be equipped with winch slew ropes for cutting control, dredge positioning and to control forward advance.

The WCP will produce a heavy mineral concentrate (HMC) and tailings. The HMC will be pumped to a land-based mineral separation plant (MSP) where it will be dewatered and stockpiled for batch processing. A tailings stacker at the rear of the WCP will deposit the tailings to fill the mined canal and achieve a final landform. The final landform will then be rehabilitated.

The dredge and WCP will be connected via a floating flexible pipeline to transport the mined sand and water, and for the supply of power and control systems. A floating walkway will connect the concentrator to the shore and provides access, power and a product pipeline for HMC transfer to the MSP.

The dredge, WCP, MSP and tailings stacker design and engineering for the DFS have been completed by Ausenco (see Section 6). Construction and commissioning of the dredge is discussed in Section 13. Figure 4.2 is a 3D representation of the operating dredge, WPC and tailings stacker from the Ausenco 3D design model.

Figure 4.2 3D Representation of the Operating Dredge and WPC

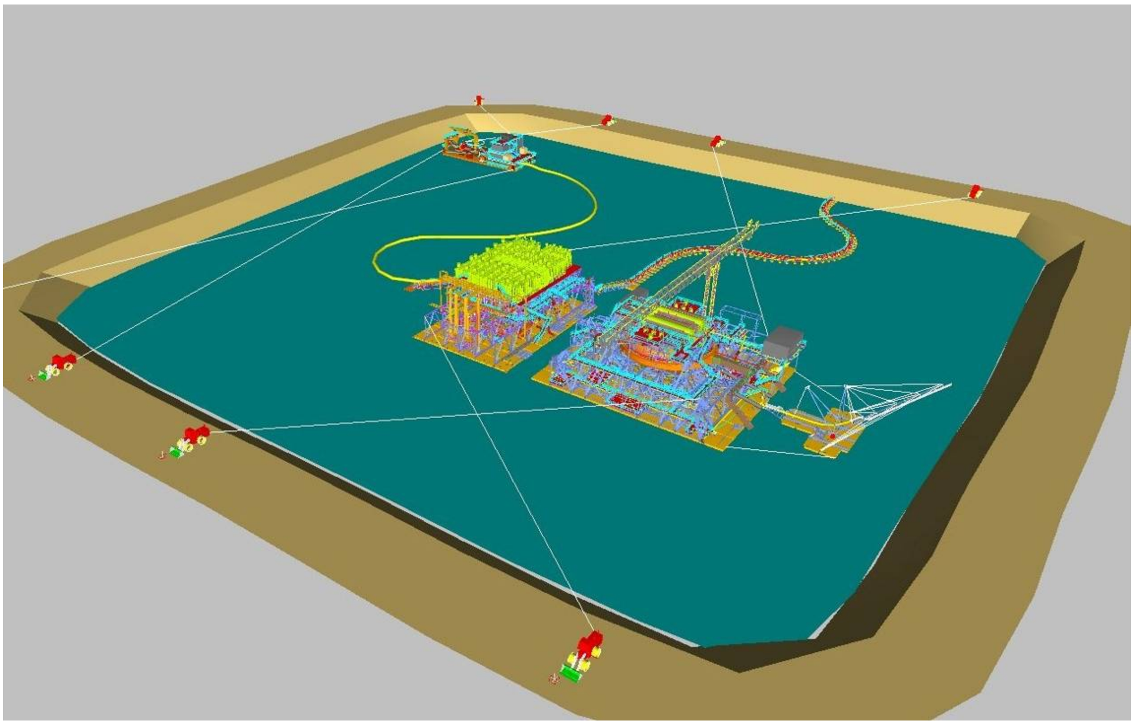


Figure 4.3 shows the wet concentrator and tails deposition at MDL's former operation.

Water losses due to natural evaporation and seepage from the dredge pond and tailings will occur. Lateral bores and pumps will reclaim the seepage and return the water to the dredge pond. This process will minimise water loss and prevent changes to the water level in the pond. The operation will return essentially all of the water used in the mining, treatment and tailings stacking processes to the active mining pond. When required, additional make-up water will be sourced from a fresh water aquifer located 400 m below surface so as not to impact on the local water table. See Section 8 for a full description of this process including the project water balance.

Figure 4.3 Typical Dredge Pond and Concentrator Plant

4.4 Mining Regulations

Mining will be undertaken according to the “Senegal Code Minier Loi No 2003 36” (the Mining Code). The Mining Code details the regulatory requirements under which exploration, mining, processing, loading and transport are conducted, including the requirements for permits and royalties.

Section 8, Chapter 3, Article 96 of the Mining Code, pertaining to health and safety in mines and quarries, details the requirement of GCO to draw up its own specific set of health and safety regulations and to have them approved by the Minister for Mines. All holders of mining operation titles are required to conform to the provisions of the approved regulations.

The technical management of the mining operation and its annexes is to be undertaken by an operations manager whose name must be supplied to the Director of Mines and Geology, who in turn informs the relevant administrative authority and the work inspector and social security agency with territorial responsibility. The operations manager is required to ensure the strict application of the regulations to which the mine site and facilities under the operations manager’s responsibility are subject. The operations manager must be invested with the required authority in relation to the other personnel to exercise the operations manager’s assigned duties.

Section 8, Chapter 3, Article 102 of the Mining Code requires authorisation from the Director of Mines and Geology to mine sides or slopes of more than 15 m in height. Authorisation will be required as the dredge path design has continuous lengths with slopes greater than 15 m high.

The Mining Code has provisions for the need to provide the workers and the communities with a safe environment. The Mining Code also refers to the Labour Code for matters of health and safety.

4.5 Mining Licences and Approvals

GCO has all licences required for the operation of the dredge and the MSP. Details of the licences and approvals related to the mining at Grande Côte are discussed in Section 20.

4.6 Mining and Rehabilitation

During mining there are three distinct activities: land clearing, dredge mining and rehabilitation. The photograph (Figure 4.4) taken from GCO's previous Australia operation illustrates this sequence. Rehabilitation will commence immediately following mining and will closely follow the dredge pond. Rehabilitation of the mine site involves restoring the topography following progress of the dredge pond, stabilisation of the dunes, redistributing available topsoil and revegetating the final landform.

Figure 4.4 Active Mining Areas Associated with Dredging Operation

The dredge and WCP occupy 4 ha at any one time. The estimated “swell” after disturbing the sand is 20%. Restoration of the topography requires a pre-mining topographic survey, which was completed by GCO in January of 2008. Post-mining surveys will be conducted to confirm that landforms have been restored satisfactorily.

Further details of environmental issues relative to mining are discussed in Section 12 and in Volume 2.

4.7 Mining Study Input Data

4.7.1 Survey

All plans and files for the Grande Côte are in the Universal Transverse Mercator (UTM) grid system Northern Hemisphere Zone 28 with a WGS84 datum. The geological modelling and mine design undertaken by AMC used a rotated coordinate system. After the modelling and mine design work was completed, the data was rotated back to the original Universal Transverse Mercator grid system.

The following transformation was used to convert from the UTM North zone 28 to AMC Block Model Grid used for the mine planning:

- Rotation is -35° on azimuth.
- Original X coordinate is 310,339.781 mE.
  Rotated X coordinate is 296,831.250 mE.
- Original Y coordinate is 1,697,683.250 mN.
  Rotated Y coordinate is 703,160.313 mN.
- No transformation in the Z plane.

4.7.2 Geological Model and Mineral Resource

The Measured and Indicated Mineral Resource was estimated from the block model by accumulating the averaging grade in 20 mE x 25 mN columns of sand (based on grades estimated into 20 m x 100 m x 1 m blocks) above a surface that is 6 m below the modelled water table (based on the average piezometer readings from 31 March 2009 to 31 March 2010).

The Measured and Indicated Mineral Resource at a cut-off grade of 1.25% HM accumulated to 6 m below the water table is listed in Table 4.1.

Table 4.1 Resource Estimate above a Surface that is 6 m below the Water Table at 1.25% HM Cut-off Grade

Resource Category	Tonnes (M)	HM (%)
Measured	1002	1.73
Indicated	74	1.77
Measured + Indicated	**1,075**	**1.73**

The bulk density data has a limited range of variability from 1.67 t/m^3 to 1.80 t/m^3, with an average of 1.75 t/m^3. GCO requested a conservative density of 1.7 t/m^3 be used throughout the deposit for resource and reserve estimation (see Section 3).
The heavy mineral has a consistent assemblage (Table 4.2).

Table 4.2 Assemblage Information

Item	Grade (% of HM)
Zircon	10.7%
Rutile	2.5%
Leucoxene	3.2%
Ilmenite	74.5%
Magnetic other	4.5%
Non-magnetic other	4.7%

On completion of resource drilling, AMC completed a JORC compliant estimate of Measured and Indicated Mineral Resource in May 2010 (see Section 3).

4.7.3 Geotechnical

The slope angles used for the dredge path design and tailings deposition were based on the geotechnical recommendations included in Section 5 of this report. The criteria used are:

- The dredge path has 35° slopes above water.
- The dredge path has 15° slopes below water.
- Tailings will have an average deposition angle of 17° (22° above water and 8° below).

A 6 m pond depth was used to provide sufficient draft for efficient mining and processing.

The angle of repose of the sand dunes was measured at 30°. The designed angle is steeper as it is expected that the slope will not reach the final angle of repose until after the dredge has passed.

4.7.4 Production Rates

The annual mining and production rate is 55 Mtpa. This rate was set by GCO and was based on marketing studies which indicated this amount of zircon product (~86,000 t) could be absorbed into the market.

Comparable mineral sand operations mining include:

- North Stradbroke (Australia) operates two dredge ponds each with a dredge and WCP. The combined production is 45 Mtpa.
- Paraíba (Brazil) operates with a single dredge and WCP at an annual production rate of 13 Mtpa.
- Moma (Mozambique) operates two dredges feeding a single WCP. Each dredge has a 2,500 tph capacity and the combined production rate is 38 Mtpa.
- Richards Bay (South Africa) operates four separate dredges and WCPs. The capacity of the dredges range between 2,200 tph and 4,000 tph and the combined production rate is 85 Mtpa.

Mining will commence at the end of the last quarter 2012–13 financial year. The production schedule allows for a ramp up period of two years. Table 4.3 lists the dredge mining rates used for production scheduling including the production ramp up. Section 6 details the ramp-up, utilisation and production rates.

Table 4.3 Dredge Mining Rates

Year	Mining Rate (Mtpa)
2013-14 financial year	41.084
2014-15 financial year	52.122
Remainder of Project	54.575

4.7.5 Dredge Path Design Criteria

The dredge path has been designed based on the following criteria:

- Fourteen years of initial dredge path based on current drilling. Debt funding advice given to GCO indicated a requirement that the mine path be designed for 14 years assuming that the debt is paid in the first 10 years with a subsequent four-year buffer period.
- Maximising the head grade for first 14 years of operation.
- All mining activities are within the Mining Concession.
- Only material with a mineral resource classification of Measured is included in the dredge path.
- A minimum width of 130 m (at the pond level). The minimum width is governed by the dimensions of the floating plant and angles of the pond below the water surface.
- A maximum width of 270 m (at the pond level). The limit of the pond width is governed by the mechanical capacity of the winches selected for the dredge.
- The dredge works most efficiently when the face is high and wide. The width of the dredge path is reduced in low-grade areas and where multiple passes of the wide dredge path would necessitate additional dilution.
- Avoid significant domiciles and cultivated areas. A key part of the dredge path design was an iterative review of affected persons and sites of significance in order that impacts on both can be minimised and/or avoided where practical. Areas avoided by the dredge path design include three cemeteries, the town of Foth, and settlements at Diournel and Thiakmat.

4.7.5.1 Depth of Dredging

To determine the best depth of dredging several designs were evaluated against the geological block model. The three scenarios analysed were:

- Mining with the dredge pond level at the current water table level.
- Mining with the dredge pond level 3 m above the current water table level.
- Mining with the dredge pond level 6 m above the current water table level.

Table 4.4 summarises the results of the assessment.

Table 4.4 Pond Level Assessment

Scenario	Tonnes (Mt)	Grade (HM %)	Design Life (years)
Pond at water table (0 m)	1,047	1.5	19.5
Raise pond 3 m above the current water table	863	1.7	16.1
Raise pond 6 m above the current water table	684	1.9	12.8

These results indicate that the overall head grade can be increased by the raised pond level. This is because the greater portion of the HM occurs in the upper portions of the sand dunes. Further financial and hydrogeological analysis has supported the elevation the pond level.

As the local topography does not always have sufficient altitude to support the raising of the pond level (it will overflow), some areas have been elevated only to the maximum level practicable. Furthermore, the dredge pond level, along the eastern edge of the dune, will be progressively raised towards the end of the first year of operation so that in the second year of mining, the dredge pond will be 6 m above the natural water table. This practice will ensure that the elevated water table does not overly affect communities adjacent to the dredging operation and will provide initial operating experience at the lower pond level.

4.8 Mine Design

4.8.1 Mine Design Assessment

Mine planning and scheduling was completed by AMC and included the following activities:

- Compile the geological resource block model to obtain total grade columns from the base of mining.
- Complete first pass 2D dredge path designs in plan.
- Evaluate the 2D design in sections to establish the preliminary design.
- Convert the design from a 2D design into a 3D design by incorporating slope angles and adjustment for depth.
- Evaluate the contents of the 3D design against the geological resource block model at a range of depths (0 m, 3 m and 6 m above the natural water table).
- Design of the tailings surface over the dredge path to calculate the volume of re-mined material and amount of tailings requiring off dredge path disposal.
- Schedule the results of the evaluation at the required production rates.
- Produce summary tables with quantities and grades by period.

4.8.2 Dredge Path Design

The 14-year dredge path design is shown in Figure 4.5. The dredge path has been coloured by year overlain on an aerial photograph. Figure 4.6 shows the location of these sections. Figure 4.7 to Figure 4.11 show cross-sections through the block model and dredge path. Appendix 4.1 contains an 1:40,000 scale drawing of the dredge path and block model.

Figure 4.5 Dredge Path Coloured by Year

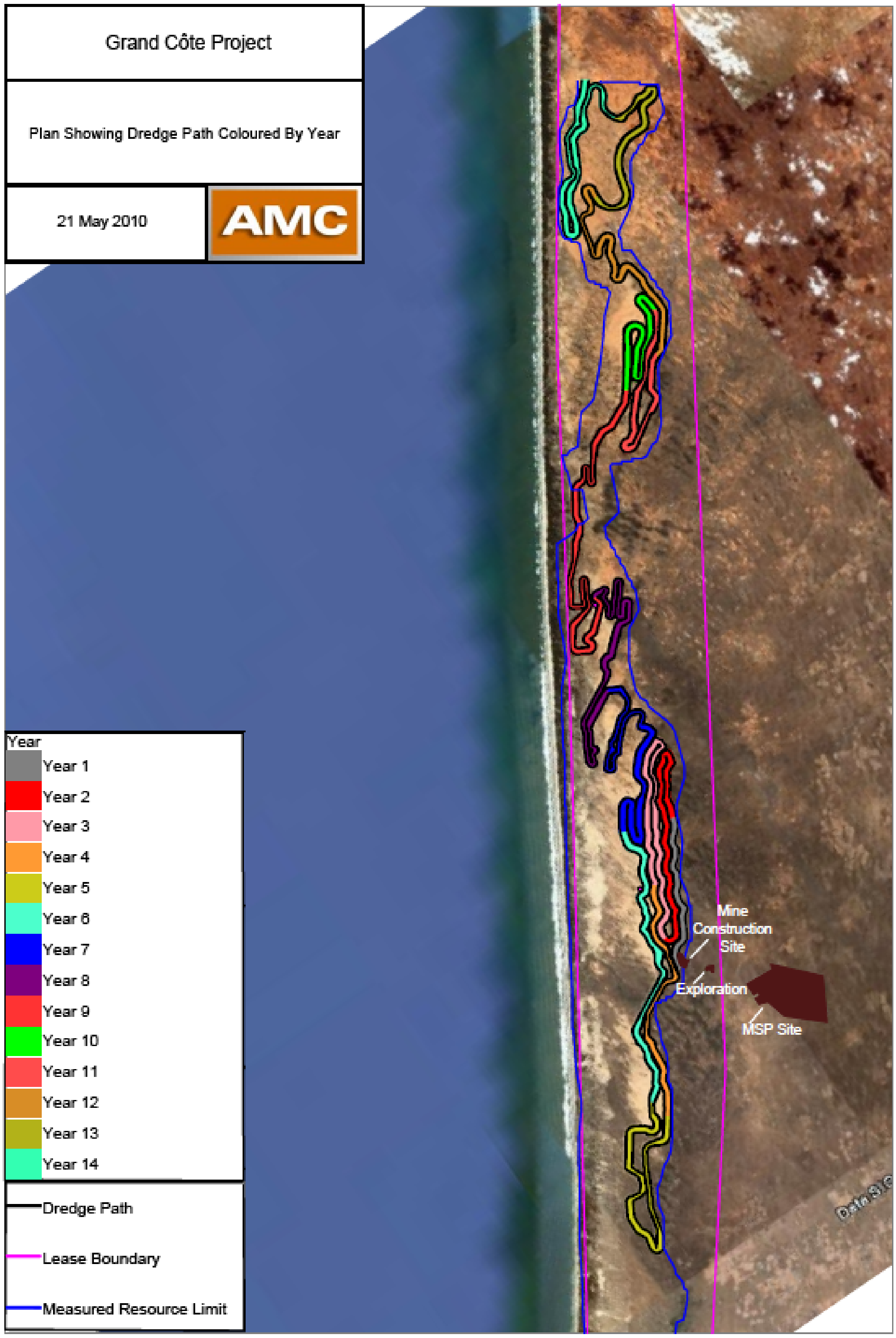


Figure 4.6 Plan Showing Section Locations

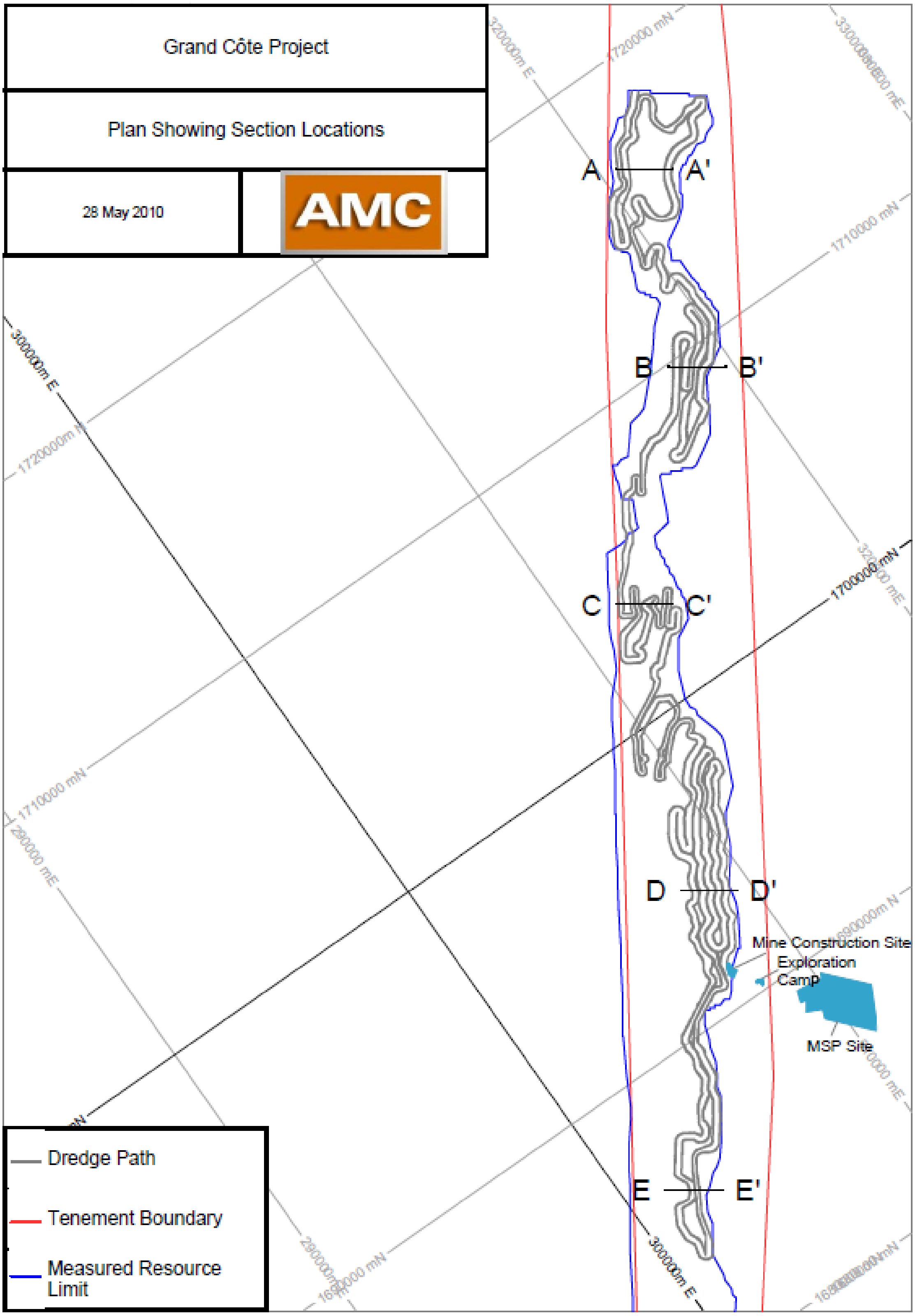


Figure 4.7 Section A-A'

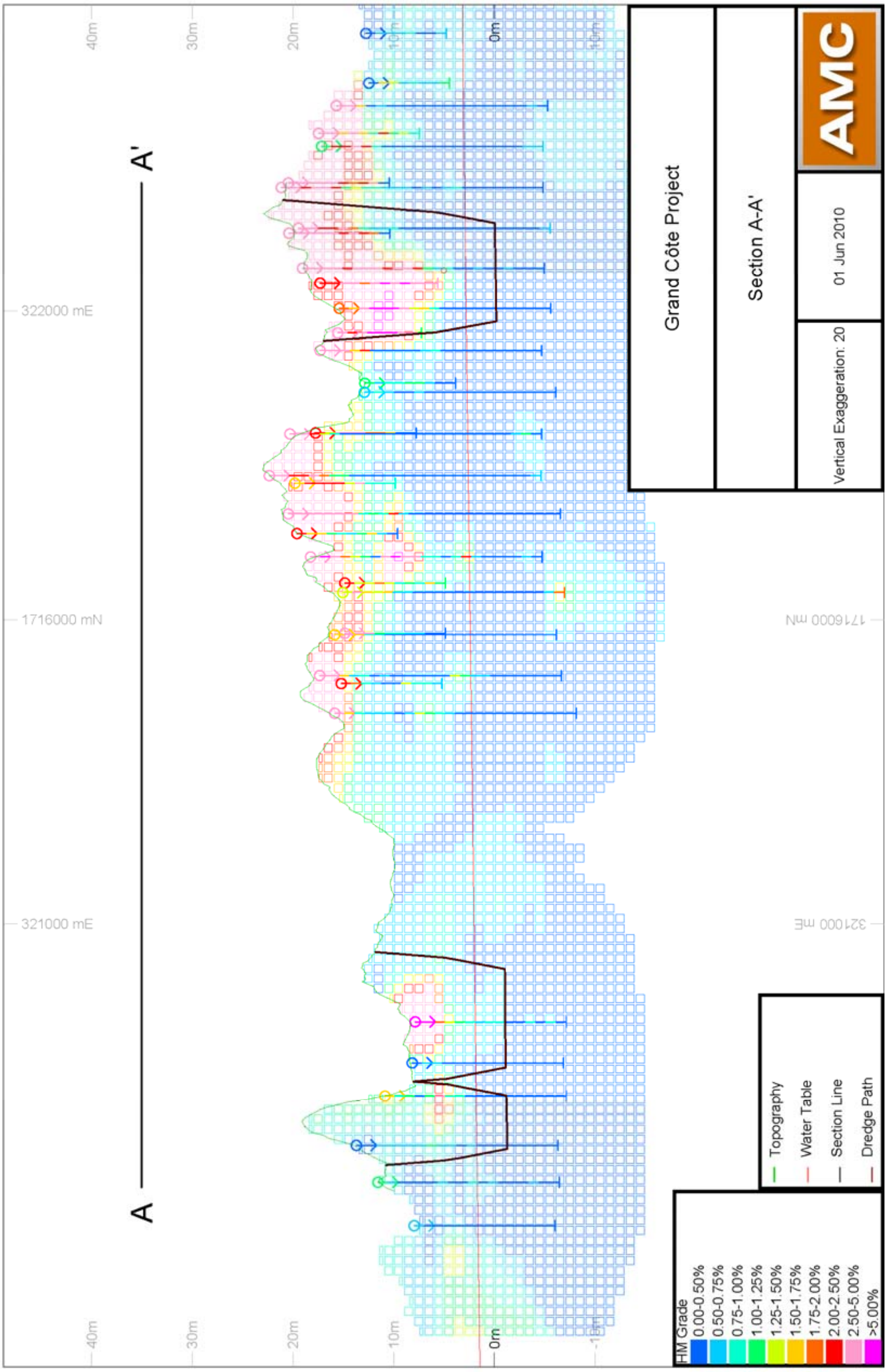


Figure 4.8 Section B-B'

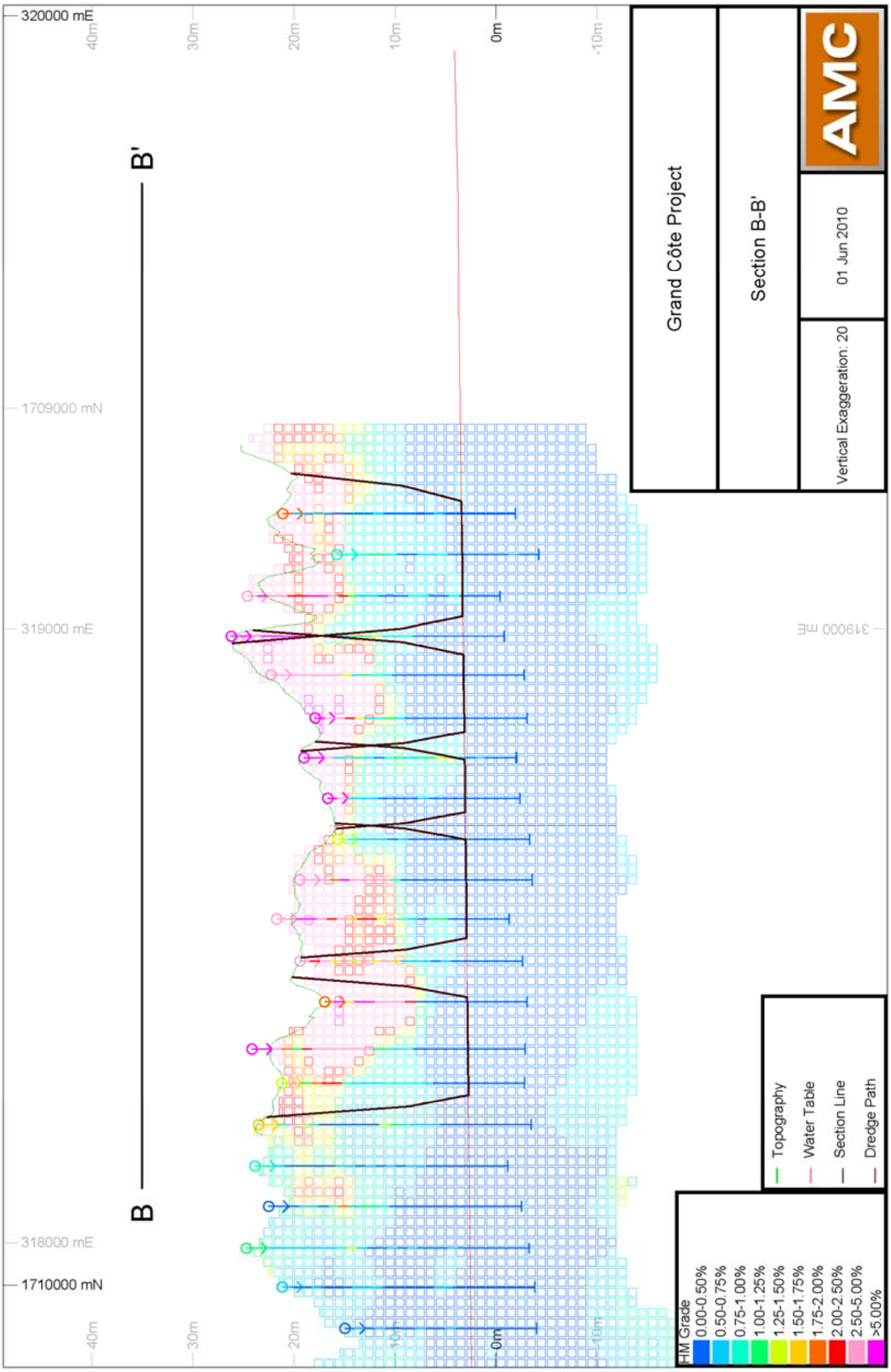


Figure 4.9 Section C-C'

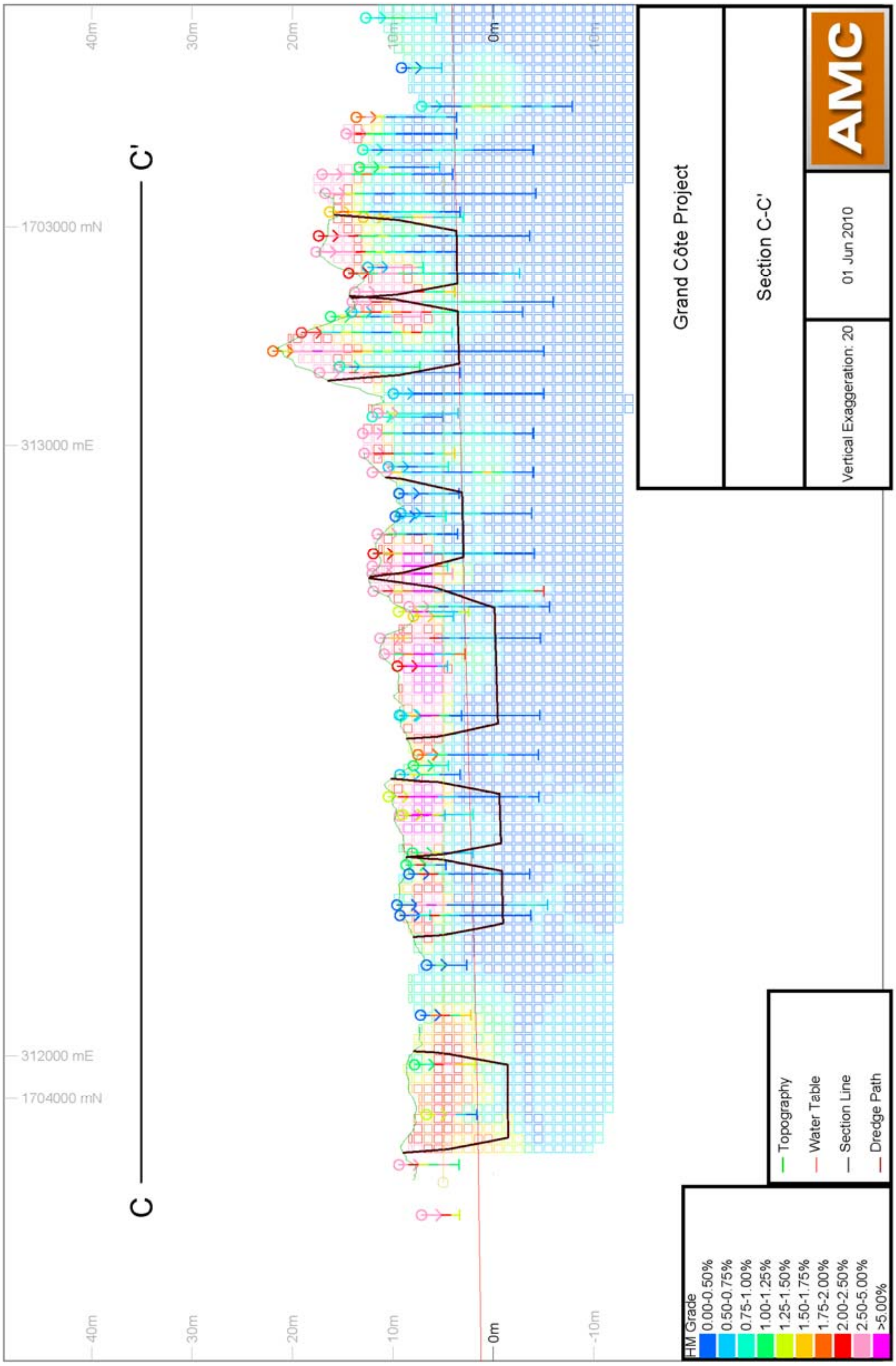


Figure 4.10 Section D-D'

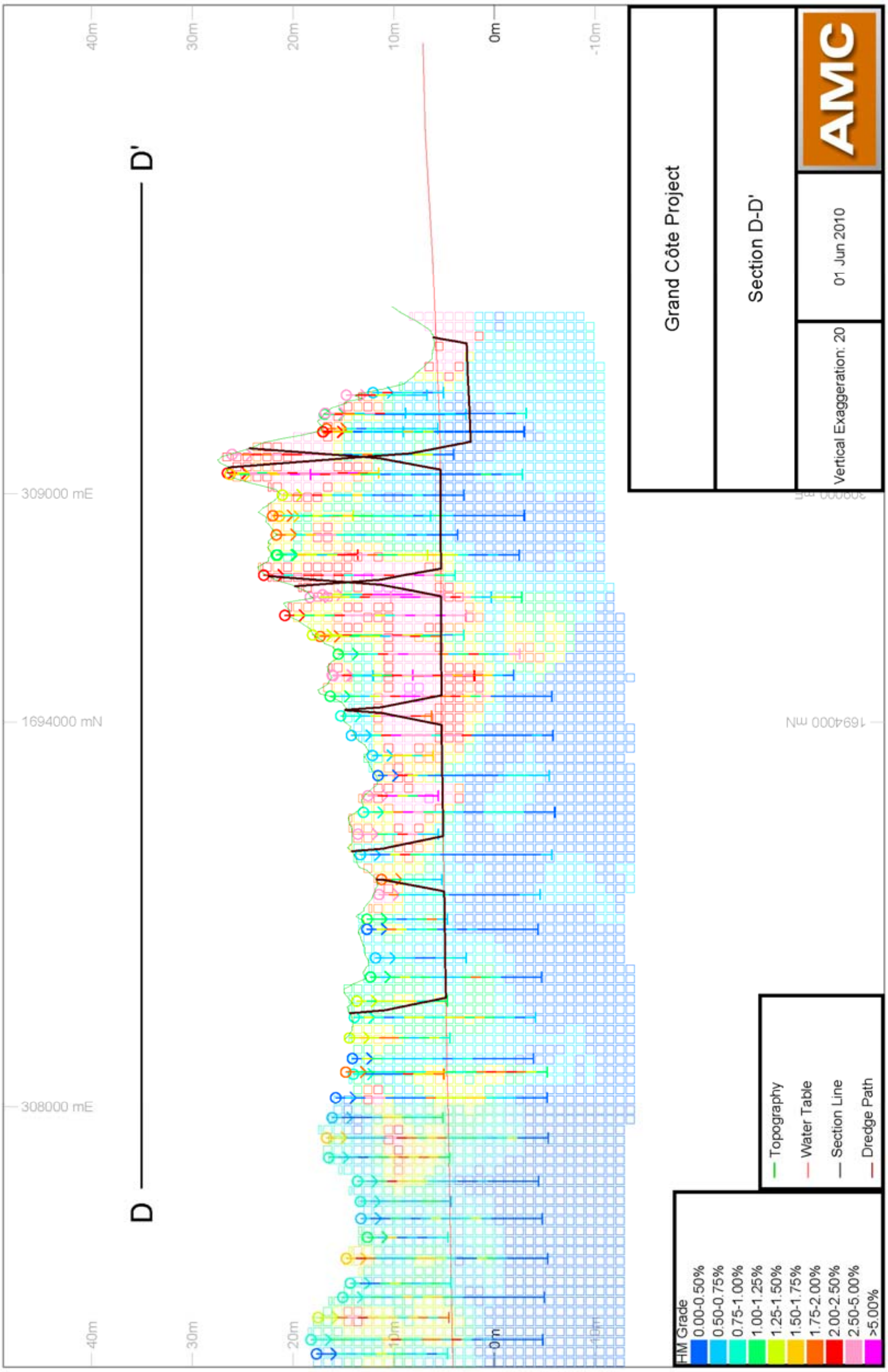
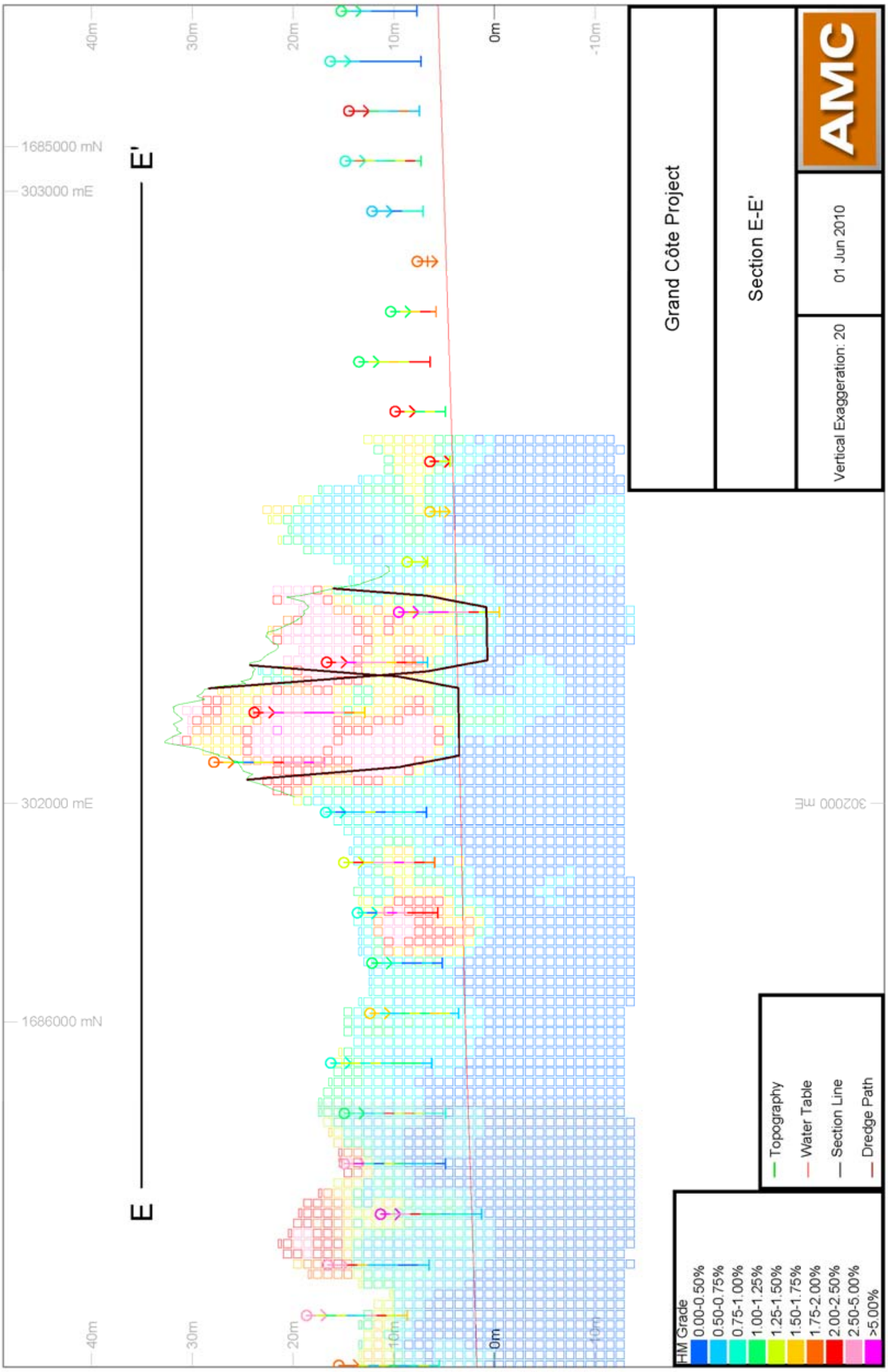


Figure 4.11 Section E-E'



The dredge path commences on the southern end of the eastern side of the dunal system. This position has the following benefits:

- The starting location is close to the zone containing the most heavy mineral.
- The mineral resource is well defined and has a mineral resource classification of measured.
- The starting location is close to the MSP.
- The starter pit is located in a flat wide swale, minimising earth works prior to dredge and concentrator construction.
- The starter pond is adjacent to a natural valley allowing tailings to be deposited away from the pond, negating many of the initial operational issues associated with tailings at the commencement of mining activities.

The dredge path initially proceeds north along the eastern edge of the mineralised dunes. In the second year of mining, the dredge path reaches the northern end of the main mineralised zone. The dredge then turns back toward the south. The adjacent dredge path is separated by 10 m at the pond level. The 10 m separation is to minimise the slumping of the previously stacked tailings. It should be noted that when mining adjacent to placed tailings, the tailings will be stacked, as far as practical, to the eastern edge of the void. This will minimise re-mining of the tailings.

The dredge path continues from south to north as shown in the plan (Figure 4.6). The dredge path is wide in this area to improve efficiencies and to maximise grade. The dredge path then progresses north, narrowing in low-grade areas and widening in wide high-grade areas.

4.8.3 Ore Reserve

The Ore Reserve has been estimated by applying modifying factors to the material contained within the dredge path design. Modifying factors typically include mining dilution and ore loss. Dilution (sub-economic material, unavoidably mined as ore) has been incorporated within the dredge path design. Additional dilution from outside of the design was not added to the Ore Reserve.

Ore loss (material intended to be mined as ore, but because of the mining method, is not mined) is thought to be negligible because of the mining action of the cutter head and the mining process.

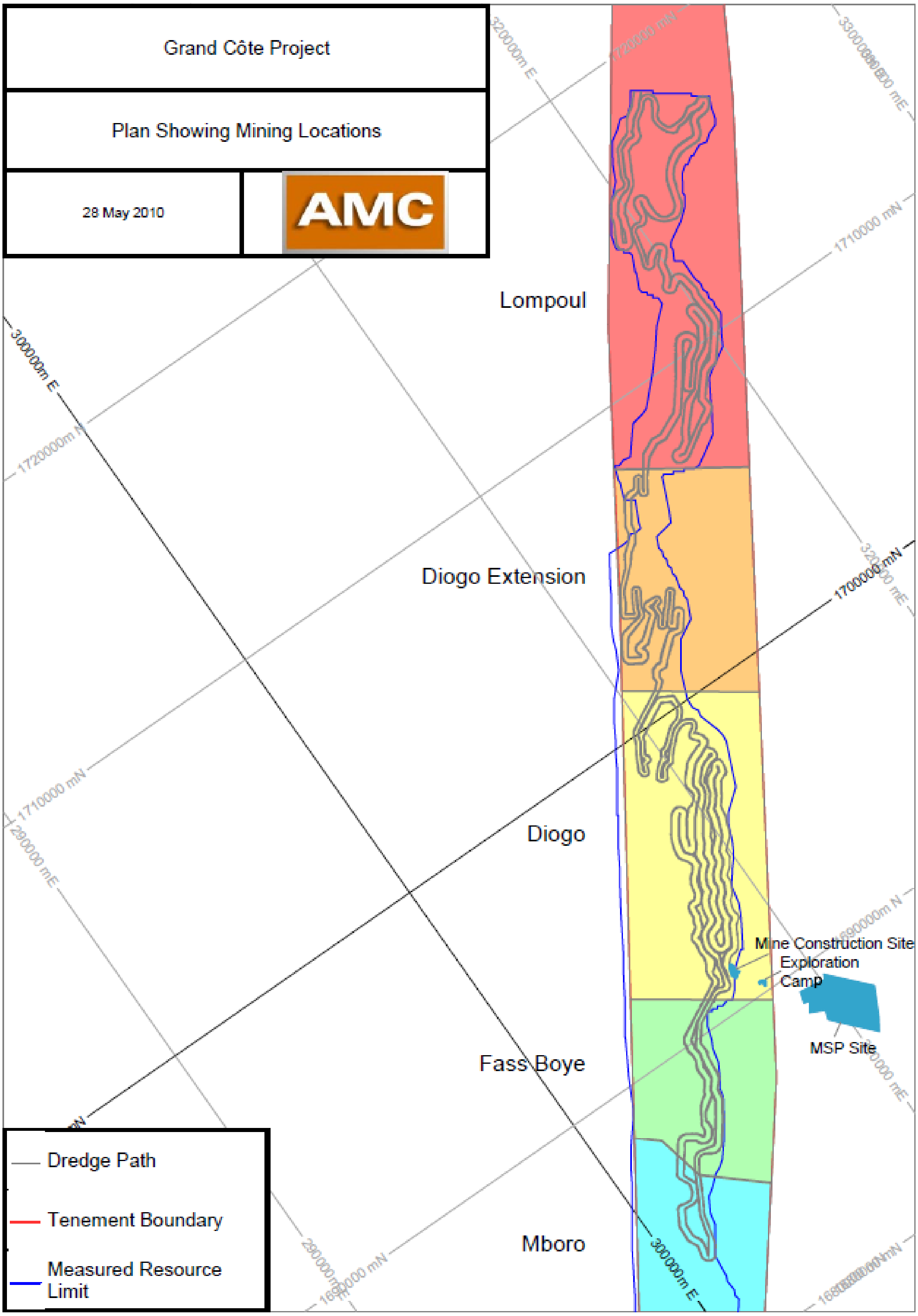
The deposit continues beyond these reserves to both the north and south and at lower grade adjacent to the designed mine path. Additional mine life will be dependent on the marginal project economics, mineral distribution, geometry and land access. Additional drilling will also be required in some areas to expand the resource base. However, it could be reasonably anticipated that a minimum of 10 additional years of mine life beyond the current reserve would be exploited in the Mining Concession.

Table 4.5 is a summary of the Ore Reserve estimate. For reporting, the Ore Reserve has been divided into mining locations. The extents of these locations are show in Figure 4.6.

Table 4.5 Ore Reserve

Location	Resource Category	Mt	HM (%)	HM (Mt)
Mboro	Proved	30	1.9	0.6
	Probable			
	Proved + Probable	30	1.9	0.6
Fass Boye	Proved	81	1.8	1.5
	Probable			
	Proved + Probable	81	1.8	1.5
Diogo	Proved	273	1.8	5.0
	Probable			
	Proved + Probable	273	1.8	5.0
Diogo Extension	Proved	69	1.9	1.3
	Probable	5	1.7	0.1
	Proved + Probable	74	1.9	1.4
Lompoul	Proved	293	1.7	4.9
	Probable			
	Proved + Probable	293	1.7	4.9
TOTAL	Proved	746	1.8	13.2
	Probable	5	1.7	0.1
	Proved + Probable	751	1.8	13.3

Figure 4.12 Mining Locations



4.9 Mining Schedules

4.9.1 Production Schedule

The mine production schedule was developed by evaluating the resource block model contained within the designed dredge path and then scheduling the results according to the production requirements (Table 4.3).

A summary of the dredge production schedule for the first 14 years of the mine life is shown in Table 4.6.

Table 4.6 Summary Mining Schedule

Year	Mt	Grade (HM %)	Mineral (HM Mt)	Area Mined (ha)	Length Mined (km)
1	41	1.8	0.76	60	5.5
2	52	2.0	1.04	220	9.6
3	55	1.8	1.01	360	12.9
4	55	1.8	0.99	380	8.9
5	55	1.8	0.99	260	12.2
6	55	1.8	0.97	350	10.6
7	55	1.8	0.96	380	14.3
8	55	1.8	1.01	410	14.3
9	55	1.7	0.94	350	16.4
10	55	1.8	0.99	440	8.4
11	55	1.7	0.92	120	9.0
12	55	1.9	1.04	400	10.2
13	55	1.6	0.89	330	7.7
14	55	1.5	0.77	260	13.2
Total	**748**	**1.8**	**13.3**	**4320**	**154.3**

The annual scheduled grade fluctuation is between 1.5 HM% and 2.0 HM%, averaging 1.8 HM%. The average annual scheduled HM mined and processed is 1 Mt.

4.10 Tailings Deposition and Final Landform

Tailings will be stacked directly behind the pond. The final landform will be contoured and rehabilitated.

The dredge and WCP will consume 440 Mm^3 of sand (contained within the 14-year dredge path design). The treated sand, because of swell, will occupy 20% more volume. Swell is the result of disturbed particles of sand not aligning in the most efficient packing arrangement. The minerals extracted have a negligible volume. The resultant volume of tailings is 528 Mm^3.

Most tailings will be deposited directly behind the WCP by the tailings stackers. The tailings stackers can only stack to a maximum height of 21 m above the pond level. In areas where the mining face is high, the volume exceeds that which can be stacked directly behind the pond. In these areas that produce a tailings surplus, the tails will need to be pumped to areas adjacent to the dredge path (off-path). The off-path tailings volumes for each of the mining areas are summarised in and Table 4.7.

Table 4.7 Summary of Off-path Tailings Volumes

Year	Volume (Mm^3)
1	10.3
2	3.5
3	0.1
4	0.0
5	0.7
6	0.4
7	0.0
8	0.0
9	0.6
10	0.0
11	1.2
12	0.7
13	0.7
14	1.5
Total	**20.6**

The volume of off-path tailings represents 2% of the total tailings volume. In the first year of mining, the volume of off-path tailings is higher (12%) than the remainder of the 14 years. The first year of mining experiences the highest mining face and the tailings will be stacked to the eastern side of the path to avoid rehandle by the adjacent dredge path.

4.11 Mobile Mining Equipment

A small fleet of mobile mining equipment is required to support the dredging operation. Mobile fleet duties include:

- Clearing ahead of the dredge. Dredge mining activities commence with land clearing and collection of vegetation and topsoil. This material will be moved off the dredge path and used in the rehabilitation process. The mining equipment used for land clearing will be bulldozers for removal of trees and vegetation, levelling of obstructions and short pushes of material.
- Rehabilitation activities. The GCP will involve large quantities of rehabilitation works; hence a small multi-purpose fleet of civil equipment will be used for these activities.
- Road and track maintenance. The continual movement of the dredge will necessitate ongoing road construction and maintenance.

- Assorted minor civil works across site.

Mobile equipment was selected based on the following key criteria:

- Availability (both new and used).
- Ability to be purchased from a single manufacturer, such as Caterpillar (CAT), Komatsu or others.
- Availability of spare parts and presence in Senegal.
- Past experience with the construction of the Sabodala and the operation of similar dredging activities in Australia.
- Special consideration was also placed on suitability to be operated in the unique all-sand environment.

The equipment selected (Table 4.8) will be used in a variety of activities, including construction, maintaining of access roads, ramp construction, dust suppression and clearing ahead of the dredge. The equipment will also be used in the rehabilitation process for reshaping the terrain and distribution of topsoil. All of the equipment is nominally CAT which is well supported in Senegal.

Table 4.8 Equipment List

Equipment	Number
CAT D9 dozer (dedicated clearing dozers)	2
CAT 330 excavator	1
CAT 730 articulated all-terrain trucks	2
CAT 16G grader	1
Seed and soil spreading machinery	1
Water truck c/w dust suppression spray rail (CAT 730 basis)	1
Service truck (CAT 730 basis)	1

4.12 Mine Services

The GCP dredging operation requires considerable services to support mine operations. These include roads, power supply and reticulation, borefield and water reticulation infrastructure. These are described below.

4.12.1 Roads

A main service corridor will be constructed parallel to the dredging path. This will be a permanent road built to nominally 8 m wide from laterite and chert material and will have the main water header and power line located adjacent to the road. Access roads will be constructed adjacent to the planned dredge path and will provide vehicular access to the working areas and water bores from the main service corridor.

Pond access ramps will be constructed by bulldozers cutting the ramp into the wall of the dredge pond and pushing sand out to form a landing above the pond water level.

Ramps will be constructed at regular intervals as required. Pond access roads and ramps will be required to carry services to and from the dredge pond (dredge and WCP), including:

- Personnel access including transport.
- Power.
- Return and make-up water pipes.
- HMC transport pipes.
- Cranes and trucks transporting replacement equipment and maintenance tools.

4.12.2 Power Reticulation

Overhead power lines will deliver power to the dredge, the WCP and bores and booster pumps. Substations will be required to distribute the power to pump sets. The overhead power lines will be constructed in parallel with the advance of the dredge pond. Further details on power and power reticulation are in Section 9.

4.12.3 Borefields and Water Reticulation

Deep water and lateral water bores will deliver water to the dredge pond and WCP and will prevent possible detrimental impact of the changing ground water level adjacent to the mining and tailing operations on nearby farms and domiciles. Water bores will require mains power, substations, pipes and a series of access roads off the main service corridor water pipeline.

4.12.4 Pumping of HMC and Return Water

Pipes will carry the HMC to the MSP from the WCP. A 250 mm diameter pipe will be placed adjacent to the main access road with a number of booster pumps and substations. Return pipes will deliver water and a waste slurry back to the pond from the MSP. Further details of this system are provided in Section 6.

4.12.5 Extension of Services

Services will be extended as the mining operation progresses. The capital cost estimate allows for the installation of services sufficient for the first two years of operation. The actual period of service provision is much longer in some instances due to the repetitive nature of the dredge path. The operating cost model contains allowances for extension of the services from the third year of operation including:

- 2 km of power and main water services on an annual basis.
- Lateral extensions of power and water at 400 m intervals in line with the dredge pond movement.
- Additional deep water and lateral bores in line with dredge movement and water requirements.

4.12.6 Specialist Equipment

Support of service extensions will require specialised machinery, including polyurethane welding machines. A service barge will be purchased for supporting floating plant maintenance activities.

4.13 Mine Maintenance

Mine maintenance practices and strategy will draw heavily on the experience of MDLs recently completed Sabodala Project in Senegal. The maintenance strategy at Sabodala was based on the development of a Management Operating Strategy (MOS) and this strategy will be adapted for the GCP.

The MOS details site wide process flows and the interrelationship with maintenance activities including, meetings roles/responsibilities and application of Key Performance Indicators such that maintenance practices can be effectively managed.

Maintenance practices will be developed concurrently with construction of site facilities. Key activities will include:

- Compilation of a complete asset register for fixed and mobile equipment.
- Criticality review of fixed and mobile plant equipment.
- Review of vendor recommended sparing and purchase relative to the criticality review.
- Development of short-, medium- and long-term maintenance procedures/ inspections for all equipment (both fixed and mobile) associated with mining operations.
- Development of work procedures for major overhauls on identified critical equipment such as the dredge cutter.
- Scheduling and planning of maintenance activates in accordance with vendor recommendations and site conditions.

All maintenance will be in-house as opposed to contract, except for specialised support such as power line installation and extensions which will be subcontracted out to specialised contractors. Manning and maintenance costs as detailed in Sections 14 and 17 respectively, reflect this approach. A workshop for fixed and mobile plant maintenance will be located at the MSP.

4.14 Manning and Personnel

Manning numbers and an organisational chart for mining activities are presented in Section 14.

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SECTION 5

Geology and Geotechnical Site Conditions

AMC CONSULTANTS

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CONTENTS

TABLES

FIGURES

5 GEOLOGY AND GEOTECHNICAL SITE CONDITIONS

5.1 Introduction

The key geotechnical issues for the Grande Côte Project are:

- Foundation conditions for proposed plant sites.
- Stand-up angles of sand during mining.
- Ground conditions for road access.
- Design bearing capacity of the sand.

The general site conditions likely to be encountered, as described in this section, have been derived from field geotechnical reports and soil laboratory testing conducted in 2007 and appended to this volume of the DFS as Appendices 5.1 and 5.2, combined with site observations by AMC personnel in early September 2009.

5.2 Regional and Local Geology

The extensive Senegal-Mauritanian Basin covers most of Senegal and is composed of Mid Jurassic to Recent, poorly cemented marine sands, marls, limestones and shales overlain by continental lacustrine and marine sediments. The Grande Côte Project (GCP) area is situated within the Senegal-Mauritanian Basin in north-west Senegal within the belt of coastal dunes that lie along the current shoreline. The dunes are Recent in age (Holocene 4,000 to 2,000 years before present), are mobile or semi-fixed, pale yellow in colour and overlie older Late Quaternary white marine sands. The dunes range between 5 m and 35 m in height (Figure 5.1).

Figure 5.1 Coastal Mobile Dunes

The Recent light yellow, mobile dunes overlie older late Quaternary white marine sands that were deposited during a time when lagoons, bars, spits and deltas formed along the coast together with the development of minor peat in lagoons and estuaries. The interface between these two layers is generally a 0.5 m humic horizon. Both the light yellow dunes and the underlying white marine sands can contain heavy minerals. The wind-blown movement of the dunes is capable of completely covering weak materials such as peat and loose sand, without leaving any visible indication as to what underlies the exposed sand.

The area to the east of the dunes consists of sand, which AMC understands is able to absorb all rainfall without any appreciable run-off (Figure 5.2). Culverts and bridges have not been required on the currently existing roads near the project area.

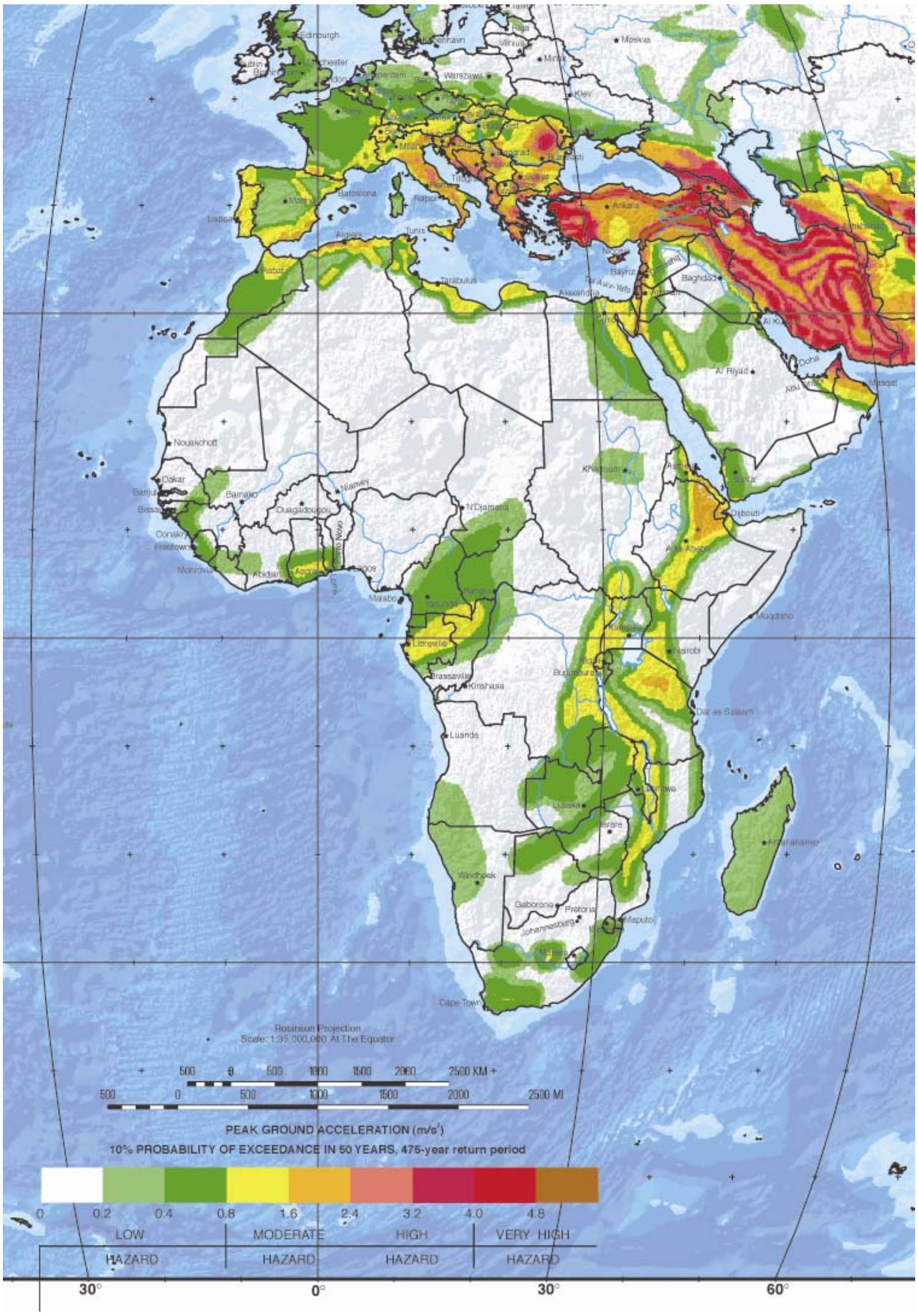
Within the project area are numerous wells and pits and by observation the depth to water in these wells varies between 1.5 m to 8 m below the humic horizon (base of swale) for an average depth of 4 m.

Figure 5.2 Typical Terrain East of the Mobile Dunes

5.3 Seismicity

Australian seismologist Mr Gary Gibson has supplied a copy of the Global Seismic Hazard Assessment Project (GSHAP) map of African earthquake hazard, which is presented in its entirety as Figure 5.3. Mr Gibson advises that it is a preliminary map mainly due to the incomplete seismograph coverage of the African Continent.

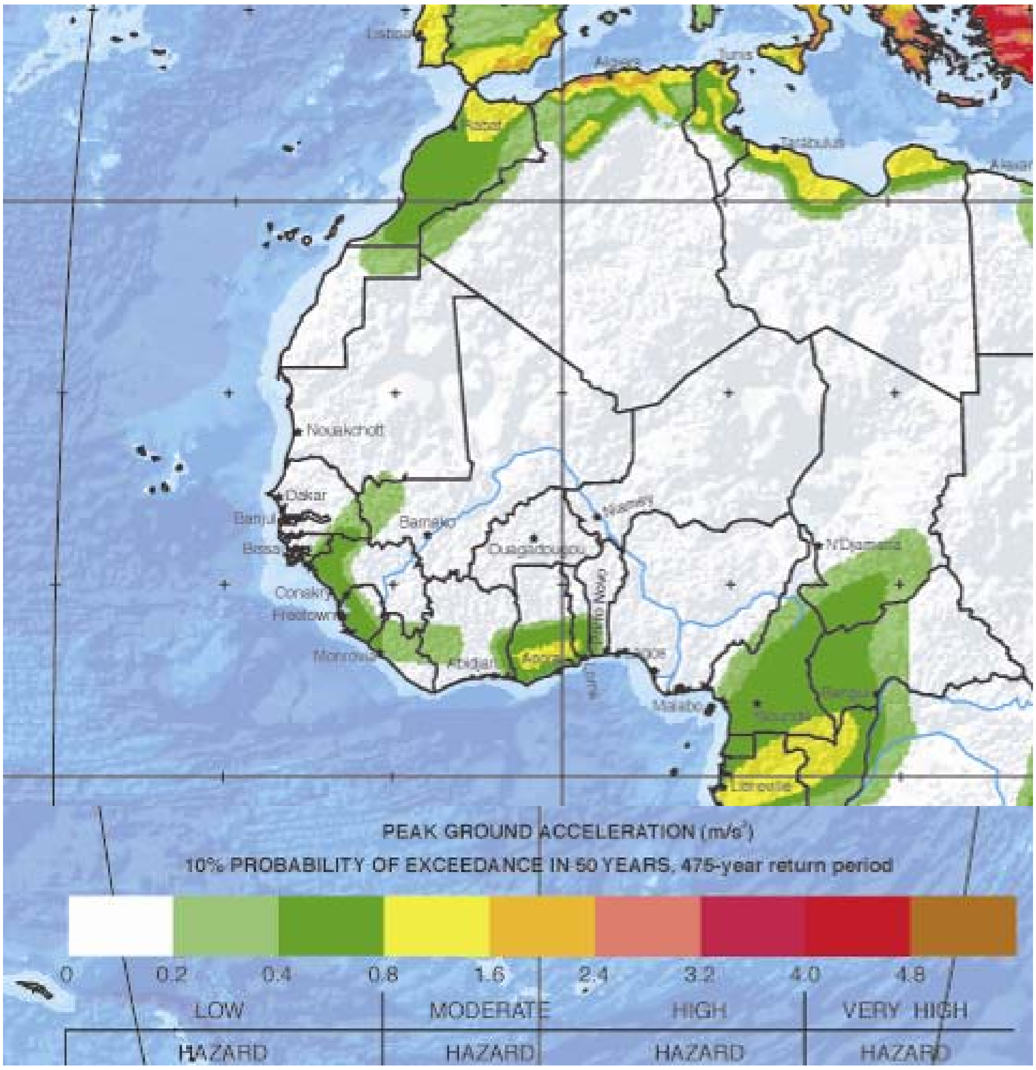
Figure 5.3 Global Seismic Hazard Assessment Project (GSHAP) Map of Africa



The closest significant seismic event to the project site was the 1939 Accra Earthquake, with a focus about 2,100 km to the south-east of the project site. The GSHAP map indicates that the predicted peak ground acceleration for a seismic event at the project site is <0.2 m per second (<0.2 m/s^2) with a 10% probability of being exceeded in 50 years. This relatively low level of seismic hazard is similar to that of most of West Africa and 99% of Australia.

An enlarged portion of the GSHAP map is presented as Figure 5.4.

Figure 5.4 Enlarged Portion of the GSHAP Map



5.4 Site Assessments

The site where the dredge will be constructed and a plant site were the subject of detailed geotechnical investigations in the period 2006 to 2007. A pattern of auger boreholes was drilled, typically to 12.5 m depth. The drill rig performed standard penetration tests (SPT) every 2 m down each borehole and bag samples were taken for subsequent laboratory testing of the material brought up by the augers in between the SPT tests. Observations of the angles of repose of mobile sand dunes in the ore deposit were made by AMC during a site visit in early September 2009 (Figure 5.5).

Figure 5.5 Measuring the Angle of Repose of the Mineralised Dune Sand

The Geotechnical Site Plan is presented as Figure 5.6 and an enlarged plan of the dredge erection site (MSC) and the potential mineral separation plant site (MSP) are presented as Figure 5.7. The sites of the SPT boreholes are shown by green '+' signs and the sites of the clinometer measurements are shown by blue '+' signs. The MDL dredge path design is shown by red lines.

Specific road alignments are yet to be reviewed. No site investigation has been done for the access roads, but generalised conclusions can be drawn from the test results for the MSC and MSP sites. The planned pavements consist of a base of aggregate and a wearing course of compacted laterite to give a total thickness of about 600 mm.

Figure 5.6 Geotechnical Site Plan

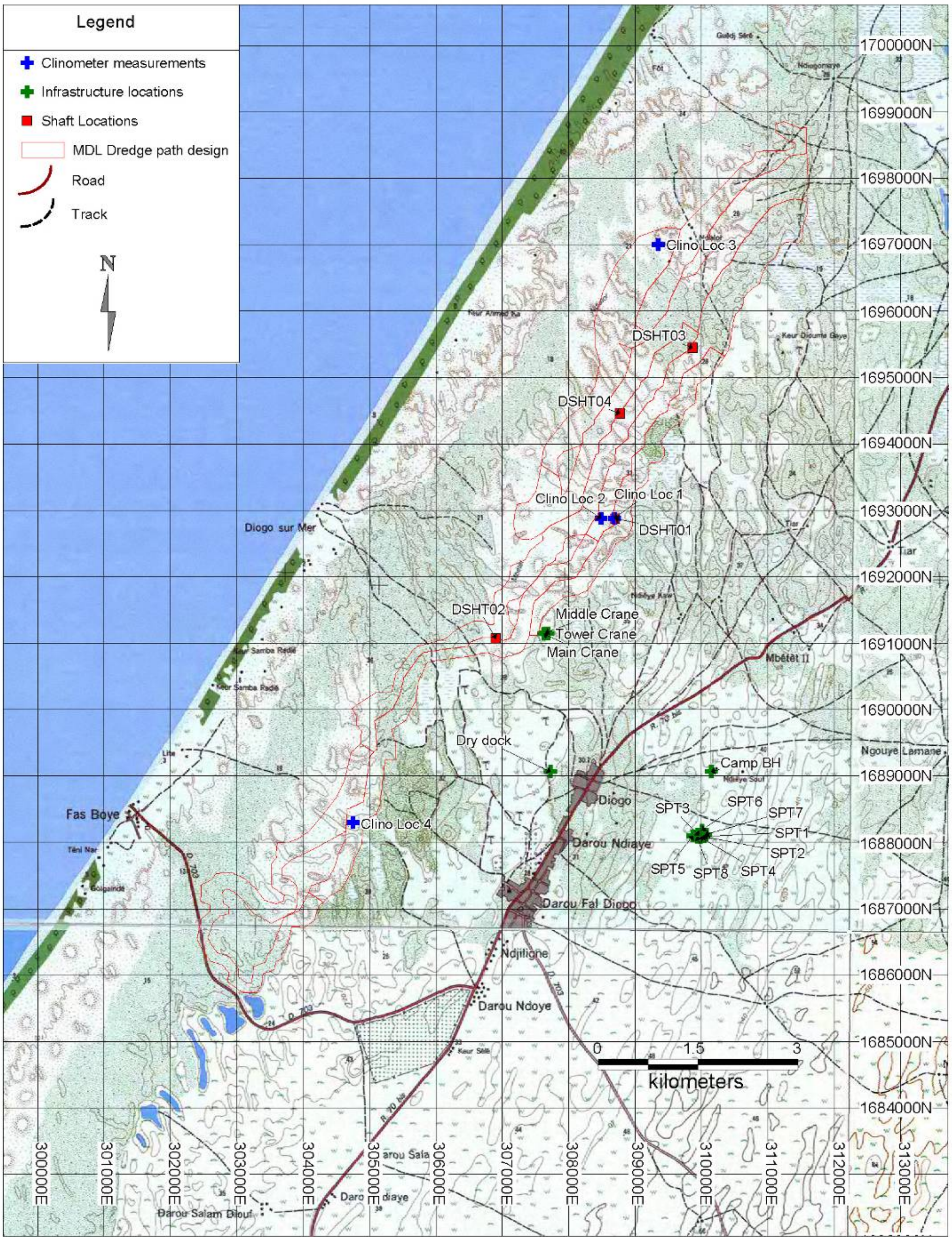
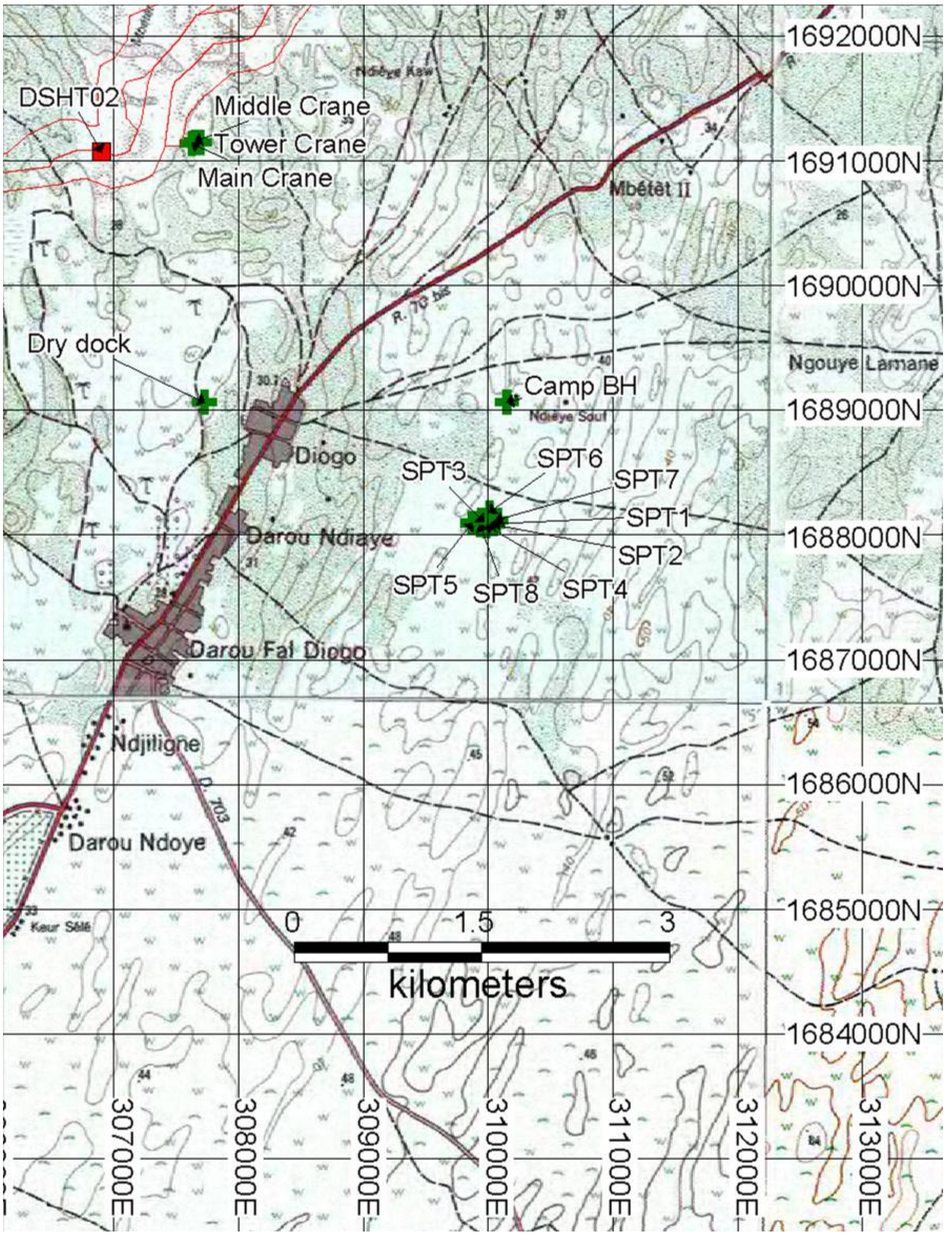


Figure 5.7 Enlargement of Part of the Geotechnical Site Plan



5.5 Measured Angles of Repose of the Dune Sand

A total of nine observations of the angle of repose were made at four different sites, shown by blue '+' signs on the site plans presented as Figure 5.6 and Figure 5.7. Seven of the nine observations were 30°, one was 25° for a convex-shaped dune slope and one was 33° for a concave dune slope. The adopted angle of repose for the dry dune sand on planar slopes is 30°. However, when first exposed by the dredge, the sand is capable of standing on an angle of 35° due to surface tension effects involving a thin layer of moisture between the sand grains. As the sand dries in the several hours following its initial exposure, the surface tension cohesion component gradually diminishes, and the angle of repose reduces back to 30°.

If there were no waves and no water turbulence in the dredge pond, a 30° angle of repose would also apply for submerged, undisturbed wind-blown sand at the site. However, allowing for these erosional effects, 15° sand slopes have been adopted below water.

5.6 Access Road Construction

The access roads are planned to be constructed on sand which, as can be seen from Figure 5.2, is easily rutted by wheeled traffic. There is a mat of grass covering the ground where no tracks exist (Figure 5.8). This will be preserved wherever possible, with only the very longest grass being cut but not pulled out, prior to the commencement of road construction. The road base and the pavement layer will be placed in 100 mm to 150 mm lifts and compacted to at least 100% standard compaction before the next lift is placed. Except where required by an unfavourable profile of the natural ground surface, the surface mat of grass will not be disrupted as the first lift of road base material is being placed. Water trucks will be available to permit the road construction materials to reach optimum moisture content as they are being compacted. A regular testing regime will be implemented to ensure the design compaction standards are met at all construction stages.

Figure 5.8 Typical Ground Inland of the Active Dunes

5.7 Construction of the Proposed Road Link to ICS Railhead

A 28 km haul road will be constructed from the MSP to the ICS railhead for haulage of bulk ilmenite. While the alignment of this road has been finalised, no site investigation has been done of the alignment. The site geotechnical site investigation will be conducted prior to the commencement of site works. It is proposed that the road will be constructed in a similar matter to that described for the access road (see Section 5.6).

5.8 Soil Properties

5.8.1 Drillholes

The sampling and testing of soil was obtained from a total of 12 drillholes, with eight located at the MSP site and three at the MSC site. The results of both field and laboratory testing were used to assess the variability of the sands across the sites and, at the MSC site, their allowable bearing capacity.

The laboratory tests were reported as two programs, Program 1 being testing completed at the MSP site (March 2007) and Program 2 at the MSC Site (April 2007). These reports are contained in Appendix 5.1 and Appendix 5.2, respectively.

5.8.2 Field Testing

SPTs were undertaken as the primary method for recovering disturbed soil samples and strength data. SPTs were completed in the boreholes typically every 2.0 m to a depth of 12.5 m.

Samples taken using a split-spoon (SPT test) are disturbed samples and do not represent the in situ conditions. The results of direct shear and density tests performed on these samples are regarded as approximate.

5.8.3 Geotechnical Laboratory Testing

The laboratory testing was conducted at Senelabo located in Dakar. The testing was conducted to French Standards (NFP). The standard applicable to each test is recorded on the laboratory testing certificates supplied.

The schedule of testing included:

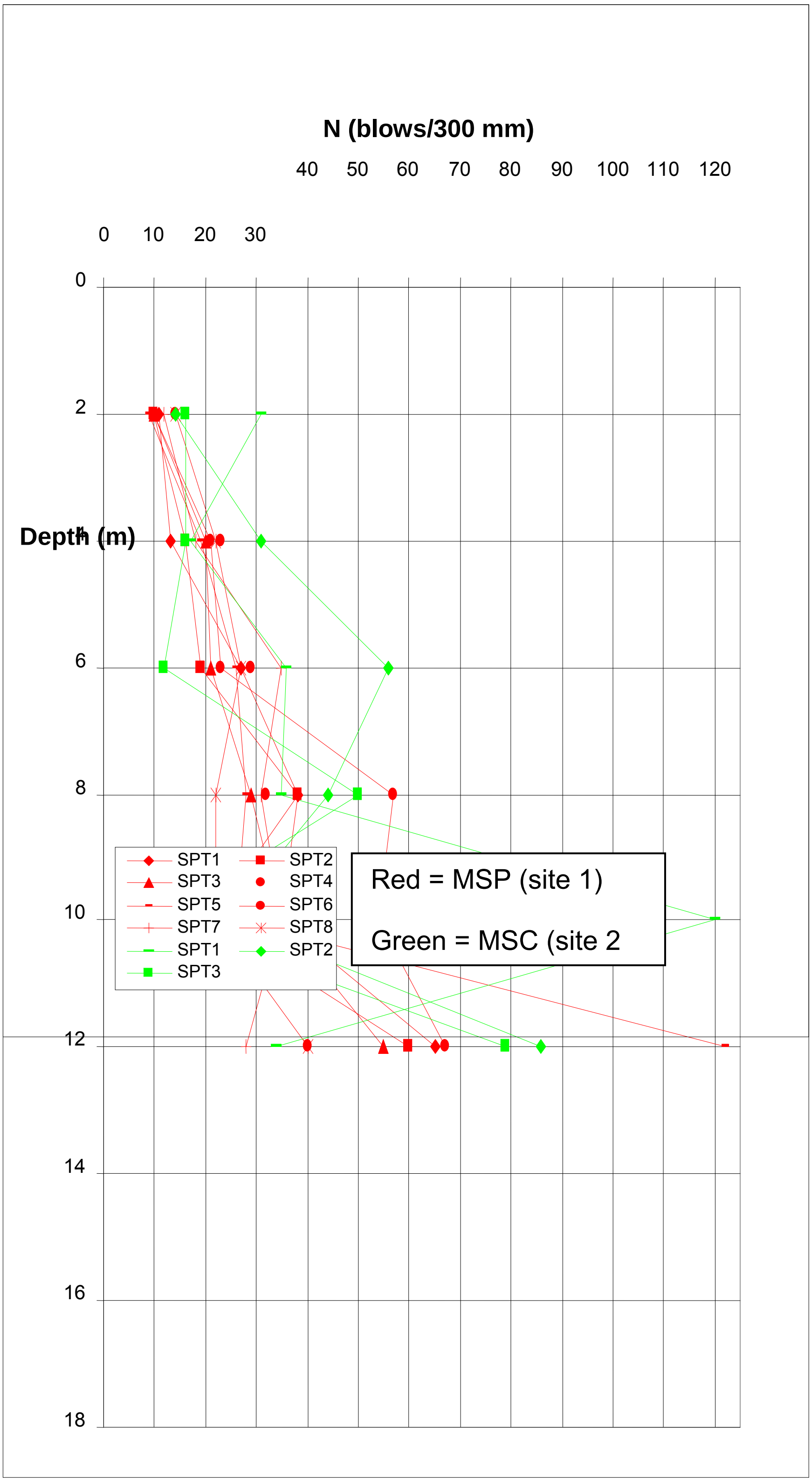
- Direct shear test - the test results are used to interpret peak and residual shear strength values.
- Particle size distribution (PSD), represented by a grading curve.
- Field moisture content and density.

5.8.4 Test Results

Standard Penetration Test Results

The SPT test measures the soil resistance, which indicates the soil shear strength or relative density. Figure 5.9 presents the SPT N-values of all tests taken for both the MSP and MSC sites relative to depth below ground surface. Results indicate that SPT tests at the MSP site (red on Figure 5.9) shows greater consistency between tests at the same depth, particularly in the upper 6 m when compared to results at the MSC site (green on Figure 5.9). A contributing factor may be that there are only three drillholes at the MSC site as compared to eight at the MSP. Similarly, the MSC site generally recorded higher N-values and with a larger degree of variability (compared to the MSP site).

Figure 5.9 SPT N-values at the MSP and MSC Sites



Results of SPT's are influenced by grading of the particles, the degree of consolidation and the time over which the sand has been undergoing consolidation. Evidence indicates that a coarse-grained sand typically records a higher N-value than a finer grained one and sand at depth records a higher N-value due to the increase of effective overburden pressure.

As mentioned, the results of SPTs can be used to indicate the relative density of sands (Terzaghi & Peck, 1967). Table 5.1 shows the range of results and associated relative density classification at 2 m depth intervals for both the MSP and MSC sites.

Table 5.1 Summary of SPT N-values

Depth of SPT Test (m)	SPT N-value Range at MSP Site		Relative Density Classification	SPT N-value Range at MSC Site		Relative Density Classification
	From (m)	To (m)		From (m)	To (m)	
2	9	14	Loose to medium dense	14	31	Medium dense
4	13	22	Medium dense	16	31	Medium dense
6	19	35	Medium dense to dense	12	56	Medium dense to very dense
8	22	57	Medium dense to very dense	36	50	Dense
10	21	54	Medium dense to very dense	11	120	Medium dense to very dense
12	28	122	Dense to very dense	34	86	Dense to very dense

At the MSP site the N-values, in general, appear slightly lower and less variable than at the MSC site. The relative density classification at the MSP site in the upper 6 m ranges from loose (near surface) to dense (at 6 m). On average, the density of the sands in the upper 6 m at the MSP site is considered to be medium. At a depth of 8 m to 12 m the N-values become more variable and the relative densities increase, with most N-values recorded being >30, suggesting the presence of dense sands. Within SPT 5, an N-value of 122 was recorded, this result may indicate the presence of a laterite or cemented zone.

At the MSC site, where the N-values are slightly higher, the relative density classification in the upper 6 m ranges from medium dense (near surface) to very dense (at 6 m). On average, the sands in the upper 6 m at the MSP site are considered to be medium dense. At 8 m depth and below, the sands are typically classified as dense to very dense according to the N-value.

Similarly to the MSP, one SPT recorded an extremely high N-value of 120. Again this may indicate the presence of a cemented or laterite zone at a depth of approximately 12 m from surface.

It should be noted that typically an N-value of 50 (for blow-count over 300 mm) is considered as penetration refusal. Sands with an N-value of >50 are classified as very dense, the highest rating, therefore further blow-counts beyond this N-value are not necessary in terms of classification.

The SPT N-values obtained from the field tests were used along with the interpreted shear strength parameters from direct shear tests to assess the allowable bearing capacities for a square foundation. This is further discussed in Section 5.9.1.

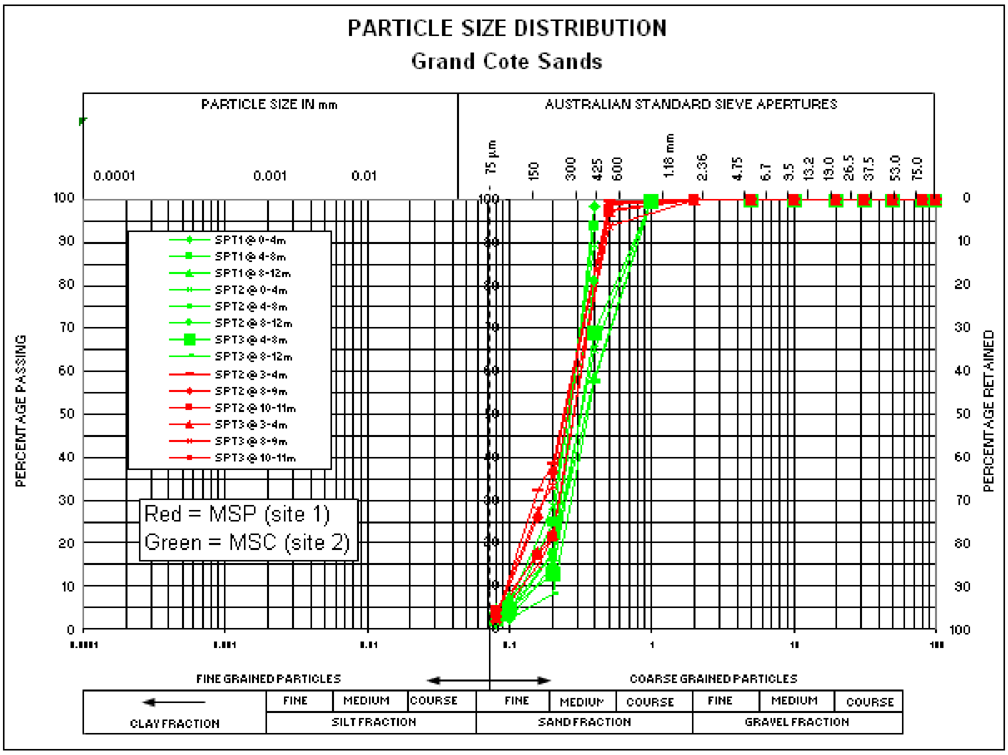
Particle Size Distributions (PSD)

Sieving was conducted on samples from both the MSP and MSC sites. At the MSP site a total of six PSDs were conducted, these were from drillholes SPT1, SPT2 and SPT3. No samples were tested from SPT4 to SPT8. At the MSC site, nine PSDs were conducted from samples within each of the three SPT holes (SPT1 to SPT3).

The particle size distributions plotted on a single chart to assess the variability in grading of the sand profile across both the MSP and MSC sites. The comparison is represented by grading curves as shown in Figure 5.10.

It should be recognised that the Australian Standard sieve sizes differ slightly to that used in the testing and there may be some difference in the grading classification.

Figure 5.10 Particle Size Distributions (Grading Curves) at the MSP and MSC Sites



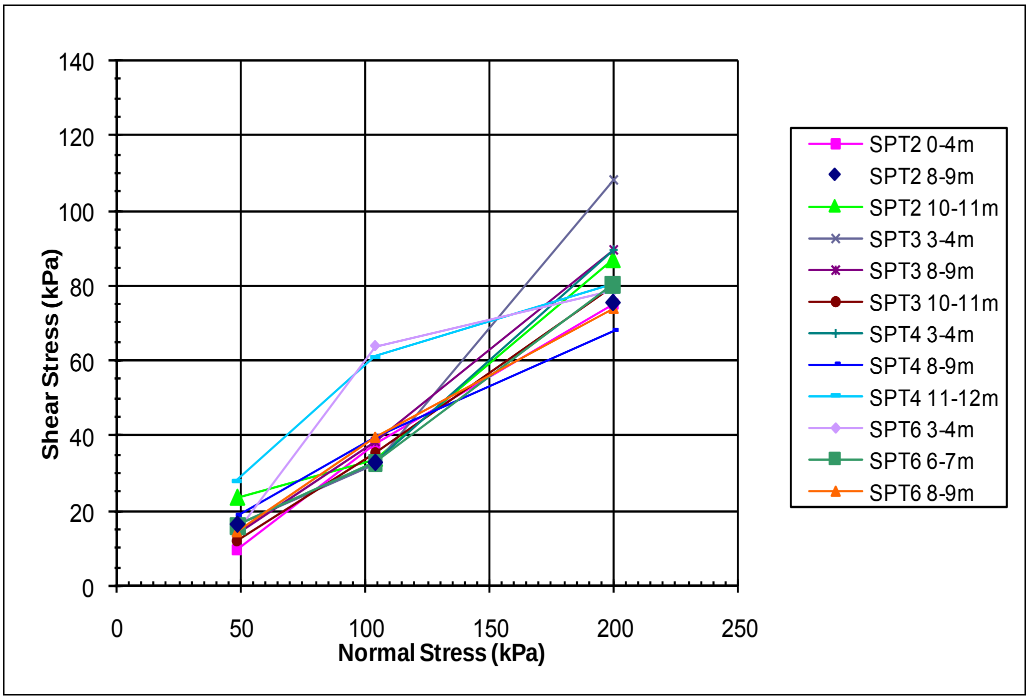
The results of the PSD tests at both sites show the sand to be classified (in accordance with Australian Standards) as uniformly graded, medium-grained sand. The sands at MSC site may be slightly coarser grained but are classified the same as the MSP site, generally it is considered that the sands at both sites are similar in terms of their grading.

Direct Shear Test

Direct shear tests were undertaken on samples obtained from both the MSP and MSC sites. At the MSP site, a total of 12 direct shear tests were carried out on samples from drillholes SPT2, SPT3, SPT4 and SPT 6. At the MSP site, a total of nine direct shear tests were conducted on samples obtained from drillholes SPT1, SPT2 and SPT3.

The results of the direct shear tests were used to interpret the effective friction angle (Φ') for the sands encountered at the MSP and MSC sites. The data from all the direct shear tests at each site was graphed on a single s-t plot and then a line of best fit determined (with the y-intercept = 0). The slope of this line was then used to indicate a representative effective friction angle. The s-t plots for the MSP and MSC sites are shown in Figure 5.11 and Figure 5.12 respectively.

Figure 5.11 Summary s-t Plot of Direct Shear Tests at the MSP Site



The data from each site was then combined and plotted on a single s-t plot, Figure 5.13. This plot also shows the interpreted “line of best fit” each site based on the data.

Figure 5.12 Summary s-t Plot of Direct Shear Tests at the MSP Site

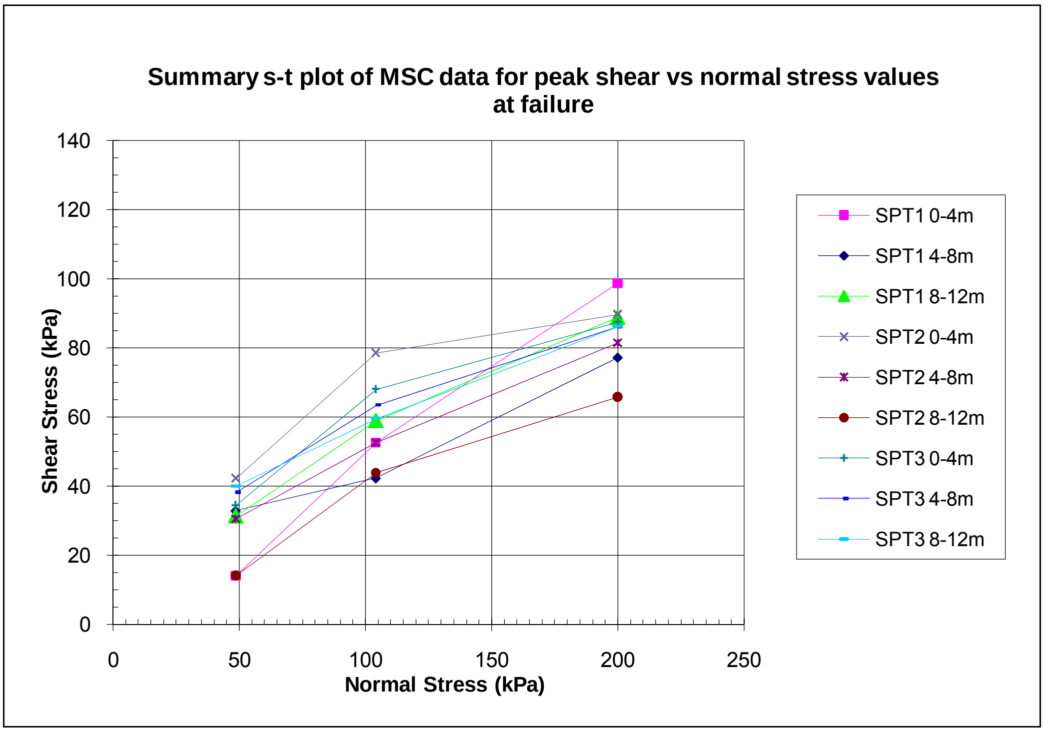
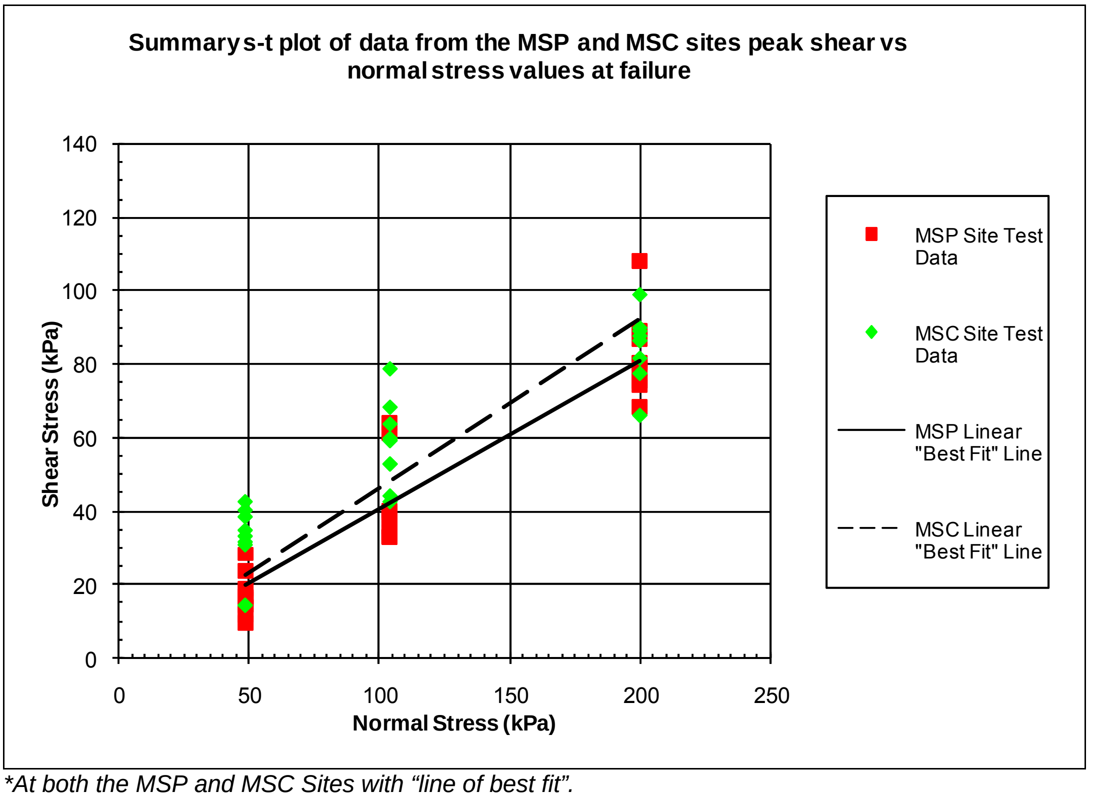


Figure 5.13 Summary s-t Plot of Direct Shear Tests



**At both the MSP and MSC Sites with "line of best fit".*
Note: the Y intercept is set to 0 kPa (no cohesion).

The interpreted effective strength parameters for each site from the s-t plots are:

- MSP site: effective cohesion = 0 kPa, effective friction angle = 22°.
- MSC site: effective cohesion = 0 kPa, effective friction angle = 25°.

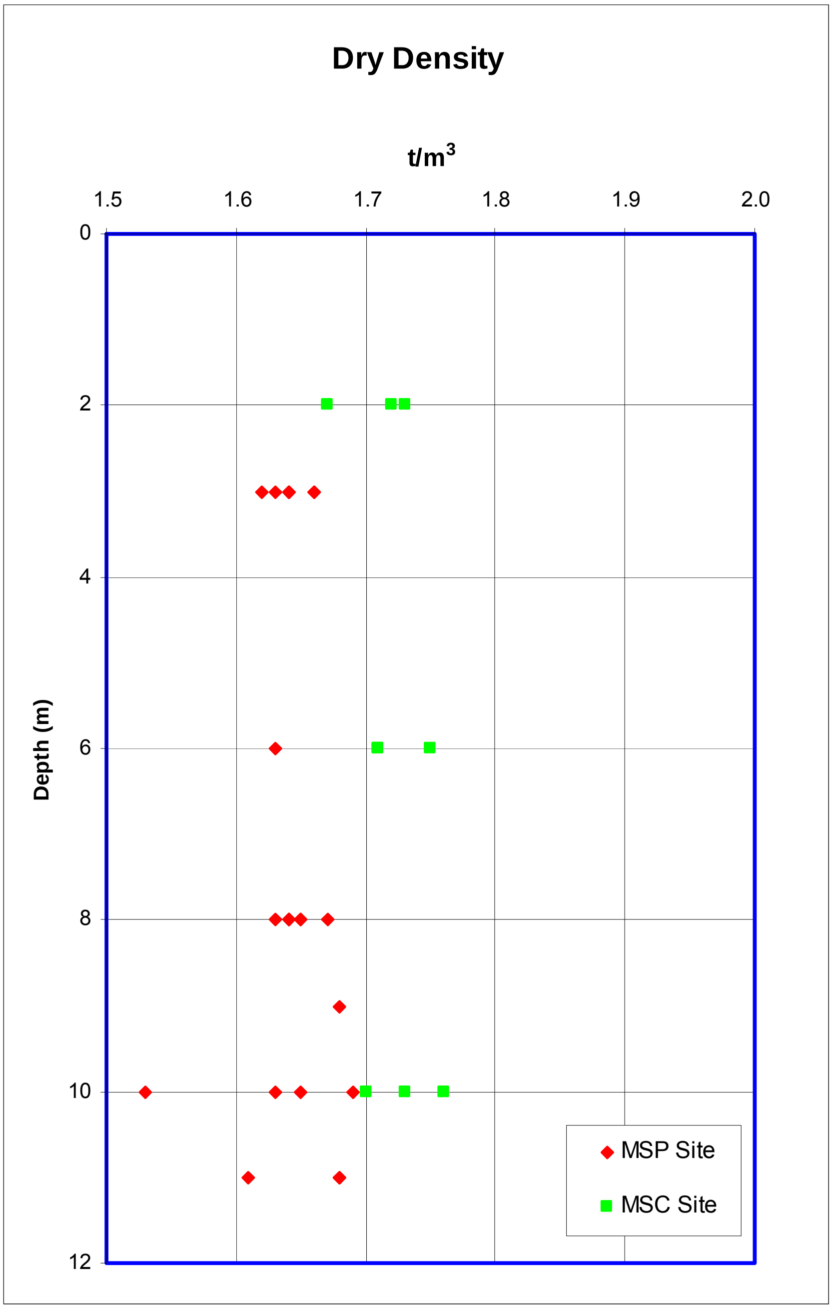
This indicates that the sands at each site have similar strengths, with the MSC site having a slightly higher effective friction angle.

The results of this analysis were further used in determining an allowable bearing capacity for shallow foundations discussed in Section 5.9.

Density

The results of the dry density tests are plotted in Figure 5.14. The results indicate that sands at the MSC site have a slightly higher dry density than those at the MSP site. Generally there is minimal variation within each site and results remain reasonably consistent with increasing depth.

Figure 5.14 Plot of Dry Density Test Results for the MSP and MSC Sites



The average dry densities at each site are:

- MSP site, average density: 1.64 t/m^3.
- MSC site, average density: 1.72 t/m^3.

5.9 Bearing Capacity at Site

The overall functionality of a foundation depends on the interaction of the structural foundation with the soil above and below. The soil at a particular site should not be considered as having an intrinsic bearing capacity, but rather it should be thought of in terms of the bearing capacity for a specific foundation arrangement that includes the structure itself and the surrounding soil.

The requirements of the design should include provision for limiting the settlement, factor of safety (FoS) against shear failure, serviceability, durability and cost. This assessment focuses on using field and laboratory testing results to determine the appropriate bearing capacity for the sand at the MSC site.

The appropriate bearing capacity for shallow foundations for this site was determined using published correlations of recorded SPT N'-values to allowable bearing capacity and by first-principles method (Meyerhof's Bearing Capacity Equation, 1963).

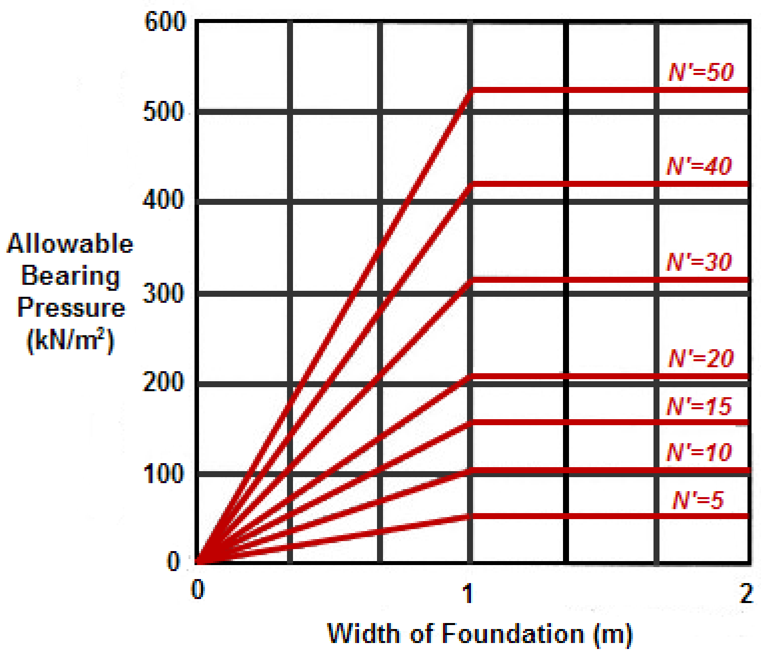
The foundation arrangement assessed relates to that for a tower crane located at the MSP site. The details of the foundation structure are understood to be:

- Square concrete slab foundation with dimension 8 m long x 8 m wide.
- Founded at a depth of 2 m from surface (with backfilled soil placed on top).

5.9.1 Allowable Bearing Capacity Derived from SPT N-value Data

Peck et al. (1974), proposed a design chart for the net allowable bearing capacity of square foundations based on the corrected SPT N-values (N'). This relationship is shown in Figure 5.15.

Figure 5.15 Design Chart of Allowable Bearing Pressure for SPT N'-Value



** Peck, 1974.*

The red lines on the chart shows the allowable bearing capacity for N'-value allowing for up to 25 mm of settlement. This incorporates a factor of safety (FoS) of 2 against shear failure criteria.

The N'-values are calculated as follows:

$N' = N \times C_N \times C_W$

Where

N = the lowest field blow-count (N-value)

C_N = the correction factor for overburden pressure

C_W = correction factor for the effect of the water table, only used if the water table is expected to rise subsequent to the investigation to a depth B (width of foundation) below the foundation.

To assess the allowable bearing capacity using the above method, the lowest N-value recorded within each of the three SPT drillholes at the MSC site was corrected to N', as detailed in Table 5.2.

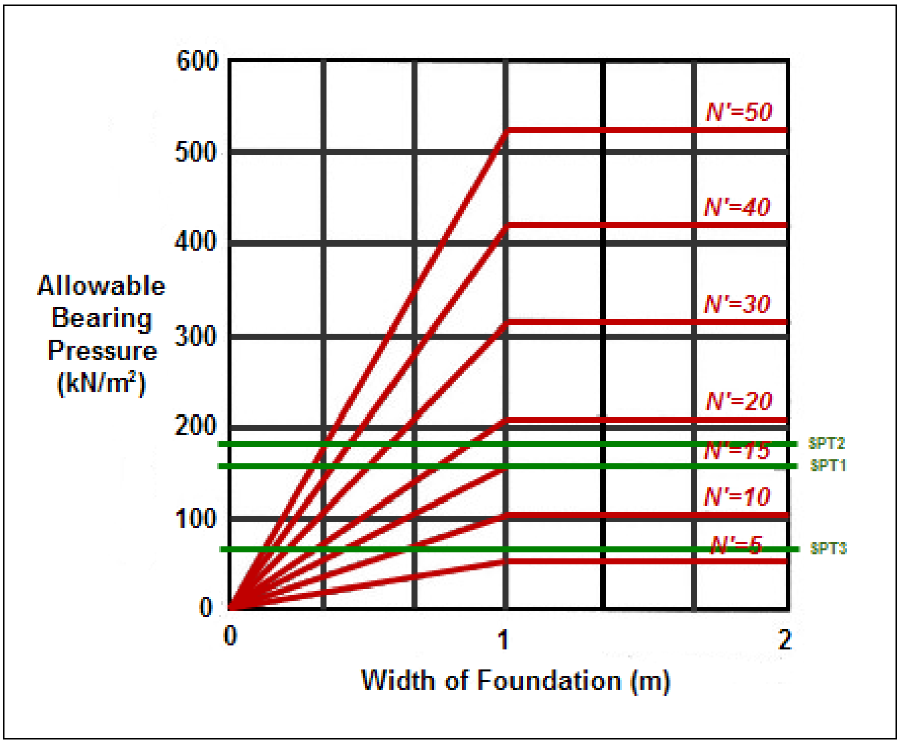
Table 5.2 Summary of the Lowest Corrected N-values at the MSC Site

SPT Drillhole (MSC Site)	Lowest N-value	Depth (m)	Effective Overburden Pressure (kPa)	C_N	C_W	N'
1	17	4	68.8	1.25	0.70	**15**
2	14	2	34.4	1.77	0.70	**17**
3	11	11	189.2	0.79	0.70	**6**

The lowest N-value recorded at SPT3 was 11, which appears unusually low at this depth in comparison the other SPT results at the site and may represent a pocket of medium dense sand buried by denser sand. This medium dense material was underlain in turn by very dense sand with an N-value of 79 at 12 m. The lowest N-value recorded in SPT1 and SPT2 are more consistent with other tests completed at the MSP site.

Each of the N'-values are plotted on the design chart to derive an allowable bearing pressure (Figure 5.16).

Figure 5.16 Design Chart of Allowable Bearing Pressure



**Based on SPT data in three drillholes at the MSC site.*

As a result of plotting the lowest N'-value from the three drillholes at the MSC site (location of the tower crane), the design chart suggests an allowable bearing capacity ranging from approximately 70 kPa (SPT3) to 180 kPa (SPT2).

5.9.2 Allowable Bearing Capacity Derived from Bearing Capacity Equation

The allowable bearing capacity was evaluated using two methods. Firstly using correlations with the SPT data, and secondly, using the bearing capacity equation (Meyerhof, 1963).

The bearing capacity equation derived for shallow footing uses a shear failure model and the condition of limiting equilibrium assumed to apply at the point of failure. The equation used (Meyerhof, 1963) takes into consideration depth and shape of the foundation structure and the inclination of the applied load (if required).

Inputs to the equation include:

- Unit weight of the sand.
- Friction angle of the sand.
- Length and width of the foundation structure.
- Depth to base of the foundation structure.
- Inclination of the load.

The equation calculates an ultimate bearing capacity. In order to determine the allowable bearing capacity a FoS is applied. It is generally recommended that for shallow foundations a minimum FoS of 3 is adopted.

Based on the laboratory tests data at the MSC site, the following soil parameters were adopted:

- Unit weight: 16.9 kN/m3 (equal to a density of 1.71 t/m^3).
- Friction angle: 25° (cohesion of 0 kPa).

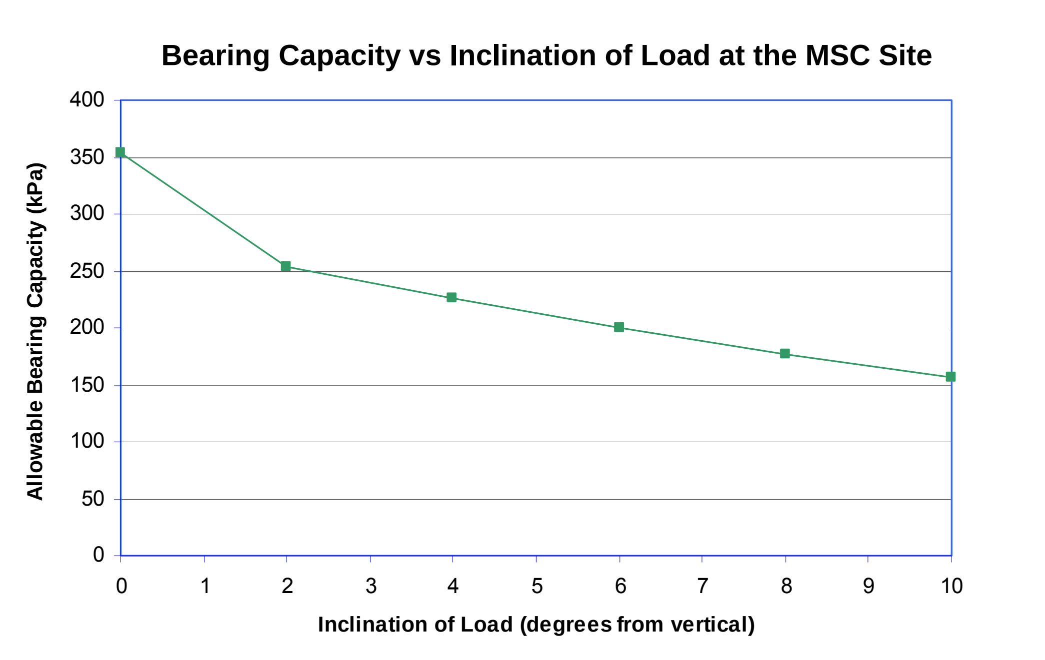
The allowable bearing capacity was calculated for an inclined load of up to 10° from vertical, the results are shown in Table 5.3 and Figure 5.17. This is particularly relevant for the foundations of tower cranes that might be involved in erecting structures at the MSC and MSP sites.

Table 5.3 Summary of the Bearing Capacity at the MSC Site

Inclination of Load (Degrees from Vertical)	Bearing Capacity	
	Ultimate (kPa)	Allowable with FoS of 3 (kPa)
0	1060	353
2	760	253
4	680	227
6	600	200
8	530	177
10	470	157

**Based on the bearing capacity equation.*

Figure 5.17 Design Chart of Allowable Bearing with Inclined Loads



5.9.3 Summary of Results

The geotechnical investigations, which included eight SPT drillholes at the MSP site and three at the MSC site, indicate that the soil profile consists of medium dense to very dense medium-grained sand.

The SPT N-value and laboratory dry density testing indicate some minor variation in density between the MSP and MSC sites. The sands at the MSC appear to be denser at shallower depths, with a relative density of medium at 2 m depth increasing to very dense at 6 m. At the MSP site, the relative density at 2 m depth was loose to medium and very dense sands were recorded at 8 m. This variation in density is also reflected in the dry density laboratory testing, with sands at the MSC recording a higher average result. Both holes show an increase in density with depth, which is expected due to an increase in effective overburden pressure.

The direct shear tests indicate that the effective friction angle of the sands at the MSC site is higher (25°) in comparison to the MSP site (22°). The particle size distribution test shows that sands at the MSC may be slightly coarser (although still medium-grained) which would contribute to a higher friction angle.

Two methods were used to determine the allowable bearing pressure using available data. These included a correlation between N'-values with allowable bearing pressure and the bearing capacity equation using laboratory test data (direct shear test and density).

An assessment of the bearing capacity for a shallow footing was conducted based on SPT and laboratory test data. It is understood that the current allowable bearing capacity adopted by Ausenco for the design of the tower crane at the MSC Site is 150 kPa. AMC understands that a bearing capacity of 150 kPa has been widely used in the past in this area. The analysis conducted suggests that 150 kPa is a reasonable average value to adopt in the design of shallow footings at the MSC site.

However, the allowable bearing capacity based on correlation with N'-values for the three drillholes at the MSC site suggests 70 kPa to 180 kPa. It should be noted that the method recommends using the minimum N-value recorded within the effective depth, and therefore there is some inherent conservatism. The allowable bearing capacity of 70 kPa determined from SPT3 appears to be relatively low in comparison to the other results. This result is affected by a deeper (11 m), less dense and locally occurring layer. Also a shallow footing with its base at 2 m applies significantly less stress to the sand at 11 m compared to the sand directly underneath it at 2 m to 4 m depth. However, the possibility remains that pockets of sand with an allowable bearing capacity of 70 kPa could exist just below the surface of the sand. Therefore the currently available test results are only applicable to the actual sites drilled, and cannot simply be extrapolated over the entire area.

The bearing capacity equation utilised the results of the laboratory tests on samples from the MSC site to calculate the ultimate bearing capacity for vertical and inclined loads. The calculation requires a representative friction angle of the sands (determined from plotting results of direct shear tests) and average result of the density tests. The allowable bearing capacity was then derived by applying a FoS of 3.

Results show that an allowable bearing capacity of 150 kPa is acceptable for vertical and inclined loads of up to approximately 10° (from vertical). It is considered therefore, that based on the bearing capacity equation, an allowable bearing capacity of 150 kPa is appropriate for most of the sand sampled at the MSC site, but that attention must also be paid to the possible existence of less dense pockets of sand.

As a consequence of the possible existence of pockets of significantly weaker sand at any depth in the profile, structures will be founded on large, heavily reinforced concrete slabs that are able to bridge over pockets of less dense sand. Once the actual locations are known for key items of plant, further drilling investigations that include SPT testing will be done at these locations.

MDL Mineral Sands Group

SECTION 6

Mineral Processing

AMC CONSULTANTS

Copy 16

CONTENTS

TABLES

FIGURES

6 MINERAL PROCESSING

6.1 Introduction

This section summarises both the historical and most recent mineral processing testwork on the Grande Côte deposit. The Ausenco flowsheets and plant design basis which have been developed from the testwork are described and the process plant design criteria are also detailed.

The testwork covered the production of zircon, rutile, leucoxene and ilmenite products, with the primary aim being increasing the recovery and specification of the final products. Upgrading of the ilmenite to synthetic rutile was considered but not included in the final treatment flowsheet.

Testwork by MDL commenced in 2001 and continued to late 2009. Studies and testwork for the Grande Côte by DuPont Chemical USA (DuPont) were summarised in a report by Consolidated Rutile dated 1993.

6.2 Summary of Historical Testwork and Engineering

In 2003 MDL's dredge and wet plant at Viney Creek and the dry plant at Hawks Nest in New South Wales were closed and the equipment earmarked for the GCP. The initial testwork was focused on the Zircon and the use of the existing equipment at a processing rate of 2,000 tph.

However, condition reports on the Hawks Nest equipment indicated that all steelwork was unsuitable for relocation and that all existing circuits were either unsuitable or uneconomic for relocation or refurbishment. Subsequent engineering studies focused on all new equipment for mining and processing.

The grade and economics of the Grande Côte deposit prompted an increase in the throughput rate to improve overall project economics. Engineering and testwork studies continued to use the existing plant layout but with high-capacity HC1 spirals. A new dredge was also deemed necessary to suit the higher throughput rate. Subsequently testwork became concentrated on producing both zircon and ilmenite products and the throughput was further increased to 7,000 tph.

From 2004, several bulk samples were collected and tested as input to the flowsheet development. Testwork results indicated that higher recoveries could be achieved with HC1RS spirals rather than the HC1 spirals and additional testwork was performed for the DFS by Downer EDI with the HC1RS spirals.

A summary and brief description of all the testwork is shown in Table 6.1. Further details of all the pre-DFS mineral processing testwork are in Appendix 6.1 and a concise review of the latest DFS testwork is in Section 6.3.

Table 6.1 Testwork Summary

<table>
<tr><th>Report Title</th><th>Testwork By</th><th>Authors</th><th>Date</th><th>Sample Type</th><th>Appendix File</th></tr>
<tr><td>Appraisal of DuPont heavy minerals and deposits, Senegal, West Africa</td><td>Consolidated Rutile Ltd</td><td>Barrett and Wickham</td><td>May 1993</td><td>na</td><td>Appendix 6.2</td></tr>
<tr><td colspan="6">Aim and Scope: To determine viability of Grande Côte as ilmenite only project.
Conclusion: The report by CRL (Barrett and Wickham, 1993) stated that the economics of the project were very sensitive to by-product credits (i.e. zircon/rutile and leucoxene). The report also stated that the most critical requirement if CRL was to have a continuing interest was to carry out metallurgical testing to validate present assumptions about these by-product credits.</td></tr>
<tr><td>Ilmenite evaluation from Senegal</td><td>Outukumpu</td><td>Webb</td><td>Nov 2001</td><td>Sand sample</td><td>Appendix 6.3</td></tr>
<tr><td colspan="6">Aim and Scope: To evaluate and define ilmenite quality and specification via two separate tests on dunal sand along with a heavy mineral concentrate (HMC). The tests were:
• Electron microprobe analysis of the heavy mineral concentrate.
• Concentration and fractionation of the two raw sand samples.
Conclusion: The testwork results indicated that the centre of the dune and rear edge of dune showed very similar mineralogy and chemistry. This suggested that there is some homogeneity to the deposit. The sample content of 4% to 7% heavy mineral and the heavy mineral assemblage (7% ilmenite, 11% zircon and 4% high-titanium rutile) were indicative of economic-type grades.
Ilmenite quality as produced was moderate. Ilmenite assayed at approximately 55% TiO_2 when mineralogical impurities were removed.
A significant amount of ilmenite was characterised by Cr_2O_3 values of 0.16% to 0.17%. Chrome contributed by way of chromite, chrome spinels, and chrome substitution in the ilmenite lattice. The chrome content showed a bimodal distribution. It was concluded that chromite should be able to be removed as high susceptibility reject.</td></tr>
<tr><td>Generation of ilmenite-type product from a sample of mineral sand originating from Senegal France</td><td>MDmt</td><td>MacHunter</td><td>Nov 2001</td><td>Sand sample</td><td>Appendix 6.4</td></tr>
<tr><td colspan="6">Aim and Scope: To generate an ilmenite product from sand sample using typical gravity, electrostatic and magnetic separation techniques (MacHunter, 2001).
Conclusion: The ilmenite product produced assayed 55% TiO_2 and 0.15 % Cr_2O_3. A sample of the ilmenite product was submitted for electron microscope analyses. Generally it was determined that Cr_2O_3 was contained evenly throughout the ilmenite grains and no individual grains of chromite were found. This would indicate that although some of the ilmenite grains had high Cr_2O_3 contents it would not be possible to remove a Cr_2O_3 rich or depleted product from this material.</td></tr>
<tr><td>Senegal sands investigation</td><td>Kumba</td><td>Shaw and van Wyk</td><td>Jul 2002</td><td>Sand sample</td><td>Appendix 6.5</td></tr>
<tr><td colspan="6">Aim and Scope: The objective of the investigation was to produce a saleable grade of zircon and to evaluate the effectively of the unroasted ilmenite circuit (URIC) process to produce a saleable ilmenite product from two samples, i.e. from Fas Boye and Mboro.
Conclusion: Conclusions as follows:
• The URIC method proved not to be a viable method of ilmenite upgrading.
• A processing route for the bulk samples was developed based on the results of the preliminary test work.
• A saleable zircon product was produced from the respective Fas Boye and Mboro samples. The process route included a gravity separation circuit to remove any free silica, magnetic separation circuit for magnetite removal and ilmenite recovery and finally electrostatic and magnetic separation circuits to produce a zircon product.
• With the exception of the difference in CaO and VHM content, the Fas Boyes and Mboro samples were identical in their composition as well as their behaviour to the applied beneficiation processes. It was concluded that the samples could easily be combined or treated separately without any expected change in process routes or separation effectiveness.</td></tr>
<tr><td>Roasting testwork on Senegal ilmenite</td><td>Outukumpu</td><td>Anon</td><td>Aug 2002</td><td>Ilmenite concentrate</td><td>Appendix 6.6</td></tr>
<tr><td colspan="6">Aim and Scope: The objective of the testwork was to increase the magnetic susceptibility of the ilmenite against the chromite and to remove the chromite impurities by magnetic separation. The aim was to remove the chromite with roasting.
Conclusion: The test results show that only minor lowering of chromite content could be achieved. The fine dispersion of chromite in the ilmenite grains was seen as the main reason.</td></tr>
</table>

<table>
<tr><th>Report Title</th><th>Testwork By</th><th>Authors</th><th>Date</th><th>Sample Type</th><th>Appendix File</th></tr>
<tr><td>Distribution of chromium in a Senegal ilmenite concentrate - characterisation and acid digestion testwork</td><td>CSIRO</td><td>Pownceby et al.</td><td>Aug 2002</td><td>Ilmenite concentrate</td><td>Appendix 6.7</td></tr>
<tr><td colspan="6">Aim and Scope: To determine the distribution of chromia impurities in the concentrate and to determine the solubility of the Cr_2O_3 and the ilmenite concentrate's suitability as a feedstock to a sulphate-type pigment plant.
Conclusion: The testwork concluded that the ilmenite concentrate may be suitable as a chloride-route feedstock. Upgrading to synthetic rutile was also considered a possibility.</td></tr>
<tr><td>Mineral separation and Becher upgrading testwork on Senegal ilmenite concentrates</td><td>CSIRO</td><td>McDonald, et al.</td><td>Nov 2002</td><td>Ilmenite concentrate</td><td>Appendix 6.8</td></tr>
<tr><td colspan="6">Aim and Scope: to determine suitability as a Becher-type ilmenite upgrading process feedstock. A second sample from a different location in the dunal deposit (SEN-2). This sample is to be magnetically fractionated and the fractions analysed to determine the extent to which the ilmenite was homogeneous within the deposit.
Conclusion: The testwork showed that the Senegal ilmenite concentrate was well suited to Becher upgrading (to synthetic rutile). A grade of 90% TiO_2 was achieved. In a commercial plant, the use of sulphur addition would be expected to increase the grade to between 92% and 93% TiO_2. Neither sieving nor magnetic separation were successful in concentrating a sub-sample of the SEN-1 concentrate containing low Cr_2O_3.</td></tr>
<tr><td>Production of primary grade zircon from Senegal sands material</td><td>Roche Mining (MT)</td><td>Kruger and MacHunter</td><td>Dec 2002</td><td>Zircon concentrate</td><td>Appendix 6.9</td></tr>
<tr><td colspan="6">Aim and Scope: Produce an on specification zircon product from Fas Boyes and Mboro using density, magnetic and electrostatic separation techniques.
Conclusion: Final zircon produced for the Fas Boyes deposit was well within typically accepted specifications with the exception of the Fe_2O_3 and Al_2O_3 levels. Subjecting this material to an acid leach process reduced these levels to primary grade parameters with the Fe_2O_3 reduced from 0.08% to 0.04% and the Al_2O_3 from 0.39% to 0.22%. Similarly the Fe_2O_3 and Al_2O_3 for the Mboro sample were reduced from 0.22% to 0.05% and 0.40% to 0.25% respectively. Initial flowsheets were developed.</td></tr>
<tr><td>Senegal mineral sands evaluation</td><td>Outukumpu</td><td>Cleaves and Webb</td><td>Jan 2003</td><td>Sand sample</td><td>Appendix 6.10</td></tr>
<tr><td colspan="6">Aim and Scope: Flowsheet development for Grande Côte. The focus of this testwork was the ilmenite in the heavy mineral suite and the reduction of the chrome content.
Conclusion: The results of this test showed that a practical flowsheet could be developed. An ilmenite product with 0.11% Cr_2O_3, could be produced with the rare earth drum magnetic separator. This product accounted for 40% of the heavy mineral concentrate and had a TiO_2 content of 54%. As the testwork report discussed, further testing on the samples failed to reproduce this lower Cr_2O_3 content. The lowest Cr_2O_3 content of the ilmenite produced in the remainder of the test work was 0.16%.</td></tr>
<tr><td>Mineral Deposits Ltd (MDL) Senegal attritioning testwork for the reduction of iron in zircon</td><td>Roche Mining (MT)</td><td>Selvey and MacHunter</td><td>Jul 2004</td><td>Zircon concentrate</td><td>Appendix 6.11</td></tr>
<tr><td colspan="6">Aim and Scope: The objective of this testwork was to reduce the iron (Fe_2O_3) content of the zircon product by attritioning. Initial testwork had indicated that the iron content of the Senegal zircon product would be approximately 0.08% Fe_2O_3, and the target for this testwork was <0.05% Fe_2O_3.
Conclusion: The Fe_2O_3 content of the zircon was verified at 0.09% to 0.08% Fe_2O_3 without attritioning while maintaining high recovery. Magnetic separation tests indicated that by cutting harder on the induced roll magnetic separator (IRM) that the iron content of the acid attritioned zircon could be reduced to 0.045% Fe_2O_3. This however resulted in reducing the zircon recovery by 25%. In order to reduce the Fe_2O_3 content of the zircon product to <0.05%, without the use of HAL, both acid attritioning and additional magnetic separation stages were required.</td></tr>
<tr><td>Mineral Deposits Ltd (MDL) Senegal wet plant and drymill bulk sample processing</td><td>Roche Mining (MT)</td><td>Selvey and MacHunter</td><td>Aug 2004</td><td>Sand sample</td><td>Appendix 6.12</td></tr>
<tr><td colspan="6">Aim and Scope: As previously noted it is proposed to utilise the Viney Creek (cone) concentrator plant and Hawks Nest wet and dry mills for treating the Grande Côte material (Selby and MacHunter, 2004b). Testwork was undertaken on behalf of MDL by Roche Mining MT in conjunction with processing consultants TiPro to determine the suitability of these plants for treating this material.
Conclusion: Simulation of the cone concentrators in the Viney Creek plant was carried out using a pilot-scale tray test rig with the same configuration as those in the plant. Acceptable recoveries were achieved when processing the GCP ROM material represented by the as-received sample through the Viney Creek plant flowsheet.</td></tr>
</table>

Report Title	Testwork By	Authors	Date	Sample Type	Appendix File
MDL Senegal wet mill and dry mill circuit revision testwork	**JKTech**	**Selvey et al.**	**Nov 2004**	**Concentrate**	**Appendix 6.13**
Aim and Scope: The previous test program used a 45 t sample GC sand through a Viney Creek cone plant flowsheet and then separated by WHIMS to remove ilmenite (Selvey et al., 2004). The scope of work in this instance involved reprocessing the WHIMS non-magnetic material through the wet mill flowsheet incorporating additional stages of spiral separators and/or wet shaking tables in the circuit to enable the production of a zircon product. **Conclusion:** After confirming the grade of zircon products by dry milling trials, the remainder of the wet mill material was processed through the dry mill circuits to produce zircon, rutile, leucoxene and ilmenite products.					
Mineral Deposits Limited Diogo mineral sands project, Senegal 50 kg sample	**Roche**	**Selvey et al.**	**Dec 2005**	**Sand sample**	**Appendix 6.14**
Aim and Scope: Characterisation testwork was carried out on a 50 kg sample of sand ore from the Diogo deposit in Senegal. **Conclusion:** A concentrate containing 98% HM was produced at a recovery of 95% of the HM in 2.3% by weight of the feed sample to produce approximately 1 kg of heavy mineral concentrate (HMC). The zircon rich stream generated was magnetically fractionated and assayed. Zircon, rutile, leucoxene and ilmenite rich streams were produced however the small quantity of these fractions made it difficult to reproduce production methods.					
WCP and MSP flowsheet confirmation and development testwork on 80 t and 40 t bulk samples	**Roche**	**Fallows et al.**	**Oct 2006**	**Sand sample**	**Appendix 6.15**
Aim and Scope: Previously a test program (MS.04/80950/1, 16 August 2004) was carried out on a 45 t bulk sample of Senegal material to generate rutile, leucoxene, ilmenite and zircon products (Fallows et al., 2006). The basis of the testwork was to utilise the existing Viney Creek cone wet concentrator plant (WCP) and the existing Hawks Nest wet gravity and drymill plant (mineral separation plant or MSP) to minimise capital expenditure for the Senegal plant. **Conclusion:** The WCP test flowsheet for a 30 t portion of the 80 t sample gave a HM recovery of 74.7% and zircon recovery of 88.7%. The grade of the wet gravity concentrate generated (excluding WHIMS treatment) was 94.1% HM. The concentrate was separated by WHIMS in the WCP to remove ilmenite (approx 75% by weight of the concentrate). The resulting non-magnetic concentrate contained approx 70% HM with a zircon recovery of approximately 95%. The highest-grade zircon product contained 0.04% Fe_2O_3; however, additional assays of the same samples indicated values of up to 0.06% highlighting typical variations in Fe_2O_3 assays.					
Removal of chromium from Diogo ilmenite, initial four tests	**CSIRO**	**Aral et al.**	**Dec 2007**	**Sand sample**	**Appendix 6.16**
Aim and Scope: Finding treatment conditions that would remove chromium from the ilmenite to make the concentrates more suitable as feedstock's for titania pigment production It was considered that a leaching process, probably associated with a heating pre-treatment, would be required to attack the ilmenite lattice to remove chromium. **Conclusion:** On the basis of the results testwork it appeared that a significant upgrading of the titania content of the ilmenite is likely to be associated with any processing that removes appreciable amounts of chromium.					
WCP flowsheet confirmation on a 40 t ROM "Sample A"	**Roche**	**Gernain**	**May 2008**	**Sand sample**	**Appendix 6.17**
Aim and Scope: Confirm developed flowsheet using 40 t bulk sample from Grande Côte. **Conclusion:** The rougher, middling scavenger and cleaner spiral sighter and bulk tests showed no significant performance difference, in terms of grades and recoveries of HM and ZrO_2, from the previous test program reported under MS.06/81339/1A final concentrate containing 88% HM was achieved at a recovery of 73% HM, 73% TiO_2 and 88% ZrO_2.					

<table>
<tr><th>Report Title</th><th>Testwork By</th><th>Authors</th><th>Date</th><th>Sample Type</th><th>Appendix File</th></tr>
<tr><td>WCP flowsheet confirmation on a 40 t ROM "Sample B" using HC1RS spiral separators</td><td>Roche</td><td>Gernain</td><td>Sep 2008</td><td>Sand sample</td><td>Appendix 6.18</td></tr>
<tr><td colspan="6">Aim and Scope: The purpose of the testwork was to quantify the additional mineral recovery that could be achieved in the plant circuit by the use of the HC1RS spiral as opposed to the HC1.
Conclusion: A final concentrate containing 89% HM was achieved with indicated recoveries of 83% HM, 85% TiO_2 and 94% ZrO_2. The use of HC1RS instead of HC1 spirals in the rougher, mid-scavenger and cleaner stages enabled the overall WCP circuit recoveries of HM, TiO_2 and ZrO_2 to be increased by 10%, 12% and 5.6% respectively.</td></tr>
<tr><td>Verification of MSP flowsheets for treating HMC from HC1RS spiral circuit</td><td>Downer EDI Mining</td><td>Gernain</td><td>Dec 2009</td><td>Heavy mineral concentrate</td><td>Appendix 6.19</td></tr>
<tr><td colspan="6">Aim and Scope: Flowsheets for the Grande Côte Senegal dry mineral separation plant (MSP) were previously defined from testwork reported in MS.06/81339/1. Subsequent wet concentrator plant (WCP) testwork reported in MS.08/81738/1 indicated that increased recovery of zircon and other valuable heavy minerals (ilmenite and rutile) could be achieved by using the HC1RS spiral concentrators in the WCP. As a consequence the heavy mineral concentrate (HMC) produced from that test program would also contain an increased proportion of light heavy minerals such as kyanite and leucoxene. Modifications to the circuits would be employed as necessary to accommodate the differences in mineralogical make-up and separator performance. Also there was concern over the performance of the electrostatic plate separators (EPS) in the plant situation as they can be significantly affected by atmospheric conditions.
Conclusion: Key points of note:
• The testwork recovery of zircon from the WCP feed to final products was 79.3% with the potential for increases to 82.0%.
• Recovery of zircon through the non-mag wet circuit was 99.8% after additional scavenging of the tailings streams.
• There has been no measurable loss of zircon recovery or quality from the treatment of Con 1 and Con 2 as a result of the use of the HC1RS spirals.
• The premium zircon testwork product streams met the 0.05% Fe_2O_3 specification, but no assays were reported below this level.
• The testwork confirmed that the majority of the EPS units in the earlier flowsheets could be replaced or eliminated.</td></tr>
<tr><td>Investigation into reduction of P_2O_5 in ilmenite Products</td><td>Downer EDI Mining</td><td>Gernain</td><td>Feb 2010</td><td>Ilmenite product</td><td>Appendix 6.20</td></tr>
<tr><td colspan="6">Aim and Scope: The aim of this testwork was to attempt to reduce P_2O_5 in ilmenite products to the preferred limit for marketing purposes of 0.03%.
Conclusion: Key points of note:
• Electrostatic separation using Carrara high tension rolls (HTR) and magnetic separation using a Reading semi-lift induced roll magnetic separator (IRM) were performed on 2 kg samples of four ilmenite products from testwork reported in MS 82041, Verification of MSP flowsheets for treating HMC from HC1RS spiral circuit. Magnetic separation has shown that up to 25% of Ilmenite 1 product can be fractionated to give a product of around 0.03% P_2O_5.
• Additional testing on production-scale magnetic separators would be required to confirm the potential production rate of such a product.</td></tr>
<tr><td>RE Drum fractionation of ilmenite 1 product to isolate a 1 P_2O_5 stream</td><td>Downer EDI Mining</td><td>Gernain</td><td>Mar 2010</td><td>Ilmenite product</td><td>Appendix 6.21</td></tr>
<tr><td colspan="6">Aim and Scope: As a follow-up to the testwork reported in an Investigation into Reduction of P_2O_5 in Ilmenite Products a sample of the ilmenite 1 product was separated into various magnetic fractions using a Reading rare earth drum (RED) separator.
Conclusion: Key points of note:
• An ilmenite product below 0.03% P_2O_5 can be produced on plant-scale RED magnetic separators.
• A maximum of 15% of the ilmenite could be directed to a product below 0.03% P_2O_5 implying that this may not be practical.</td></tr>
</table>

6.3 Current DFS Testwork

6.3.1 Introduction

The most recent full testwork is reported in Downer EDI Mining Report No MS.09/82041/1 Verification of MSP Flowsheets for Treating HMC from HC1RS Spiral Circuit (Appendix 6.19). A summary of the report is contained below.

The proposed products from this testwork were:

- Multiple zircon products.
- Rutile.
- Leucoxene.
- Multiple ilmenite products.

Flowsheets for the Grande Côte Senegal dry mineral separation plant (MSP) were previously defined from testwork reported in MS.06/81339/1. At the time of testing the main focus was on recovery and production of zircon concentrates. Subsequent wet concentrator plant (WCP) testwork reported in MS.08/81738/1 indicated that increased recovery of zircon and other valuable heavy minerals (ilmenite and rutile) could be achieved by using the HC1RS spiral concentrators in the WCP. As a consequence the heavy mineral concentrate (HMC) produced from that test program would also contain an increased proportion of light heavy minerals such as kyanite and leucoxene.

Some difficulty was noted in the previous dry mill test programs in the effective separation/rejection of these light heavy minerals. The presence of additional quantities of these minerals may impact the efficiency of the MSP separation processes and require some modifications to the separation flowsheets originally proposed. Hence this current program was aimed at verifying the suitability of the proposed flowsheets when treating the HMC generated from the HC1RS spiral circuit.

Modifications to the circuits would be employed as necessary to accommodate the differences in mineralogical make-up and separator performance. Also there was concern over the performance of the electrostatic plate separators (EPS) in the plant situation as they can be significantly affected by atmospheric conditions. Thus the approach was taken to eliminate the EPS units where possible and use high-tension roll (HTR)-type separators instead.

6.3.2 Scope of Work

The feedstock for this testwork program was the HMC generated in testwork reported in MS.08/81738/1 (Appendix 6.18). A total of 1,037 kg was available.

In summary the scope of work was:

- Process MS81738 (Appendix 6.18) Test 400 concentrate through LIMS and WHIMS to generate non-magnetic concentrate for processing through a wet circuit based on the flowsheet in the MS.06/81339 testwork (Appendix 6.15) with circuit revision as required.
- Review and test dry mill circuit from the MS.06/81339 testwork (Appendix 6.15) for suitability in processing Con 1 and Con 2, particularly the use of EPS units.
- Prepare metallurgical balance and preliminary circuit diagrams for each circuit.

6.3.3 Summary of Testwork Procedures

6.3.3.1 Spiral Separator

6.3.3.1.1. Closed Circuit Operation

Spiral testwork was conducted in a closed circuit test rig consisting of the test spiral separator (single start), a sump, pump and full-stream deflection samplers. The pump discharge reported to a distributor with a portion of the feed stream directed to the spiral feed box and the remainder returning to the feed sump.

The products were weighed wet and then dried. The resultant data were then processed and used to calculate the physical parameters (rate [tph] and % solids) of each stream and the feed. Sub-samples of each stream were then representatively extracted using riffle or carousel splitters for assay purposes.

6.3.3.1.2. Open Circuit Operation

In order to produce large quantities of spiral products it was necessary to process a bulk sample over the spiral separator. The spiral was operated in closed circuit until steady state and then product stream deflection samplers were held open and spiral products bled from the circuit. Simultaneously new feed was added at an equivalent rate in order to maintain constant operating conditions. Bulk products were then blended and dewatered. Core samples were extracted from each product to provide representative sub-samples. A moisture analysis was also conducted on the sub-samples. These values were then applied to the bulk products in order to estimate total dry weights.

6.3.3.2 Wet Table

A No. 13 oversize Australian Wilfley wet table was employed for all testwork. Dry or dewatered feed was introduced at a constant rate into the feed box and dilution water was added. The products were collected, dried, weighed and a sub-sample representatively extracted from each using a riffle splitter for assay purposes.

6.3.3.3 Up-Current Classifier

Release tests were conducted using a laboratory-scale 150 mm diameter batch fed up-current classifier (UCC). A charge of approximately 5 kg was added to the slurry chamber and up-current water flow rate adjusted to produce an overflow containing solids, which was collected. The flow rate was maintained until no further solids reported to the overflow. The up-current water flow rate was then increased to deport more solids to the overflow. This fraction was collected separately to the previous overflow. The procedure was repeated until the desired number of overflow increments was collected. The up-current water was shut off and the solids remaining in the feed chamber were collected and designated as underflow.

Bulk separations were also performed in the 150 mm unit due to the small sample weights available for testing. Consequently the quality of the separation was not necessarily indicative of a plant-scale unit.

6.3.3.4 WHIMS

6.3.3.4.1. Feed Preparation

Any oversize material was removed by screening at 0.85 mm. The content of highly susceptible (HS) magnetics was determined prior to processing. LIMS treatment of WHIMS feed is a mandatory inclusion in process flowsheet design.

6.3.3.4.2. WHIMS Operation

A Reading 16-pole WHIMS (wet high-intensity magnetic separator) production-scale unit was used for the testwork where eight separate feed points are available. All testwork was conducted in open circuit configuration using a single feed-point.

6.3.3.5 Testwork Procedure

The dried feed material was placed in a funnel with a calibrated discharge orifice and discharged into a mixing funnel. Dilution water was added to the mixing funnel and was set to give the desired feed pulp density (usually 35% solids). The mags WW and non-magnetic WW were set at the desired flow rates and the coil current adjusted to the desired amperage setting (max. 150 amps). When all the feed material was discharged and washed the mag, mid and non-mag samples were dried and weighed.

6.3.3.6 Dry Testwork

The equipment and process associated with dry testwork was as follows:

- A laboratory-scale single-stage Reading IRMS fitted with a 133 mm diameter roll was used for the testwork.
- Single-stage Reading laboratory-scale unit.

- Single-stage, laboratory-scale Carrara HTR separator. Feed material was pre-heated and passed over the separator operating at the required feed rate, roll speed and electrode voltage to generate conductor, middlings and non-conductor fractions.
- Electrostatic plate separator (EPS) testwork was performed making use of a four-stage pilot unit. Feed material was pre-heated to the required temperature and passed over the separator operating at the required feed rate and electrode voltage, producing conductor and non-conductor fractions.

6.3.4 Sampling and Analysis

Dry samples were sub-sampled using a 10-way rotary sampler fed by hopper and vibrating feeder or by a two-way riffle splitter. Particle size analysis was carried out using 200 mm diameter, certified square-mesh test sieves above 38 µm aperture. Density separations were conducted using heavy liquid separation (HLS) float–sink method.

XRF chemical analyses were carried out by Ultra Trace Laboratories (Perth, Western Australia).

6.3.5 Summary of Results

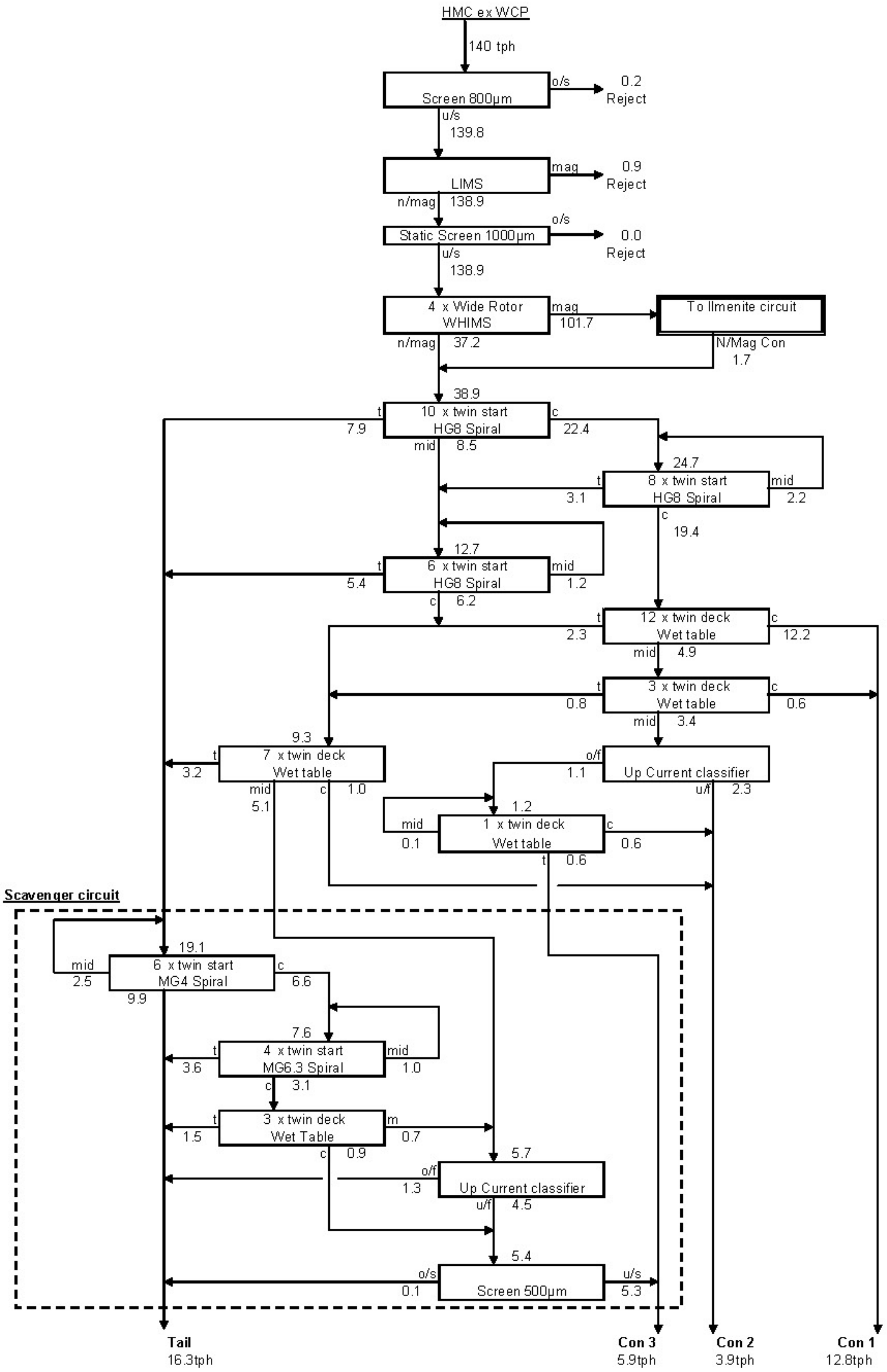
6.3.5.1 Wet Circuit

The WHIMS separation of the HMC gave 72.7% weight reporting to the magnetics, which compares to 70.5% achieved in the MS.06/81339 testwork (Appendix 6.15). This increase could reflect the increased ilmenite recovery achieved by the HC1RS spirals.

The non-magnetics wet gravity stages gave similar results to the MS.06/81339 testwork. The only circuit variation was in the separate wet table treatment of the UCC overflow due to the absence of significant levels of quartz contaminant. A customised riffle pattern was required on the wet table to permit effective separation of zircon and kyanite. The total output of Con 1, 2 and 3 was 22.6 tph compared to the 22 tph nominated design capacity of the dry mill.

The tails scavenging circuit recovered an additional 7.3% ZrO_2 for an overall non-mag wet circuit recovery of 99.8%. The wet mill circuit is shown in Figure 6.1.

Figure 6.1 Proposed Non-Mag Wet Circuit



6.3.5.2 Dry Circuit

Additional stages of middlings separation were introduced into the primary electrostatics circuit to ensure that the plant circuit would be robust and capable of maintaining the zircon product while optimising leucoxene recovery. The zircon cleaning circuit was simplified by eliminating EPS separators. The use of rare earth roll (RER) magnetic separators in the place of some IRM units assisted the selective rejection of unwanted magnetics and very high-iron zircon grains.

Separation of Con 2, with the higher TiO_2 content, highlighted the need for a middlings circuit and additional stages in the rutile cleaning circuit to ensure that both grade and recovery of rutile and leucoxene would be maintained in the operating plant.

Premium-grade zircon was achieved from both Con 1 and Con 2 although the Fe_2O_3 contaminant only met the 0.05% specification as supplied by MDL in product specification guidelines at commencement of the EDI testwork. No assays showed levels below this limit, which would suggest that this will be a difficult target to consistently achieve in a plant operation where the quality of the feed may vary throughout the orebody. Consequently a relaxation of the Fe_2O_3 specification by MDL should be considered.

Zircon products from the secondary treatment of the magnetic streams reported higher Fe_2O_3 and Al_2O_3 such that all streams were classified as foundry zircon based on MDL guidelines. No streams met the client-supplied guidelines for “Intermediate” and “Standard” grade.

The rutile products from Con 1 and Con 2 showed quality achieving 96.0% and 95.3% TiO_2 respectively; however, the SiO_2 levels were higher than ideal at 1.19% and 1.31%.

The scavenged concentrate, Con 3, was significantly TiO_2 rich as opposed to the zircon rich Con 1 and Con 2. Its treatment yielded an additional 2.9% zircon recovery into the MDL specified foundry grade along with 80% of the leucoxene yield. A rutile product above 95% TiO_2 could not be achieved due to a very high (2.5%) SiO_2 level.

Consideration should be given to inclusion of a hot acid leach circuit if a zircon product below 0.05% Fe_2O_3 is required, or if there is evidence of zircon quality variation throughout the orebody.

The proposed plant flowsheets for Con 1, 2 and 3 are presented in Figure 6.2, Figure 6.3 and Figure 6.4.

Figure 6.2 Proposed Dry Circuit for Con 1

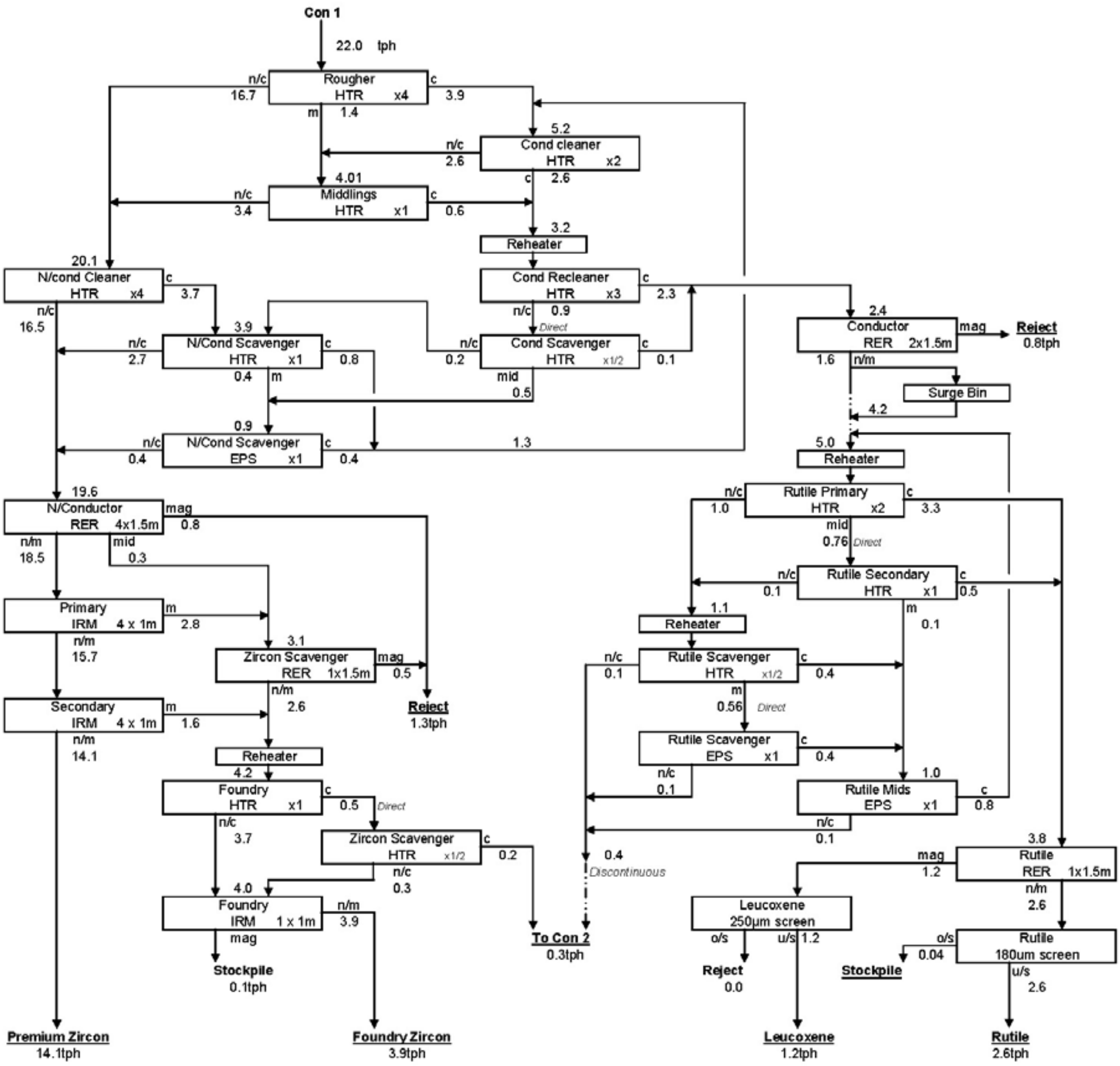


Figure 6.3 Proposed Dry Circuit for Con 2

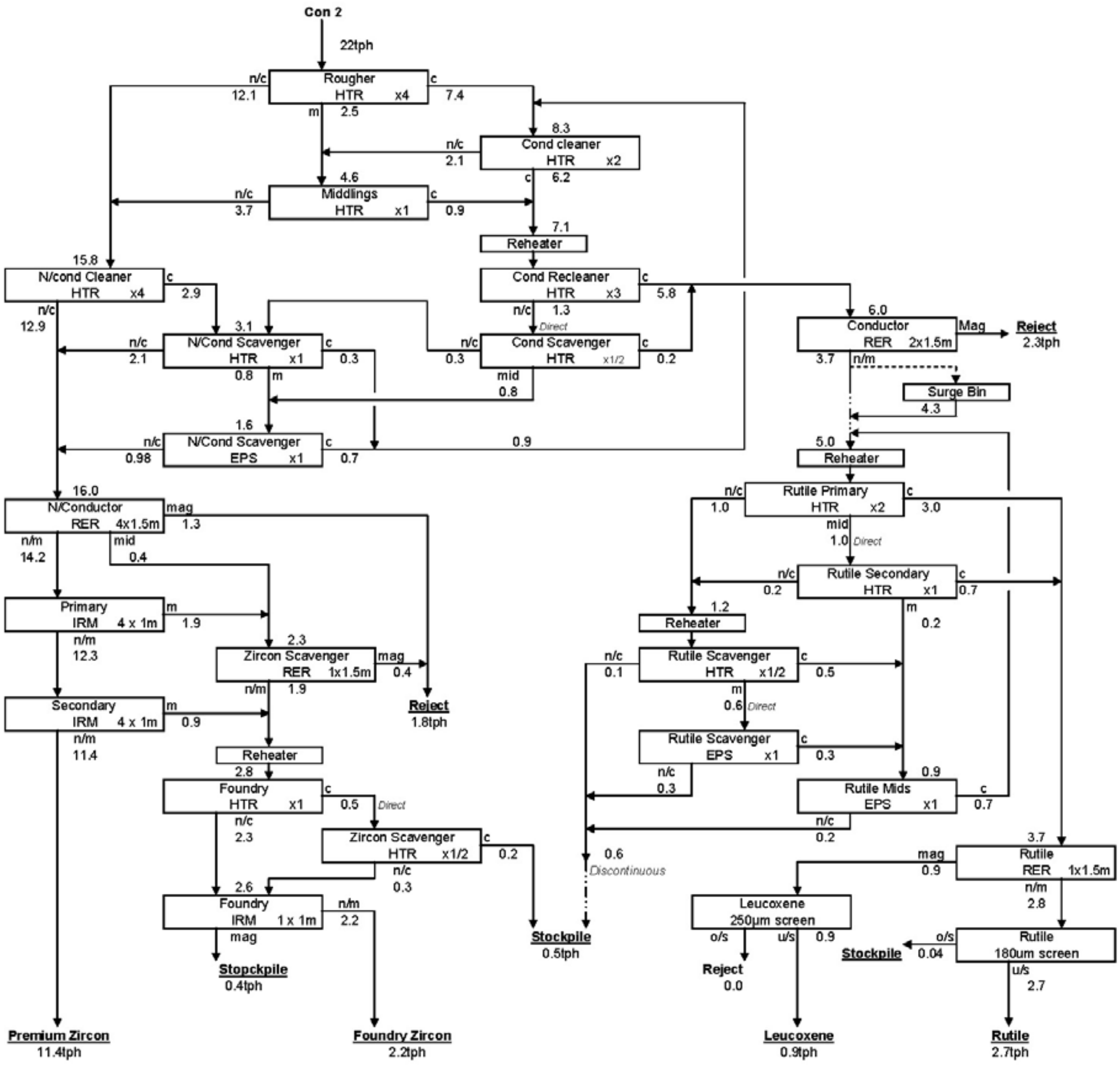
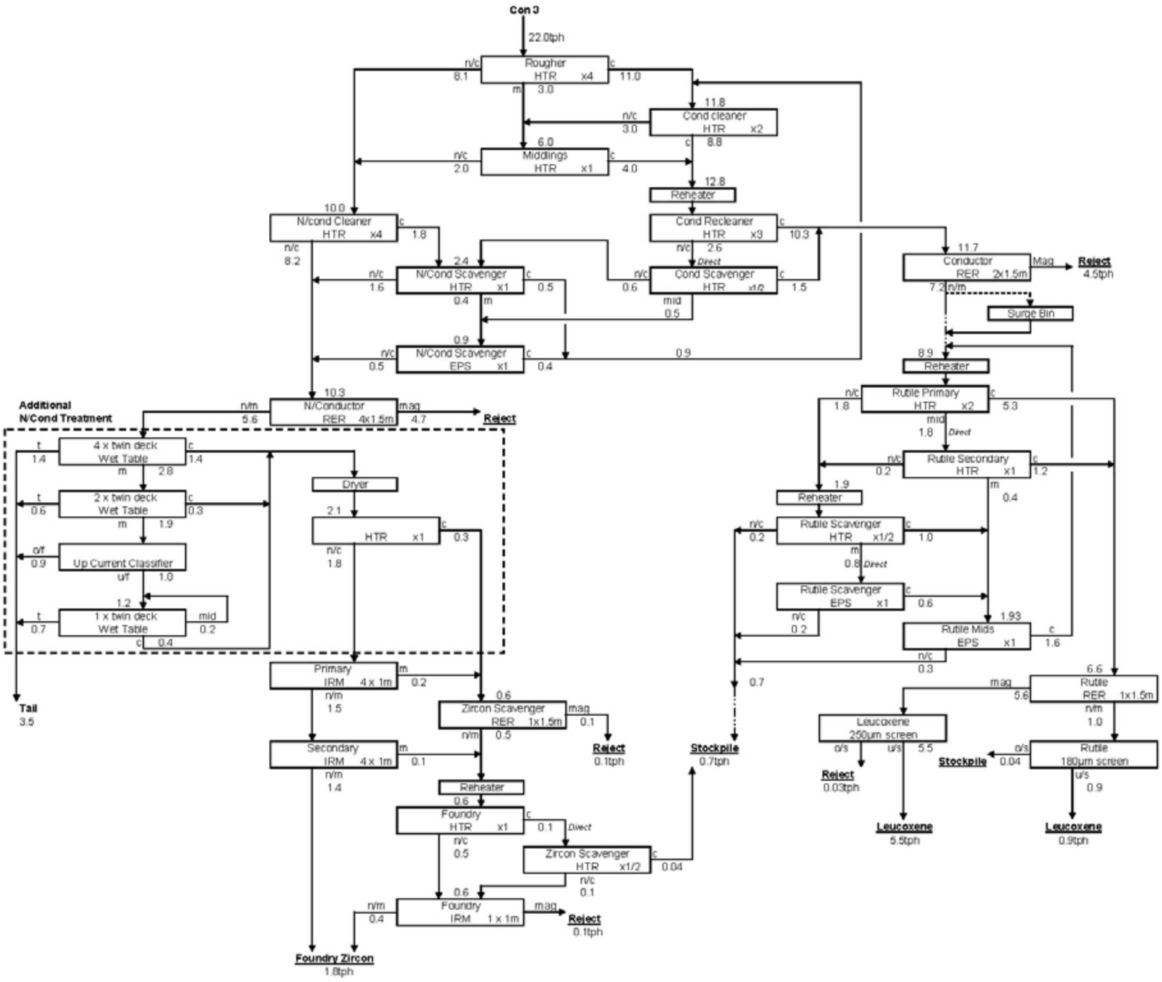


Figure 6.4 Proposed Dry Circuit for Con 3

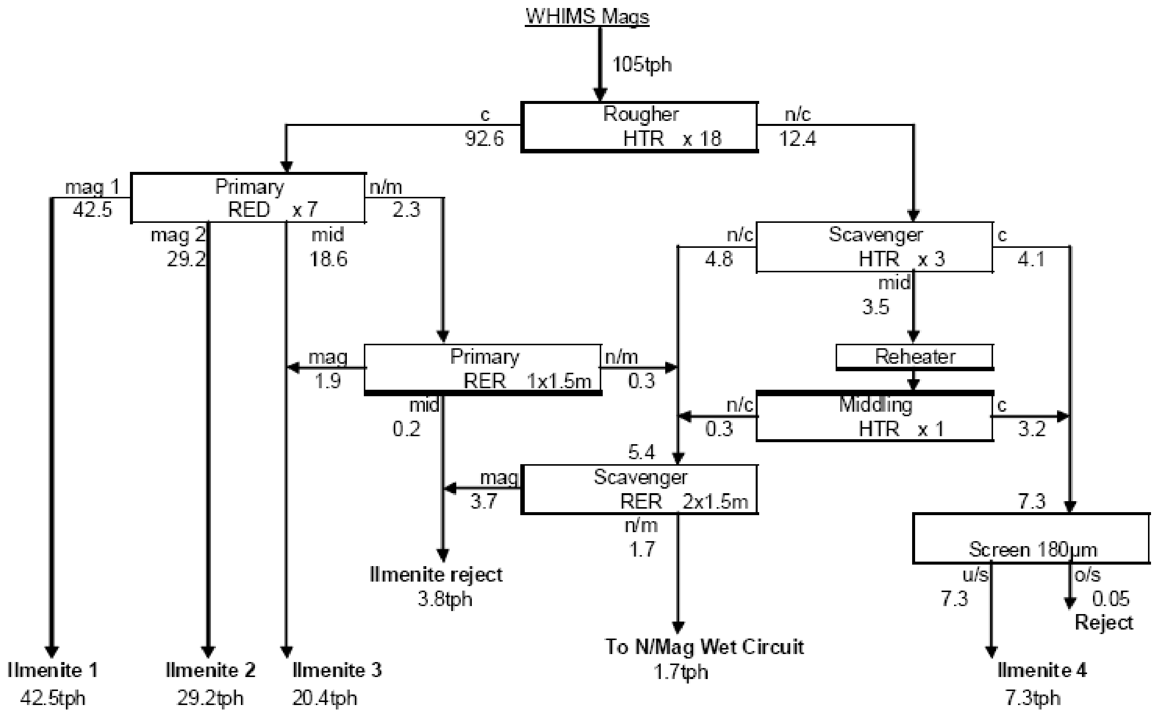


6.3.5.3 Ilmenite Circuit

The ilmenite circuit was modified by removal of six EPS units and replacing them with one RER and one HTR separator (see Figure 6.5). No loss of efficiency was apparent with the yield to ilmenite products being 94.7% compared to 92.7% reported in the October 2007 Tipro Report.

Scavenging of the non-magnetic rejects and treating them through the wet and dry mill circuits yielded an additional 3.7% zircon recovery. The quality of the zircon products was similar to that produced from Con 1 and 2 and thus the scavenged rejects are recommended to be blended with the main WHIMS non-magnetics stream for treatment in the non-mag wet circuit.

Figure 6.5 Proposed Ilmenite Circuit



6.3.5.4 Product Summary

The total zircon recovery from the WCP feed into final products calculated to 79.3%. The recovery of zircon from Con 1 and Con 2 totalled 72.7%, which compares to the figure of 75.0% for the equivalent recovery reported in the MS.06/81339 testwork (Appendix 6.15). However, the impurity levels for the MS 81339 zircon were all significantly higher than those achieved in the current program.

Additional recovery was achieved in the MS.06/81339 testwork (Appendix 6.15) by the inclusion of minor streams with very high contaminant levels. Such streams were generated in the current program but were not included in the final products due to the tighter specification guidelines. Inclusion of such streams would increase the zircon recovery from Con 1 and 2 to 75.5%. Nevertheless, the overall quality of the combined zircon would still significantly better than the MS.06/81339 testwork product (Appendix 6.15). There is potential for an overall zircon recovery up to 82.0% depending on the quality required from a marketing perspective.

These recovery levels should be viewed as the maximum likely in a plant situation. The actual recovery level achieved will depend on the stability of the feed quantity and quality at each stage of the operation. Also of major importance will be the level of attention to the operational details and maintenance of all separation equipment, in particular the wet tables.

The quality of the products achieved in the testwork program are summarised in Table 6.2, which includes a comparison with the zircon produced in the MS.06/81339 testwork (Appendix 6.15).

Table 6.2 Overall Testwork Metallurgical Balance

	Circuit Wt%	Wt% from WHIMS N/mag	Wt% from WCP HMC	ASSAY TiO_2 %	Fe_2O_3 %	SiO_2 %	Al_2O_3 %	Cr_2O_3 %	MgO %	MnO %	ZrO_2 +HfO_2 %	P_2O_5 %	U ppm	Th ppm	V_2O_5 %	Nb_2O_5 %	SO_3 %	CaO %	K_2O %	CeO_2 %	LOI_{1000} %	DISTRIBUTION From Circuit TiO_2	From Circuit ZrO_2	From WCP Feed ZrO_2	From WHIMS N/mag TiO_2
WCP ex MS 81738																									
Calc Head	100.0			1.43	1.13	96.1	0.56	0.007	0.04	0.03	0.23	0.010	-	-	0.007	0.003	0.012	0.041	0.043	0.001	0.32				
HMC (T400con)	2.91			42.0	30.3	16.5	1.76	0.159	0.46	0.78	7.46	0.061	44	70	0.190	0.074	0.012	0.220	0.020	0.02	-0.41	85.3	93.9	93.9	
Wet Magnetics Circuit																									
Magnetics	73.4		73.4	52.9	40.5	2.35	1.34	0.19	0.57	1.009	0.72	0.06	10	81	0.26	0.08	0.18	0.01	0.01	0.01	-0.68	92.6	7.0	6.6	
N/Mags	26.6		26.6	11.7	2.34	55.0	2.74	0.08	0.15	0.05	26.4	0.10	68	149	0.04	0.043	0.02	0.3	0.03	0.02	0.41	7.4	93.0	87.3	100
Calc Head	100.0		100.0	42.0	30.3	16.4	1.72	0.2	0.5	0.8	7.55	0.07	25.4	99.4	0.2	0.1	0.1	0.1	0.0	0.02	-0.4	100.0	100.0	93.9	
N/Mag Wet Circuit																									
Con 1	33.1	33.1	8.8	8.71	1.47	29.5	0.36	0.037	0.01	0.053	59.1	0.12	176	204	0.03	0.04	0.03	0.04	0.01	0.039	0.23	24.4	74.1	64.7	24.4
Con 2	10.1	10.1	2.7	22.0	4.00	23.9	0.79	0.088	0.06	0.107	48.1	0.13	195	270	0.08	0.09	0.01	0.07	0.02	0.023	0.44	18.7	18.4	16.1	18.7
Con 3	15.4	15.4	4.1	40.5	8.77	19.4	13.2	0.348	0.71	0.19	12.6	0.219	134	272	0.13	0.125	0.02	1.42	0.05	0.052	1.15	52.7	7.3	6.4	52.7
Tail	41.4	41.4	11.0	1.19	0.41	96.2	1.35	0.010	0.10	0.01	0.12	0.01	10	16	0.01	0.00	0.02	0.17	0.03	0.006	0.23	4.2	0.2	0.2	4.2
Calc Head	100.0	100.0	26.6	11.8	2.4	55.0	2.79	0.08	0.16	0.06	26.4	0.09	103	143	0.04	0.04	0.02	0.31	0.03	0.03	0.39	100.0	100.0	87.3	100.0
Con 1 Drymill																									
N/cond mags	6.0	1.98	0.53	1.55	1.29	30.8	1.91	0.04	0.11	0.04	60.3	0.66	683	1249	0.03	0.00	0.04	0.39	0.03	0.31	0.66	1.1	6.1	3.9	0.3
Ilmenite reject	3.9	1.29	0.34	61.4	33.1	0.99	1.15	0.50	0.47	0.95	0.35	0.10	14	177	0.23	0.29	0.01	0.05	0.02	0.03	0.25	27.3	0.0	0.0	6.7
Cond mags	1.2	0.40	0.11	90.5	1.48	2.21	1.13	0.44	0.02	0.03	1.64	0.11	37	248	0.15	0.66	0.03	0.05	0.05	0.02	0.71	12.4	0.0	0.0	3.0
N/cond mids to Con 2	3.2	1.04	0.28	5.57	0.68	30.7	0.27	0.05	0.01	0.03	61.9	0.13	189	280	0.02	0.01	0.03	0.03	0.02	0.06	0.18	2.0	3.3	2.1	0.5
Reprocess streams	1.3	0.42	0.11	6.98	0.20	30.4	0.26	0.01	0.01	0.01	61.6	0.11	237	163	0.02	0.01	0.02	0.05	0.02	0.03	0.17	1.0	1.3	0.9	0.2
Premium Zircon:	62.6	20.8	5.52	0.05	0.05	32.6	0.17				66.6	0.09	185	94				0.02		0.02	0.15	0.4	70.6	45.6	0.1
Foundry Zircon	16.8	5.57	1.48	0.14	0.19	32.7	0.43				65.4	0.15	285	212				0.06		0.02	0.30	0.3	18.6	12.0	0.1
Rutile	4.4	1.45	0.39	96.0	0.49	1.19	0.47	0.12	<0.01	<0.01	0.68	0.02	43	43	0.21	0.31	0.02	<0.01	0.04	<0.002	0.21	48.3	0.1	0.0	11.8
Leucoxene	0.67	0.22	0.06	93.6	1.04	1.95	0.95	0.24	0.03	0.02	0.53	0.07	37	123	0.14	0.55	0.03	0.04	0.06	0.01	0.39	7.2	0.0	0.0	1.8
Calc Head	100.0	33.1	8.8	8.72	1.50	29.2	0.39	0.04	0.03	0.04	59.1	0.13	217	193	0.02	0.04	0.01	0.05	0.01	0.04	0.22	100.0	100.0	64.7	24.4
Con 2 Drymill																									
N/cond mags	9.0	1.00	0.27	2.05	1.80	30.2	3.12	0.06	0.20	0.05	59.0	0.64	897	1107	0.03	0.02	0.02	0.52	0.03	0.16	0.85	0.9	10.8	2.0	0.2
Ilmenite reject	10.6	1.18	0.31	61.9	31.8	1.01	1.20	0.44	0.42	0.85	0.56	0.11	22	235	0.24	0.21	0.01	0.06	0.02	0.03	0.71	31.6	0.1	0.0	6.1
Cond mags	1.3	0.15	0.04	84.9	2.42	3.15	1.62	0.82	0.05	0.04	3.35	0.22	92	528	0.20	0.79	0.03	0.11	0.06	0.05	0.77	5.4	0.1	0.0	1.0
Reprocess streams	3.0	0.34	0.09	5.83	0.28	30.4	0.30	0.01	0.01	0.01	62.2	0.13	311	261	0.03	0.03	0.01	0.11	0.02	0.04	0.27	0.9	3.8	0.7	0.2
Premium Zircon	51.7	5.76	1.53	0.04	0.05	32.5	0.27				66.8	0.09	177	108				0.02		0.02	0.19	0.1	70.2	12.8	0.0
Foundry Zircon	9.2	1.03	0.27	0.11	0.21	32.5	0.94				65.6	0.16	318	251				0.09		0.03	0.35	0.0	12.3	2.2	0.0
Off spec Zircon	1.8	0.20	0.05	0.25	0.39	32.3	1.62				64.1	0.23	468	369				0.15		0.05	0.53	0.0	2.4	0.4	0.0
Rutile	10.9	1.21	0.32	95.3	0.53	1.31	0.53	0.12	0.01	0.01	0.72	0.03	32	41	0.21	0.32	0.01	0.02	0.04	0.01	0.41	50.3	0.2	0.0	9.7
Leucoxene	2.4	0.27	0.07	92.0	1.15	2.22	1.16	0.32	0.01	0.02	1.06	0.10	62	154	0.14	0.56	0.02	0.06	0.07	0.03	0.64	10.8	0.1	0.0	2.1
Calc Head	100.0	11.1	3.0	20.7	3.70	24.4	0.78	0.08	0.07	0.10	49.2	0.15	228	233	0.06	0.08	0.01	0.08	0.01	0.03	0.37	100.0	100.0	18.2	19.2
			Note: includes N/cond mids from Con 1																						
Con 3 Drymill																									
Wet gravity tails	15.7	2.4	0.64	2.02	0.44	45.6	29.0	0.03	0.20	0.01	20.3	0.21	182	165	0.03	0.01	0.03	0.20	0.04	0.06	0.68	0.8	25.7	1.6	0.4
N/cond mags	21.8	3.4	0.89	2.34	10.2	32.7	31.0	0.07	2.58	0.16	8.74	0.32	174	254	0.05	0.01	0.03	5.78	0.05	0.10	1.71	1.3	15.4	1.0	0.7
Ilmenite reject	22.7	3.5	0.93	62.8	25.9	2.36	3.53	0.58	0.42	0.66	0.31	0.19	30	377	0.25	0.13	0.01	0.25	0.03	0.02	1.37	35.0	0.6	0.0	18.4
Retreatable streams	3.7	0.6	0.15	24.3	0.95	25.6	6.79	0.15	0.13	0.02	39.3	0.33	408	419	0.05	0.07	0.07	0.26	0.08	0.08	0.84	2.2	11.8	0.8	1.2
Rejects	0.12	0.0	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Foundry Zircon	8.4	1.3	0.34	0.07	0.08	32.7	0.56				65.8	0.11	183	156				0.04		0.02	0.29	0.0	44.7	2.9	0.0
Leucoxene 1	5.5	0.8	0.23	94.5	0.42	2.51	0.81	0.10	0.02	<0.01	0.44	0.03	147	23	0.16	0.29	0.02	<0.01	0.06	0.008	0.43	12.8	0.2	0.0	6.8
Leucoxene 2	22.1	3.4	0.90	88.5	2.21	3.06	2.10	0.88	0.06	0.03	0.88	0.22	61	372	0.16	0.36	0.11	0.02	0.09	0.05	0.76	48.0	1.6	0.1	25.3
Calc Head	100	15.4	4.1	40.7	8.73	19.3	12.9	0.36	0.71	0.19	12.4	0.22	126	279	0.12	0.13	0.04	1.37	0.05	0.05	1.04	100.0	100.0	6.4	52.7
Ilmenite Circuit																									
Total Ilmenite	94.7		69.5	55.2	41.9	0.64	0.73	0.20	0.57	1.07	0.09	0.05	24	79	0.25	0.09	0.01	0.01	0.02	0.008	-0.92	97.9	11.6	0.8	
Rejects	3.69		2.7	28.1	20.9	19.9	17.2	0.26	1.59	0.79	3.24	0.19	86	336	0.14	0.07	0.01	4.27	0.07	0.099	1.31	1.9	16.6	1.1	
N/mag Con	1.64		1.2	5.11	0.52	59.3	1.86	0.04	0.15	0.01	31.5	0.14	145	225	0.02	0.03	0.01	0.14	0.02	0.06	0.28	0.2	71.8	4.8	
Calc Head	100.0		73.4	53.4	40.4	2.32	1.36	0.20	0.60	1.04	0.72	0.06	28	91	0.24	0.09	0.01	0.17	0.02	0.012	-0.82	100.0	100.0	6.6	
Ilmenite N/mags Scavenger																									
Rejects	60.1		0.73	5.96	0.75	77.7	2.89	0.06	0.25	0.02	10.1	0.15	103	261	0.02	0.03	0.02	0.21	0.04	0.08	0.36	70.0	19.2	0.9	
Retreat	2.95		0.04	51.2	1.24	15.1	0.76	0.22	0.05	0.03	28.7	0.20	186	563	0.11	0.31	0.02	0.07	0.04	0.10	0.46	29.6	2.7	0.1	
Premium Zircon	26.9		0.32	0.04	0.06	32.8	0.22	0.00	0.00	0.00	67.0	0.10	185	114	0.00	0.00	0.00	0.01	0.00	0.01	0.08	0.2	57.1	2.7	
Foundry Zircon	10.1		0.12	0.13	0.20	33.0	0.43	0.00	0.00	0.00	65.5	0.16	282	206	0.00	0.00	0.00	0.05	0.00	0.02	0.26	0.3	21.0	1.0	
Calc Head	100.0		1.2	5.11	0.52	59.3	1.86	0.04	0.15	0.01	31.5	0.14	145	225	0.02	0.03	0.01	0.14	0.02	0.06	0.28	100.0	100.0	4.8	
Total Zircon products																									
Premium Zircon			7.4	0.05	0.05	32.6	0.19				66.7	0.09	183	98				0.02		0.02	0.16			61.1	
Foundry Zircon			2.2	0.13	0.17	32.7	0.52				65.5	0.15	273	208				0.06		0.02	0.30			18.1	
Total Zircon			9.6	0.07	0.08	32.6	0.27				66.4	0.10	204	123				0.03		0.02	0.19			79.3	
Total Zircon ex MS81339				0.10	0.17		0.39				66.3	0.13	216	166										75.0	
Zircon Rich Rejects																									
Con 2 Off Spec Zircon	1.84		0.05	0.25	0.39	32.3	1.62				64.1	0.23	468	369				0.15		0.05	0.53			0.4	
Con 2 - T 923 Mag	2.87		0.08	1.24	0.69	31.3	1.38				63.3	0.39	746	601				0.28		0.07	0.67		3.7	0.7	
Con 1 - T 628 Mag	2.38		0.21	1.11	0.61	31.7	0.72				63.8	0.38	629	584				0.19		0.05	0.52		2.6	1.7	
Total zircon + rejects			9.9	0.10	0.10	32.6	0.29				66.3	0.11	219	138				0.04		0.02	0.20			82.0	
Total Retreatable streams			0.39	17.5	0.60	27.1	2.85	0.09	0.06	0.02	50.1	0.21	316	322	0.04	0.06	0.04	0.15	0.05	0.06	0.48			2.4	
Rutile / Leucoxene Products																									
Rutile		2.7	0.7	95.7	0.51	1.24	0.50	0.12	0.01	0.01	0.70	0.02	38	42	0.21	0.31	0.02	0.01	0.04	0.005	0.30				21.5
Leucoxene + Cond mags		5.3	1.4	89.9	1.77	2.82	1.71	0.66	0.04	0.02	0.93	0.17	73	289	0.16	0.40	0.08	0.03	0.08	0.04	0.68				39.9
Total TiO_2 Products		7.9	2.1																						61.4

6.3.6 Conclusions and Recommendations

The following conclusions were reported by Downer EDI based on the testwork:

- The testwork recovery of zircon from the WCP feed to final products was 79.3% with the potential for increases to 82.0% with the inclusion of some lower-quality streams.
- The proportion of ZrO_2 reporting to the WHIMS magnetics was 7.0% compared to 4.8% reported in the MS.06/81339 testwork (Appendix 6.15). The increase was most likely due to a small variation in the proportion of stained or magnetic zircon in the ore sample rather than any inherent difference in the quality of the zircon recovered by the HC1RS spirals.
- Zircon scavenged from the WHIMS magnetics was of similar quality to the mainstream zircon products. The unrecovered zircon was typically iron stained or contained magnetic inclusions.
- Recovery of zircon through the non-mag wet circuit was 99.8% after additional scavenging of the tailings streams.
- There has been no measurable loss of zircon recovery or quality from the treatment of Con 1 and Con 2 as a result of the use of the HC1RS spirals.
- Refinements to the dry mill circuit have permitted a reduction in the impurity levels in the overall zircon product compared to the previous MS.06/81339 testwork (Appendix 6.15).
- Amendments to the dry mill circuit resulted from the need for a robust plant circuit able to cope with increased levels of light heavy minerals, to optimise leucoxene recovery and to handle typical feed variations. Leucoxene recovered from Con 3 represented 80% of the total leucoxene yield.
- An additional zircon recovery of 2.9% was generated from a scavenged non-mag wet circuit concentrate, Con 3.
- Leucoxene recovered from Con 3 represented 80% of the total leucoxene yield.
- The premium-grade zircon testwork product streams met a 0.05% Fe2O3 specification, but no assays were reported below this level.
- The testwork confirmed that the majority of the EPS units in the earlier flowsheets could be replaced or eliminated.
- The zircon product specification guidelines supplied by Grande Côte Operations resulted in the testwork product streams qualifying only for the client designated premium or foundry grades. Consequently a relaxation of the specifications by MDL should be considered.
- The current testwork is based on a single bulk ore sample and may not represent the mineralogical composition found in other areas of the orebody. Nevertheless, results were relatively consistent with previous testwork undertaken for MDL/Grande Côte under MS.06/81339.

The following recommendations were made by Downer EDI based on the testwork:

- An additional static screening stage should be included immediately ahead of the WHIMS to ensure that no oversize particles enter the rotors.

  GCO will consider this option as part of the value engineering study to be completed after the DFS.

- The non-magnetics scavenged from the WHIMS circuit should be blended back into the WHIMS non-magnetics stream.

  This has been incorporated into the plant design.

- Additional middlings treatment stages have been recommended in the dry circuit to permit maximum recovery of leucoxene and to make a more robust circuit that will cope with expected variations in the quality of the HMC concentrate.

  This has been incorporated into the dry mill design.

- Additional separation stages have been recommended in the rutile cleaning circuit to permit optimisation of leucoxene recovery and ensure the quality and recovery of rutile.

  This has been incorporated into the plant design.

- The zircon product specification guidelines supplied for this testwork should be reviewed with regard to Fe2O3 and Al2O3.

  This has been reviewed as part of the TZMI review of GCO product specifications (refer Section 2).

- A surge bin should be included at the head of the rutile cleaning circuit to permit batch feeding at the full capacity of the circuit to enable separation temperatures to be maintained.

  GCO will consider this option as part of the value engineering study to be completed after the DFS.

The following comments relate to processing rates and equipment numbers:

- The required treatment rate of HMC from the WCP is 140 tph with the dry mill capable of 22 tph. The equipment numbers indicated at each separation stage reflect the number of units required based on this current test program with allowance for expected variations within the circuit due to normal operational reasons. Allowance has not been made for significant variations in the proportion of the various minerals comprising the HMC. Variations in the properties of the individual minerals, such as the degree of alteration of ilmenite or the presence of an increased proportion of iron stained zircon, have not been allowed for.

- The scavenger circuit has been included as part of the non-mag wet circuit. The flowsheet shows the combined output of Con 1, 2 and 3 to total 22.6 tph, which exceeds the nominated design capacity of the dry mill at 22 tph.

6.4 Plant Design Basis

6.4.1 Introduction

Detailed flowsheets, plant layouts and the plant design basis have been developed by Ausenco. The engineering and general arrangement drawings are provided in Appendix 6.22. A description of the engineering studies and the resultant designs follows.

As previously noted, the initial scope of engineering studies assumed the relocation and upgrading of the Hawks Nest operation owned by Mineral Deposits Limited (MDL), which had been decommissioned. The Hawks Nest operation consisted of:

- Twin dredges.
- A floating wet concentrator using a combination of cone and spiral separators.
- A MSP consisting of a wet circuit and a dry zircon circuit capable of producing zircon and rutile.

The proposed upgrading of the Hawks Nest plant included conversion of one dredge to operate at a higher capacity and retrofitting of some dry mill equipment to meet an acceptable operational standard for occupational health and safety (OHS) with respect to equipment guarding and dust control.

Following an adverse condition report on various items of equipment, the approach was revised to exclude the existing separation equipment from the floating wet concentrator and replace with an all new spiral circuit.

The project progressed through a number of development phases, eventually concluding that all major components within all circuits were either or both unsuitable or uneconomic for relocation or refurbishment. Relevant equipment lists were generated with the plan then being to use only the pontoons and structural steel of the floating wet concentrator. This constrained the footprint for the layout and associated design engineering. Following additional condition reports on the Hawks Nest facilities, all steel work was rejected as being unsuitable for relocation.

As a function of revisions of the resource grades and project economics, the nominal capacity of the operation was progressively increased through a number of iterations from 2,200 tph to the currently proposed 7,000 tph. Testwork results have resulted in changes to the flowsheets, and equipment types have been selected embracing newer technologies.

This has necessitated changes to most engineering design, equipment specifications and flowsheets. Due to a number of the original plant layout constraints, there have been design inefficiencies that have been carried through these phases to the current design. These design shortcomings impact on the estimated capital cost. It is expected that optimisation of the design would result in a decrease in the estimated capital cost and as such an allowance for reengineering has been included in the capital budget.

An example of this is that all three separation facilities within the MSP are discrete structures. Each has a control room, lunch room and ablutions, motor control centre (MCC) or sub-stations, etc. Significant clearways have been allowed between each building, which unnecessarily increases material handling costs, piping and cabling distribution costs, and earthworks, concrete and structural steel costs.

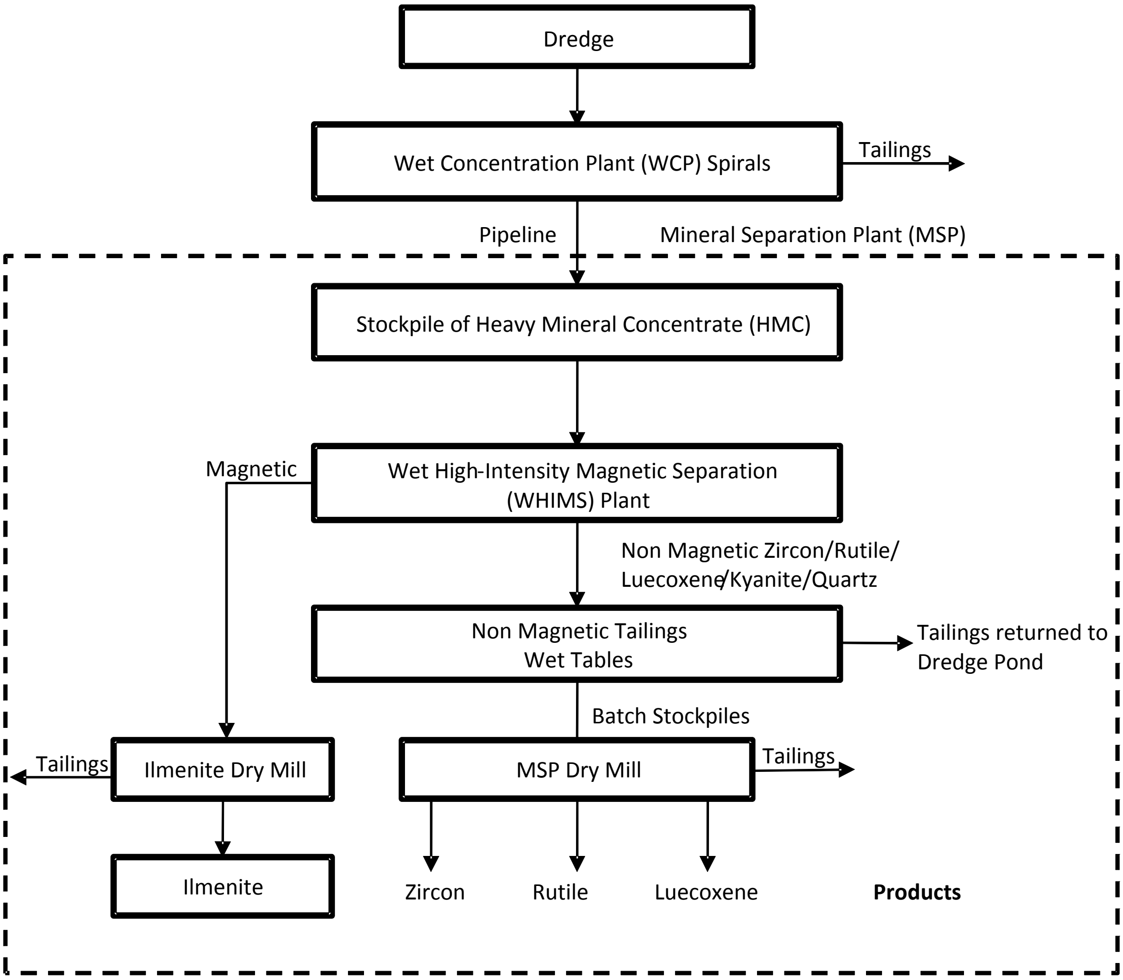
Previous project design engineering has generated in excess of 500 drawings through to detailed design. The DFS required additional or revised drawings for the process flowsheets (15), general arrangements (34), four electrical and two mechanical (related to dredge) drawings.

The latest testwork programs, for circuits downstream of the wet concentrator plant (WCP), were conducted in parallel with the DFS. Due to time constraints, it was necessary to freeze the flowsheets and design criteria for the mineral separation plant (MSP) circuits based on 2006 testwork using heavy mineral concentrate (HMC) produced in the 2006 WCP testwork, to allow engineering, drafting and estimating to progress. However, all equipment lists, load lists, the majority of general arrangement drawing (GAs) were updated at a high level in line with most recent 2009 testwork. The HMC from the 2006 testwork reflected lower heavy mineral (HM) recovery but higher grades hence the overall impact is considered negligible.

Changes in production outputs resulting from the current testwork have been applied in the production model presented. In addition the capital costs, load and equipment lists reflect the recent testwork.

A high-level flowsheet is shown in Figure 6.6.

Figure 6.6 High Level Process Flowsheet



6.4.2 Mine and Wet Concentrator Plant (WCP) Area

The flowsheets for the mine and WCP present mass balances using the nominal feed tonnage (7,000 tph) from the dredge and a plant feed heavy mineral (HM) grade of 2.0%.

It should be noted that the testwork on which the flowsheets have been developed was undertaken on a sample containing 3.1% HM compared to the current mine path average of 1.8%. Considering the variability of the ore body and design throughput this difference should not be significant.

The mass balance has been modelled on the testwork incorporating the HC1RS spirals presented in the Downer EDI (DEDI) Mining Report MS.08/81738/1 (Appendix 6.18). Due to issues in simulating recirculating loads in the testwork, the curves used in the model have been offset to provide a level of design margin.

The mining unit consists of a dredge with a nominal rating of 7,000 tph and maximum rating of 8,750 tph. This dredge operates on the mining face which can be up to 270 m wide with a pond depth of 6 m. The dredge delivers the slurried ore via a floating pipeline to a two-way distributor on the surge bin module. The water balance for the mine is discussed in Section 8.

The slurry is split to two trommels to remove coarse trash material, with trommel undersize reporting to a 25 m diameter surge bin. The surge bin provides nominally 12 minutes of surge capacity to reduce fluctuations in feed rate to the spiral circuits during high or low production periods from the dredge. The oversize flows by gravity to the rear of the plant for disposal into the pond.

The surge bin is fitted with an overflow recovery system whereby a proportion of the slurry that would otherwise overflow is drawn from a submerged manifold below the top of the surge bin. The extracted slurry is pumped to a set of hydrocyclones with cyclone underflow reporting back to the surge bin and cyclone overflow being laundered to the pond. This affects a lower rising velocity for the remaining surge bin overflow which minimises loss of mineral to the surge bin overflow launder.

Two pumps draw the sand from the bottom of the surge bin which is agitated and diluted by water injection to attain the nominated slurry density for transfer to the WCP module.

The WCP module consists of a five stage spiral circuit using:

- Three stages (rougher, middling and cleaner) of HC1RS-type spirals.
- Two stages (recleaner and finisher) of HG10-type spirals.

These produce a heavy mineral concentrate (HMC) and a rejectable tailing. The tailing is densified with dewatering hydrocyclones. Cyclone underflow is pumped via two separate pumps and lines to a single tailings stacker at the rear of the plant. Tailings cyclone overflow discharges into the pond.

The HMC is pumped by a series of overland pumps to the MSP where it is stacked on a drainage pad by an elevated dewatering hydrocyclone. The HMC overland pumping system is designed to handle up to 200 tph of HMC (nominal average is 140 tph) to cater for sections in the ore body where above average head feed grades are encountered. When HMC production exceeds 200 tph the feed rate presented to the WCP will need to be reduced.

The nominal HM grade and recovery to the HMC are 88% and 82% respectively based on the testwork completed on Sample “B” (DEDI Mining Report MS/08/81738/11 in Appendix 6.18).

Process water is drawn from the pond both through the dredge operation and various other pumps to sustain hopper levels and the required process slurry densities. Water is returned to the pond from a combination of hopper overflows, cyclone overflows, decantation from the deposited tailings, and returned water from the HMC overland pumping process and reject water streams from the MSP.

Water losses, due to evaporation, seepage through the pond floor and walls and retention within the tailings, is balanced with new inflows from the pond side recovery shallow bores and the deep water bores. Further details on the water balance are in Section 8.

Power is supplied to the dredge and WCP via 33 kV overhead power lines from the power station located at the MSP. The power is stepped down from 33 kV to 11 kV for transmission via trailing cables across the floating walkway to the WCP and further along the floating delivery line to the dredge.

The flowsheets for the mine and WCP area (Drawings 1938-F-001 to 003) are presented in Appendix 6.23. Detailed descriptions of the flowsheet and services for the dredge and WCP are presented in the relevant control philosophies in Appendix 6.24.

6.4.3 Mineral Separation Plant Area

The mineral separation plant (MSP) consists of three separate circuits: wet circuit, zircon dry circuit and ilmenite dry circuit.

HMC is reclaimed from the stockpiled material by wheel loader to the wet circuit feed hopper. It is prepared for processing by screening and low-intensity magnetic separation to remove trash material and gangue minerals. The undersize non-magnetics fraction is then presented to a single stage of WHIMS processing with the magnetics fraction, consisting predominantly of the ilmenite, stockpiled for processing through the ilmenite dry circuit.

The non-magnetics fraction is upgraded further through a multi-stage spiral and shaking table circuit to facilitate rejection of free silica and kyanite and concentration of zircon, rutile and leucoxene. Three separate concentrate streams are generated: low-Al_2O_3, medium-Al_2O_3 and scavenger concentrates, with each product stockpiled separately on drainage pads for processing in campaigns through the zircon dry circuit.

Each of the wet plant non-magnetic concentrates is campaigned through the zircon dry circuit where the material is dried and then processed through a multi-stage circuit consisting of electrostatic, magnetic and screening equipment to generate two separate zircon products of different quality plus rutile, leucoxene and a rejects stream. These products are stockpiled in a covered shed ahead of loading into shipping containers for transport to markets.

The WHIMS magnetic product is recovered from the stockpile to the ilmenite dry circuit where the material is dried and processed through a multi-stage circuit consisting of electrostatic, magnetic and screening equipment to generate two separate ilmenite products of different quality, plus non-magnetic non-conductor product for retreatment in the wet circuit or dry zircon circuit and a rejects stream. The ilmenite products are stockpiled in a covered shed ahead of loading to bulk rail for transport to markets.

The combined rejects are pumped by a series of overland pumps to the mining area for disposal in the pond.

The MSP flowsheets present mass balances based on the previous Ausenco flowsheets (Job Numbers 1520 and 1736) derived from testwork completed in 2007 to 2009.

Allowances have been made to account for the higher HM recovery and lower HMC grade achieved in the current testwork. These changes have been extrapolated through the wet magnetic separation circuit and the non-magnetics spiral-table circuit. No changes have been made in the mass recovery shown in current flowsheets, additional equipment is, however, included in the capital estimate and the project production model reflects the latest data and circuit changes. This issue will be further examined as part of the value engineering study to be completed after the DFS.

An additional wet rejects scavenger circuit has also been modelled based on the HM and zircon contents of the feed streams. This circuit has been incorporated into the wet circuit for the capital estimate.

Power is supplied from the power station to the MSP via a number of separate sub-stations to the individual plant and infrastructure areas. Process water is supplied from a deep bore located near the MSP area servicing both a process water pond and the fire system tanks.

A detailed description of the flowsheet and services is presented in the Ausenco MSP control philosophy document in Appendix 6.24. The flowsheets for the MSP area (Drawings 1938-F-004 to 015) are presented in Appendix 6.23.

6.5 Process Plant Design Criteria

The primary design criteria applied are listed in Table 6.3.

Table 6.3 Primary Design Criteria - Process Plant

Item		Unit	Maximum	Nominal
Dredge output		tph	8,750	7,000
Pond	– length	m	250	
	– width	m	270	
	– depth	m	6	
Surge bin residence time		minutes	12	
Dredge/WCP availability		%		85
Tails discharge density		$\%^{w}/_{w}$ solids	63	
Ore HM grade		%HM		2.0
HMC production		tph	200	140
MSP wet high-intensity magnetic separator (WHIMS) feed		tph	140	
MSP zircon dry circuit feed		tph	24	22
MSP ilmenite dry circuit feed		tph	120	110

The process plant design criteria, for the Dredge, Surge Bin - WCP - Tails Stacking and MSP are presented in Appendix 6.25 (Ausenco Document 1938-DC-001 Rev B).

6.5.1 Civil Design Criteria

Ausenco developed initial civil design criteria, including a design bearing capacity of 150 kPa, in 2007 and this is detailed in Appendix 6.26. Subsequently geotechnical site investigations and analyses were undertaken (see Section 5) in the local areas proposed for the dredge erection site (MSC) and MSP.

These preliminary site investigations confirmed the suitability of the assumed bearing capacity. The estimated minimum bearing capacities at the MSC site are in the range of 70 kPa to 180 kPa for localised areas of soft sand. Additional standard penetration tests (SPT) will however be required prior to construction once the final sites for the MSC tower crane and MSP are determined.

6.5.2 Civil Construction Material

Construction materials for the GCP are readily available in the vicinity of the site. Road material is available from the ICS phosphate operations about 20 km from the MSP. Local sand would be screened and washed for use in construction. There are other locally available aggregate sources. Concrete will be produced on site by the EPCM contractor's batch plant.

6.5.3 Process Control and Instrumentation

The process control philosophies for each of the Dredge, WCP and MSP are presented in Ausenco documents 1938-PCP-001, 002 and 003 in Appendix 6.24.

These documents have been predominantly generated from the original P&IDs developed for the previous study due to updates of these P&IDs being excluded from the current scope of work. Where changes of circuit configuration or circuit additions have been made, the documents have used typical control philosophies to describe their operation and function.

The level of functionality incorporated into the process control system (PCS) reflects the complexity of the dredge and plant operations and the skill set of operating personnel will require a high level of status monitoring, automation and control.

6.5.4 Production Model

The production model for the GCP has been generated from a number of data sources and provides product tonnage inputs into the financial model. The production model aims to track the flows from the ore body through the dredge, WCP and HMC stockpile followed by the MSP magnetics circuit, non-magnetics wet circuits, non-magnetics concentrate dry and ilmenite dry circuits, and into the relevant product storage.

The various datasheets used in the preparation and model outputs are presented in Appendix 6.27. The production model is based on the mining schedule (see Section 4) and the mineral processing testwork.

The model includes a ramp-up in production and mineral processing performance. To estimate the utilisation for Year 1 of operation, a preliminary ramp-up estimate was prepared for the dredge and WCP based on the expected progression of tonnage and recovery ramp-up. The ramp-up in tonnage is a function of both materials handling factors and production coordination (i.e. opening mine pond width; plant, services and anchor move coordination; operator training and normal mechanical and electrical commissioning activities). The ramp-up in recovery is a function of normal process commissioning activities, operating training and the high number of start and stops typically experienced in the initial phases of plant commissioning.

The outcome indicates an average HMC production of approximately 60% of target. Based on previous experience it has been assumed that the MSP will ramp up at the same rate. The likely outcome through the MSP is for zircon recovery to final product being comparable to the flowsheets but during the ramp-up the split between premium- and foundry-grade zircon will be biased towards the foundry product.

Ramp-up of the dredge and FWC is planned to cover 18 to 24 months from start-up and is reflected in modelled availabilities of 67% and 85% for the first two years of operation. Ramp-up consists of the following functions that are illustrated in Figure 6.7 below:

- Operating hours versus design of 89% availability. This is a function of reduced operating hours in the initial phases due to normal commissioning activities, low operator skill levels/familiarisation, development of logistical support functions (e.g. plant moves). This typically presents an initial fast increase before flattening out over the period of 6 to 18 months.
- Feed tonnage versus design of 7,000 tph. This is a function of normal controlled ramp-up of feed tonnage to design. This typically starts at a moderate level but improves rapidly over the first 3 to 6 months.
- Heavy mineral recovery versus design at 82.6%. This is impacted initially by the disrupted operations and low operation skill knowledge and plant set-up and is shown to start at 75% of design but slowly improves as operations and skill increase.

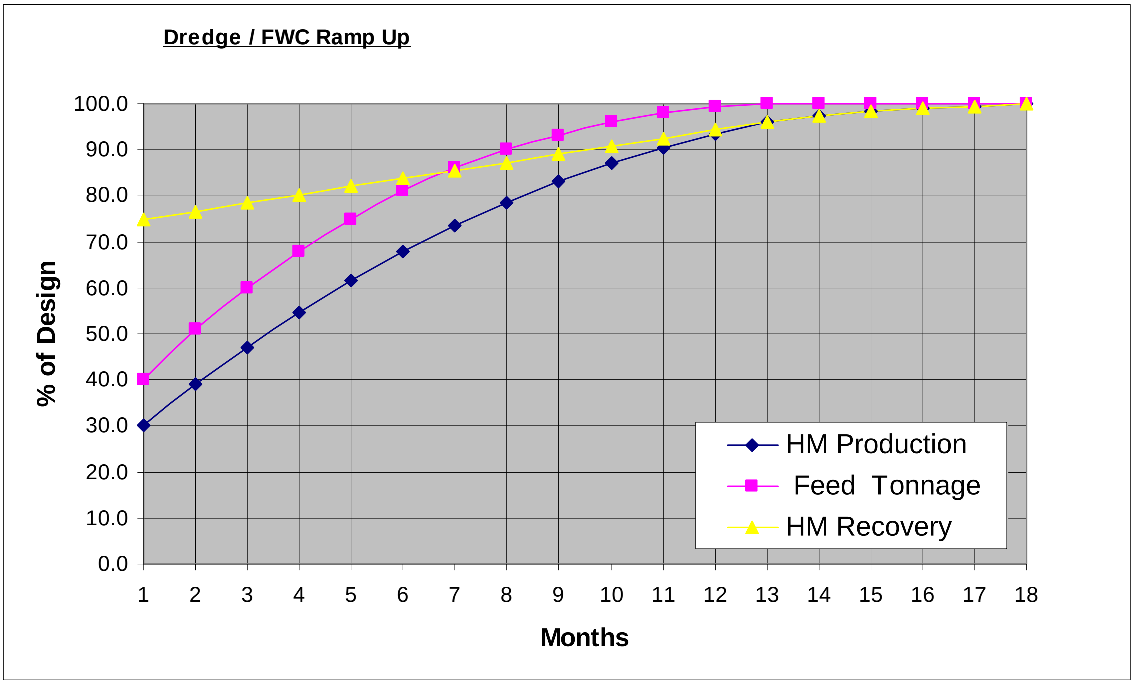
In Table 6.4 feed tonnage and HM recovery are relative and expressed as a percentage of design. The ore mined equates to 62.5% x 89% availability x 7,000 tph gives an average of 93,450 tpd versus design of 149,500 tpd. The HM recovery is 79.3% of 82.6%, i.e. 65.5%.

Table 6.4 Production Ramp-up

	% of Design		
Month	**Feed Tonnage**	**HM Recovery**	**HM Production**
Month 1-6	62.5	79.3	50.0
Months 7-12	93.7	89.8	84.3
Month 13-18	100.0	98.4	98.4

In the production model this data is averaged across Years 1 and 2 production data.

Figure 6.7 Production Model Year 1 Ramp-up



The production model developed (Table 6.5) to date has the following limitations:

- WCP HMC grade: Recoveries relationships are fixed with respect to feed grade, due to lack of testwork to generate curves at different feed grades, i.e. the HMC grade–recovery relationship is assumed to be constant across all feed grades based on the relationship from the 3.1% feed grade sample used for the flowsheet development. It is possible that lower grade feeds may result in lower recoveries as per Section 6.4.2.
- WCP recoveries: Inputs used are HM, zircon (based on XRF assay) and total TiO_2 only (based on XRF assays). Correlation of total TiO_2 with the various mineral species (e.g. leucoxene, ilmenite, and rutile) is not complete, so relative mineral recoveries are uncertain.
- WHIMS recoveries: Inputs used are zircon (based on XRF assay) and mass yield between magnetics and non-magnetics achieved in the 2009 testwork. Any change in the mineralogy of the HMC will not be reflected in the production model, as it has currently been developed.
- Zircon and titaniferous mineral production through the MSP wet and dry mill circuits are based on mass yields (not recovery) giving the production model limited validity for application where feed grades, mineralogy, circuit separation efficiencies or the circuit itself changes from those of the sample and testwork used to generate the data.

Table 6.5 Production Model Product Outputs

Total Production	Year	1	2	3	4	5	6	7	8
Primary Zircon	tpa	46,498	68,567	63,731	63,098	62,409	61,400	60,731	61,650
Foundry Zircon	tpa	14,064	20,934	19,457	19,264	19,054	18,746	18,541	18,822
Total Zircon	tpa	**60,562**	**89,500**	**83,188**	**82,363**	**81,463**	**80,146**	**79,272**	**80,473**
Rutile	tpa	4,521	6,457	6,002	5,942	5,877	5,782	5,719	5,806
Leucoxene	tpa	8,288	11,837	11,002	10,893	10,774	10,599	10,484	10,643
Primary Ilmenite	tpa	88,934	496,744	465,395	460,778	455,742	448,377	443,487	450,203
Secondary Ilmenite	tpa	25,391	141,823	132,873	131,554	130,117	128,014	126,618	128,535
Total sales products	tpa	187,697	746,361	698,460	691,530	683,972	672,919	665,579	675,659

Total Production	Year	9	10	11	12	13	14
Primary Zircon	tpa	62,167	60,269	62,401	65,336	56,845	52,378
Foundry Zircon	tpa	18,980	18,401	19,051	19,948	17,355	15,991
Total Zircon	tpa	**81,147**	**78,670**	**81,453**	**85,284**	**74,200**	**68,369**
Rutile	tpa	5,854	5,676	5,876	6,153	5,353	4,933
Leucoxene	tpa	10,732	10,404	10,772	11,279	9,813	9,042
Primary Ilmenite	tpa	453,979	440,118	455,685	477,120	415,111	382,488
Secondary Ilmenite	tpa	129,613	125,656	130,101	136,220	118,516	109,202
Total sales products	tpa	681,325	660,524	683,887	716,056	622,994	574,033

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SECTION 7

Tailings Disposal

Copy 16

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CONTENTS

FIGURES

7 TAILINGS DISPOSAL

7.1 Overview

Tailings represents approximately 98% of all material mined by the dredge. Once the dredge is fully commissioned and operational the tailings disposal system will be required to place 54 Mt of sand per annum.

The high rate of mining advance and the size of required pipework make it is necessary to directly discharge the tailings from the rear of the plant. For efficient stockpiling and to prevent a build-up of sand under and around the floating modules it is necessary to jet the tails to a sufficient distance from the rear of the plant and at a maximum practical solids density to provide the steepest stacking angle.

The tailings disposal system has been designed to account for these constraints and is described below.

7.2 Tailings Testwork

Practical trials were completed during the spiral testwork program to assess tails stacking and to investigate possible angles of repose. This testwork indicated angles of repose of 25° to 30° above and below the water line. However, this was for cyclone underflows with slurry densities of 70% to 75% solids.

Experienced operations personnel and consultants including EDI, Tipro and Ausenco advised that the following figures should be used for the proposed placement method and slurry density:

- Stacking angle above the water line - 22°.
- Stacking angle below the water line - 8°.

7.3 Design Criteria, Assumptions and Basis

To achieve high density and displacement of tails from the rear of the plant, the WCP module design includes a cyclone dewatering stage on the final tails before discharging the tails at approximately 63%$^{w}/_{w}$ solids via twin pipes from a jet stacker with:

- A discharge height of approximately 20 m above the pond level.
- A nominal stacking peak at 50 m from the rear of the floating pontoon bearing the stacker.
- A discharge velocity of approximately 21 mps.

Adopting a stacking angle of repose of 17° above the water line (to provide a design margin) and applying the calculated jet trajectory, the maximum stacking height will be approximately 21 m above pond level. If the stacking angle of repose is increased above 17°, the maximum may reach +25 m.

The movements of the WCP module will be dependent upon the required stack height and will aim to minimise rehandling by bulldozer for dune re-profiling.

7.4 General Layout and Staged Development

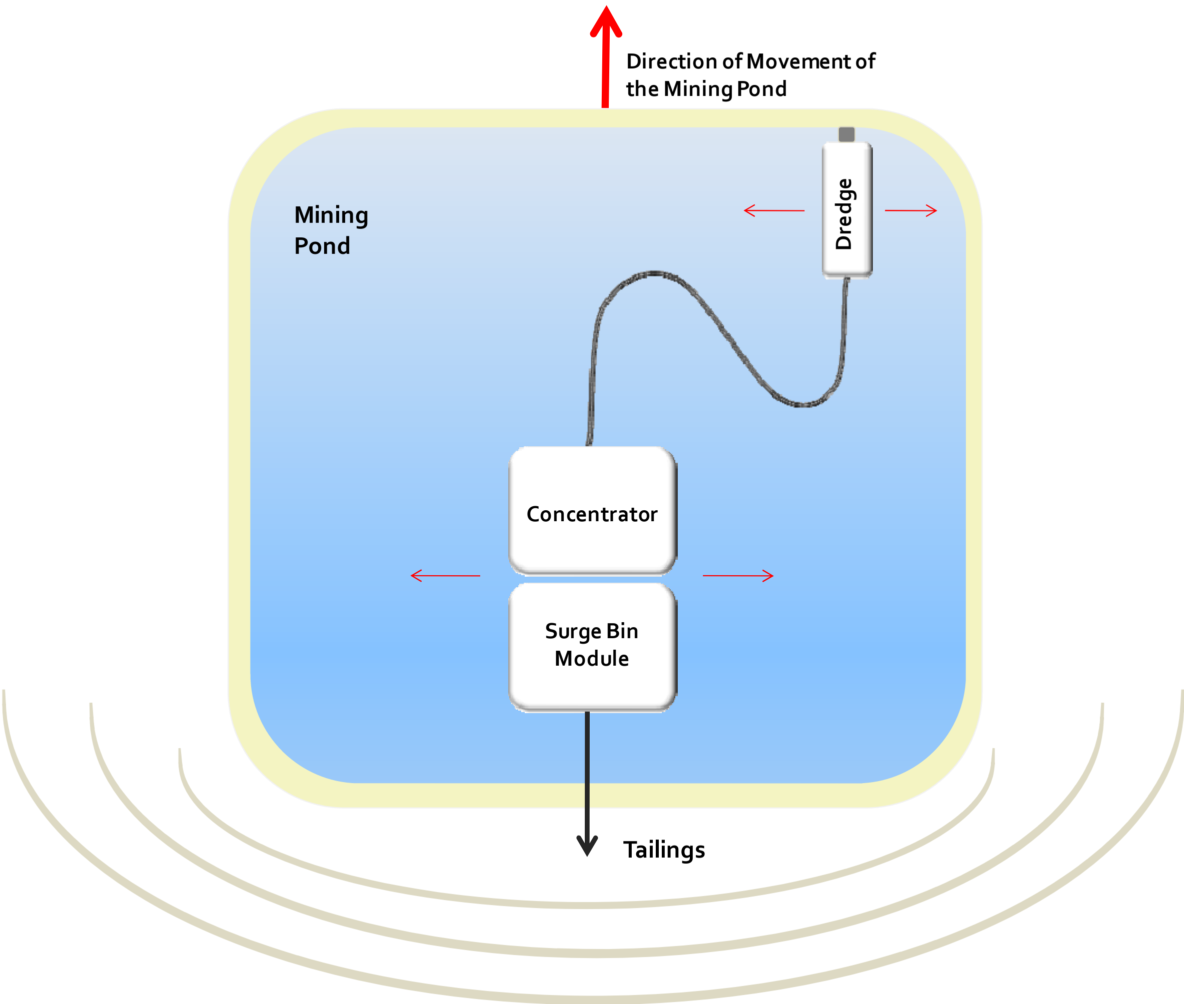
During the initial period of mining, the area and volume available at the discharge from the tails stacking arrangement is insufficient to handle the tails generated in the process of deepening and widening the mine pond. This necessitates pumping the tails to an adjacent valley over which the project has full ownership.

During this period, the tails stacker will be lowered onto the bank at the back of the surge bin, the nozzle removed and additional piping added to extend the discharge up to 500 m behind the plant. The tailings will be discharged in the natural valley and water recovered back to the active mining pond.

This initial operating mode will be required for approximately two to three months depending upon mining ramp-up and advancement. Once the mine pond is suitably deepened and widened, the normal mode of operation will be instituted.

Under normal operating conditions the tails stacker module will be slewed back and forth through a defined arc to create an elongated stockpile. The stacker slews behind the direction of traverse for the surge bin module across the mining pond to minimise the likelihood of sanding in front of the surge bin module (see Figure 7.1). When traversing in the opposite direction, the arc is to the opposite side. It should be noted that the stacker is slewed on a continuous basis to layer the tails and allow drainage between layers, thereby maximising the stack angle of the tails above the water line.

Figure 7.1 Tails Stacking Schematic - Plan View



7.5 Tailing Pipework

To achieve the required placement of the dewatered tails, it is necessary to discharge the tails at a velocity greater than 20 m/s, at the nominated angles of repose above and below the waterline. This will minimise the risk of tails building up and hindering the slewing of the tails stacker and the traverse of the surge bin module.

To achieve this velocity, a reducing nozzle is fitted at the discharge of each of the two tails stacking pipes reducing the internal diameter of the pipe from approximately 500 mm to approximately 220 mm. This nozzle is cast from ceramic to provide a suitable wear life.

7.6 Process Control and Instrumentation

The process control philosophies (PCS) for both tails stacking modes of operation have been developed by Ausenco (Appendix 6.21). The document has been predominantly generated from the original P&IDs developed for the previous project design.

The level of functionality incorporated into the PCS reflects the complexity of the tails stacking operations and the skill set of operating personnel. It will require a high level of status monitoring, automation and control to function efficiently.

For the normal operating mode, the slewing rate and slewing range of the tails stacker are automated to suit the required stacking philosophy and tailings profile. The operations control room is situated at the rear of the surge bin module to allow viewing of the tails stacking operations to promote regular operator attention to the tails stacking system.

The proposed philosophy is to slew the tails across the proposed stacking arc to allow dewatering of the tails before stacking further material, to maximise the angle of repose. The tailings stacker module total slewing angle will be approximately 150°. However, the operating angle will be approximately 90° subject to the direction of overall plant travel across the pond. Once the required tails profile is achieved or the dredge delivery line becomes fully extended, the WCP will be relocated to a position either laterally or in the direction of mining.

7.7 Tailings Schedule

The tailings schedule and the shape of the resultant landform are described in Section 4.

7.8 Capital and Operating Costs

Capital and operating costs associated with the stacking of tailings are detailed in Sections 16 and 17 respectively.

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SECTION 8

Water Management and Hydrology

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Copy 16

CONTENTS

TABLES

FIGURES

8 WATER MANAGEMENT AND HYDROLOGY

8.1 Introduction

Water management is one of the key operational issues that may affect the success of the GCP. It is important for the operation of the mine; the transfer of concentrates to the MSP; the mineral separation processes and for the needs of the local community who depend on it for their survival.

This section discusses the water requirements and water sources for the project. Water quality and water infrastructure and operations are also discussed. All capital and operating costs associated with water infrastructure are incorporated in Sections 16 and 17 respectively.

8.2 Water Requirements

There are three predominant uses of water for the GCP:

- Flotation of the mining dredge, surge bin and wet concentrator modules and slurrying of dunal orebody for processing.
- Pumping mineral concentrates as slurries from the mine to the MSP and waste return to the mine.
- Processing of mineral streams in the MSP.

In addition, water is required for other facilities, such as plant offices/buildings and rehabilitation.

8.2.1 Mining

The principal requirement for mining activities is dredge pond make-up water. The water level in the dredge pond will vary between 0 m and 6 m above the current existing water table during the life of the mining operation. As the water table is raised, additional water will be required with the quantity of make-up water a function of the height and width of the operating pond level. Modelling of the project water requirements has been completed by PSM Australia Pty Ltd (Appendix 8.1), specialist hydrogeological consultants.

8.2.2 Processing

Process water for the WCP and MSP will be a mixture of dredge pond water, raw water supplied from groundwater bores and water recovered from lateral containment bores. Processing water requirements have been determined by Ausenco (see Appendix 6.25) and are summarised in Table 8.1.

Table 8.1 Processing Water Requirements

Facility	Area	Description	Units	Quantity
02	00	**Wet concentrator**		
02	01	Surge bin module		
		Trash screen – spray water	m^3ph	480
		Surge bin – agitation water	m^3ph	848
		Surge bin – secondary agitation water	m^3ph	500
02	06	Wet concentrator services		
		Potable water	m^3/day	80
03	00	**Mineral separation plant**		
03	02	Wet mill		
		Wet shaking tables – cleaner wet shaking tables – wash water	m^3ph	64
		Wet shaking tables – middling wet shaking tables – wash water	m^3ph	32
		Wet shaking tables – cleaner scavenger wet shaking tables – wash water	m^3ph	24
		Wet Shaking tables – rejects scavenger cleaner wet shaking tables – wash water	m^3ph	16
		Wet shaking tables – rejects scavenger middling wet shaking tables – wash water	m^3ph	8
		Up stream classifier	m^3ph	1.8
03	05	MSP services		
		Potable water	m^3/day	80
03	06	WHIMS module		
		Wet high-intensity magnetic separator – mags wash water	m^3ph	192
		Wet high intensity magnetic separator – non-mags wash water	m^3ph	96

8.2.3 WCP

Water required for the WCP is sourced from the dredge pond. The specific water requirements for the WCP are described in more detail below.

8.2.3.1 Process Water

Two submersible pumps will be employed to provide process water for the plant. Process water is mainly make-up water for spiral hopper levels and density control. The pumps are intended to be submerged in the dredge pond and fitted with a coarse (20 mm aperture) intake screen to exclude trash. Under stable operating conditions, only one process water pump will operate. The second pump will operate at times of increased water demand (mainly during plant start-ups and shutdowns). The pumps will be configured to start and stop to maintain adequate pressure in the process water supply header.

8.2.3.2 Surge Bin Primary Agitation Water

A single submersible pump is to be provided to supply primary agitation water to the surge bin. The pump will be submerged in the dredge pond and is fitted with a coarse intake screen to exclude trash. The pump will be fixed speed and operate continuously. Primary agitation water will be supplied to the base of the surge bin to provide dilution and promote flow into the pump suctions.

8.2.3.3 Trommel Spray Water

A single submersible pump is to be provided to supply trommel spray water. The pump will be submerged in the dredge pond and fitted with an intake screen to exclude trash. The pump is intended to be fixed speed and operate continuously. The trommel spray water supply line will be fitted with in-line filters to remove fine particulates, which may block the spray nozzles.

8.2.3.4 Surge Bin Secondary Agitation

A single submersible pump will be provided to supply secondary agitation water to the surge bin. The pump is to be submerged in the dredge pond and fitted with an intake screen to exclude trash. The pump will be fixed speed and operate continuously. Secondary agitation water will be provided to a ring main around the circumference of the surge bin. Secondary agitation water is designed to be added through a series of nozzles in the ring main, to points near the bin wall to prevent solids from hanging up and thus ensure a steady flow of material to the base of the surge bin.

8.2.4 MSP

Water will be drawn from a deep water bore (lower Maestrichtian [Cretaceous age] aquifer) adjacent to the plant site and will be stored in the process water pond located within the MSP site. The pond will also receive recycled water from the spiral and tabling circuits (via two sand traps for solids recovery). Water supply for the MSP from the process water pond will be provided by a pair of submersible reclaim pumps and will involve two independent supply systems being employed:

- Variable-pressure plant water (make-up water).
- Constant-pressure water.

Process water, air and fire water services for the MSP dry mill are to be provided by common systems shared with the MSP wet mill.

8.2.5 Facilities

A nominal allowance of 80 m^3/day has been included in the plant water balance for ablutions and messing facilities at the MSP.

8.2.6 Rehabilitation

Water for rehabilitation activities will likely be sourced from the upper aquifer and will be closely monitored in its usage so as to be less than the recommended extraction quantity limits.

8.3 Modelling of the Existing Water Resources

Modelling of existing water resources and the affects of mining on the water table has been completed by specialist hydrogeologists PSM Australia Pty Ltd (PSM), Appendix 8.1. This modelling included incorporating regional data such as rainfall, irrigation practices plus data from a project-based weather station. In summary:

- Recorded annual rainfalls at Thies and Louga (south and north of the GCP) from 1922 have been analysed as part of this study. The data shows rainfall declines from 1950 to 1972, but then there is no obvious trend from 1972 to 2009.
- Increases in irrigated areas around the proposed mining area from 1992 to 2009 have been determined from LANDSAT imagery. The calculated area of cropping has increased from 551,620 m^2 to 6,585,060 m^2, with a corresponding extraction rate increase from 2.5 M litres/day to 30 M litres/day. 30 M litres/day represents approximately 15% of recharge. Seasonal and inter annual variability in recharge (e.g. Figure 8.1) means the significant extraction rate increase may require a few years to definitively relate declines in regional groundwater table (RGWT). The scale of water table fluctuations between 2006 and 2009 is summarised in Figure 8.1.
- Acting on early PSM advice, GCO installed an automatic weather station at Diogo. This station has been providing information since December 2006.

Figure 8.1 Historical Water Level Fluctuations in the Proposed Mining Area

8.4 Legislation Affecting Water Use

National Legislation, regulations, policies and guidelines relevant to water use are listed in Section 4.1.2 of Volume 2 - Environmental and Social Management Strategy (Table 4.1).

The principal legislative requirements (Laws and Regulations) are:

- Environment Code.
- Water Code.
- Inter-ministerial Decree No. 1555 applying Wastewater Discharge Standard NS05-061.

Potentially applicable guidelines regarding water quality for the GCP are outlined in Section 4.1.2.4 of Volume 2 - Environmental and Social Management Strategy. These cover discharge to water and water quality. The most applicable laws and regulations and other relevant GCO documentation and leading practice guidelines for managing surface water and groundwater are detailed in Section 5.3, Appendix 2.1 of Volume 2 - Environmental and Social Management Strategy.

8.5 Water Sources

Two viable sources of water are available to provide the quantities of water required for the GCP. These sources are both groundwater aquifers; the upper sand aquifer (Quaternary age) and a lower Maestrichtian (Cretaceous age) aquifer.

It should be noted that there is no visible running water sources at the MSP site and direct make-up contributions from rainfall have been assessed as zero due to the location of the project in an area that experiences one defined wet season for approximately three months during the year.

8.5.1 Upper Aquifer

The upper aquifer, a Quaternary sand sheet comprising unconsolidated Holocene sands, contains a significant groundwater resource that is used for domestic and agricultural sources. The upper aquifer is underlain by upper Eocene marl, which forms an impermeable substrate to the sand sheet aquifer. While not a government regulation or rule, a recommendation from the PAEP (Program of Support in Farmers' Entrepreneurship) indicated groundwater bores exploiting this resource be limited to a pumping rate of 15 m^3ph to minimise drawdown and maintain a sustainable water supply in the region.

The upper aquifer natural water level will be the initial mining pond level. This aquifer will not be used as a source of pond make-up water, but rather as a means of recovering water lost from the mining pond. The aquifer will be subject to evaporation as is applicable to the open area of the dredge pond and will also be affected by inflows and outflows as a result of losses from the dredge pond through the pond walls. Current modelling suggests that at least 70% to 80% of required pond make-up water will be redrawn from the upper aquifer specifically to maintain the natural water table and reduce any localised effects on the nearby farmers due to changes in the water table as a result of water additions by GCO.

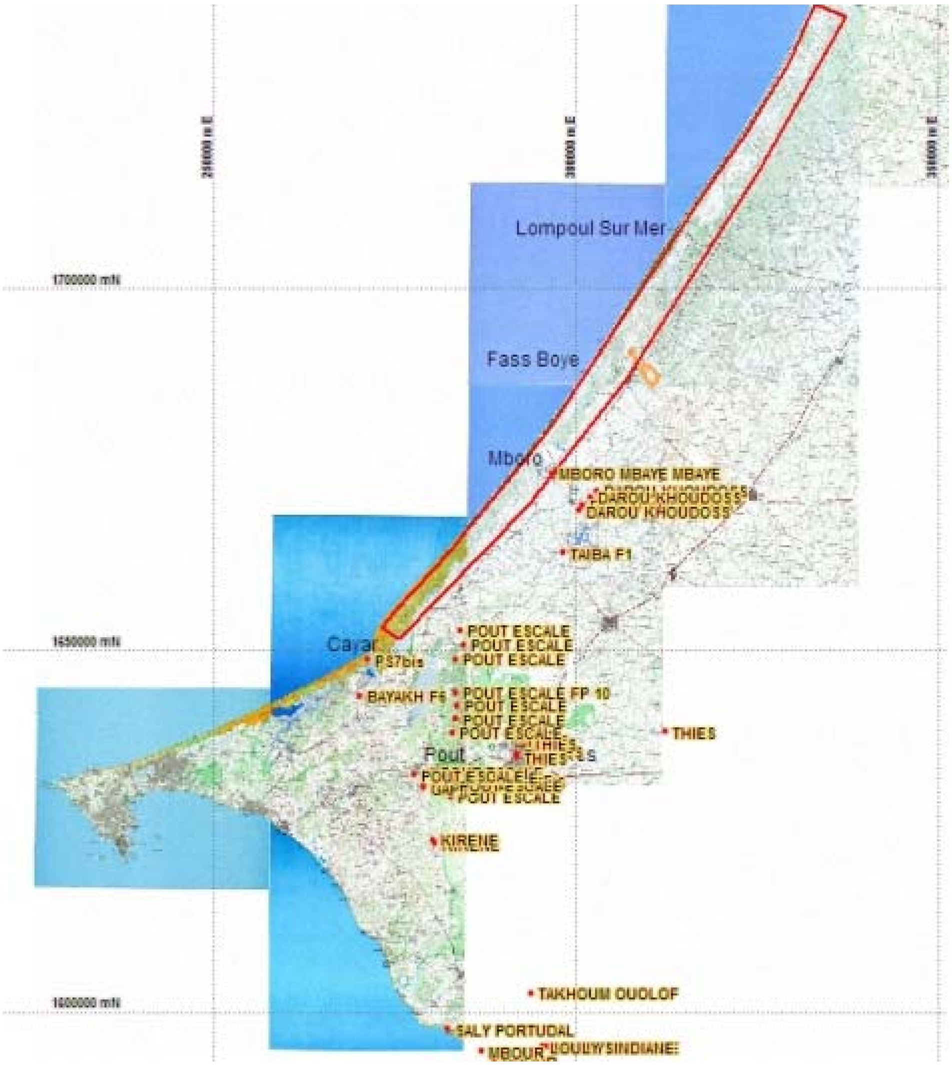
8.5.2 Lower Aquifer

Underlying the impermeable basement at depths of more than 400 m is an aquifer of Maestrichtian age. This aquifer is not currently exploited in the area immediately adjacent to the GCP orebody. However, a number of other users have bores into this aquifer with applicable bore details summarised in Table 8.2 and shown relative to the project site in Figure 8.2.

Table 8.2 Details of a Number of Bores into the Maestrichtian Age Aquifer

Bore ID	Bore Depth (m)	Yield (m^3ph)	Drawdown (m)	Region
Linguere	250.00	163	8.5	Louga
Darou Khoudoss	480.00	165	24	Thies
Saly Portudal	311.00	170	77	Thies
Darou Khoudoss	481.00	180	38.3	Thies
Mbour	244.00	188	34	Thies
Taiba F1	491.00	198	56.26	Thies
Bayakh F6	240.00	200	8.22	Thies
Pout S7 Bis	319.4	200	19	Thies
Pout Escale	358.00	200	20	Thies
Pout Escale	400.00	202	44.5	Thies
Louly Sindiane	180.00	208	25.2	Thies
P S7 Bis	303.00	210	27.11	Thies
Pout Escale	300.00	238	35.8	Thies
Kirene	–	250	41.5	Thies
Pout Escale	321.00	252	36.5	Thies
Khodoba	270.00	253	31.8	Thies
Pout Escale	320.00	256	28.1	Thies
Pout Escale	350.00	260	17.12	Thies
Pout Escale	353.00	261	15.55	Thies
Gappe	362.00	268	39.7	Thies
Pout Escale	271.00	270	32.6	Thies
Pout Escale FP 10	361.00	272	24.07	Thies
Pout Escale	352.00	275	18.53	Thies
Louly Sindiane	202.00	278	26	Thies
Pout Escale	360.00	300	27.11	Thies
Pout Escale	320.00	300	27.1	Thies
Pout Escale	344.00	305	23.61	Thies
Kirene	195.00	324	44.3	Thies
Pout Escale	327.00	390	43	Thies

Figure 8.2 Location of Bores into the Deeper Maestrichtian Age Aquifer In Relation To the GCP



The lower aquifer will be the source of all make-up water, which includes make-up water for the dredge pond, processing water for the MSP and drinking water for site personnel. To assess the feasibility of the proposed water strategy and yield from the lower aquifer, for the GCP a bore has been drilled and cased to a depth of 526 m adjacent to the initial mine path in the Diogo portion of the deposit. Based on these results, a deep water borefield will be designed with 10 bores along the service corridor adjacent to the dredge path. A further deep water bore will be located at the MSP to meet plant requirements.

8.6 Water Quality

Baseline water quality testing of groundwater from some 30 wells and bores in the Diogo area has been undertaken as part of baseline environmental studies (see Volume 2 - Environmental and Social Management Strategy). Water has been tested for a wide range of parameters, which included:

- Field pH.
- Field electrical conductivity.
- Lab electrical conductivity.
- Faecal coliforms.
- Organophosphates.
- Nitrates.
- Potassium.
- Hydrocarbons.
- Iron.
- Sulphate.
- Chloride.
- Arsenic.

Water monitoring is intended to be ongoing at a defined interval as outlined in detail as part the Groundwater Quality Monitoring Plan (GWQMP) for the GCP that has been prepared by Environmental Consultants Umwelt (Australia) Pty Limited (Volume 2 Appendix 2.7).

8.7 Water balance

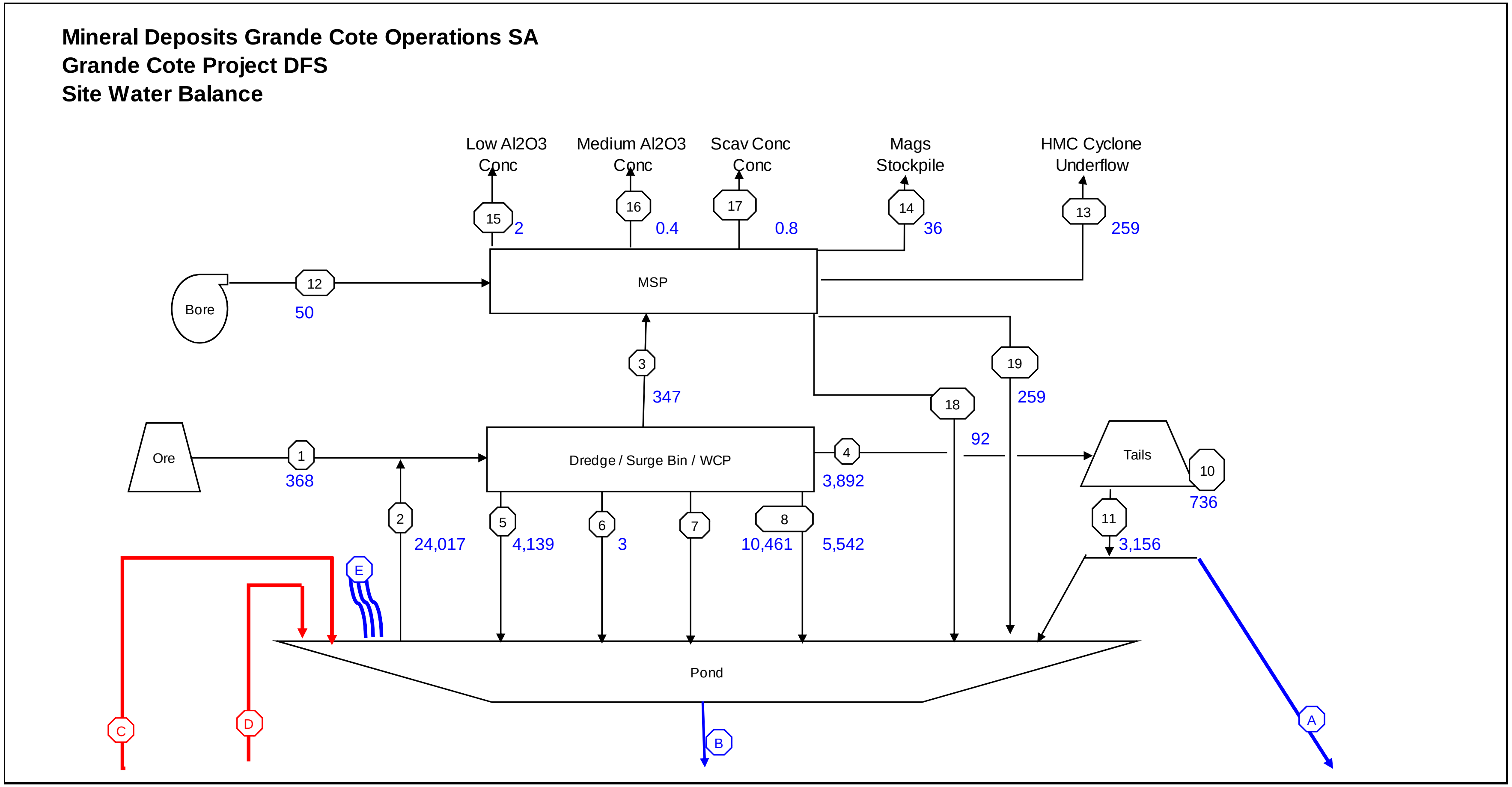
A site water balance has been prepared by PSM and Ausenco (2009a) to calculate the various plant flows of solids and water. The water balance reflects:

- Losses from water entrained in the sand tailings after ore is processed at the mine.
- Losses through the wall of the mining pond due to permeability of the sand ore being mined.
- Losses from evaporation of the surface of the dredge pond.
- Losses from stockpile drainage at the MSP.
- Losses from evaporative drying at the MSP during mineral processing.
- Transfers to the MSP from the mine and the return of tailings from the MSP.

The most significant contributors to the water loss and hence the need for make-up water are the water entrained in tailings and wall loss through permeability. The losses are proportional to the dune height above the water table and to the operating width of the pond as dictated by the mine path.

The overall water balance is shown in Figure 8.3.

Figure 8.3 Grande Côte Site Water Balance



For a detailed description of the water balance, see Appendix 8.2.

8.8 Water Reticulation Stages

Water reticulation stages correspond to the mining phases and comprise deep bore elements and shallow containment bores.

The initial deep water bore field will be sized and scoped for the first two years of production. The recently completed bore will be augmented by an additional nine bores, which will be drilled and completed prior to dredging. The 10 deep bores will be equipped with electric submersible pumps with power reticulated via transformers from the 11 kV power feeder line.

The main header piping system will be 8 km in length using 600 mm polyethylene pipe and will have isolation valves for each bore pump and a series of valved T-branches for the supply of water to the mining pond. As the pond advances, the lateral pipes that feed into the pond will be progressively stepped along the main pipeline. A telemetry system will be installed for remote control of the pumping system from the wet concentrator control room.

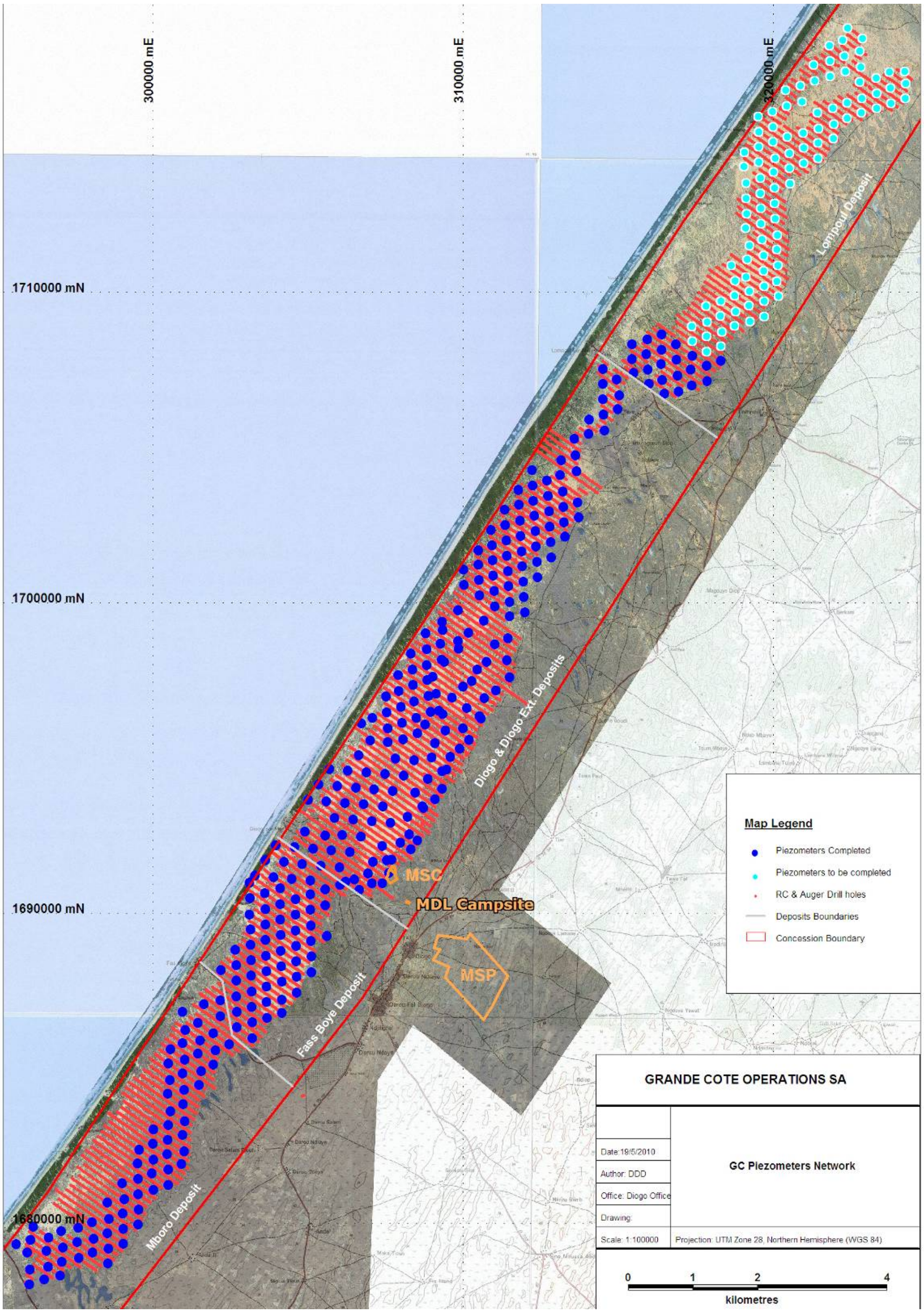
The water lost through the pond wall to the upper aquifer will have a noticeable effect in the first two years of mining as the initial mine path is adjacent to the Niayes and the local farming. The mining operation will cause a temporary and localised rise in the water table.

To manage any potential issues due to a change in the level of the natural water table and in order to recover water lost from the dredge pond hence minimising water drawn for the deep water aquifer, a system of lateral bore pumps will be installed either side of the dredge path. Based on modelling by PSM (Appendix 8.1), 52 active bores are required spaced a 50 m intervals in two 1.3 km lines each side of the dredge path (see Section 8.12).

8.9 Water Table Monitoring

A total of 360 piezometers have been established over the GCP area (Figure 8.4). The principal aim of these piezometers is to measure baseline RGWT fluctuations prior to, during and post mining activities. Monitoring currently takes place on a monthly basis and will continue during operations to ensure RGWT trends are analysed and used for management of the water resource. Piezometer water level was also extensively used by AMC in the resource block model development.

Figure 8.4 Grande Côte Piezometer Locations



8.10 Water Quality Monitoring

A Groundwater Quality Monitoring Plan (GWQMP) for the GCP has been prepared by environmental consultants Umwelt (Australia) Pty Limited (Umwelt, 2010, Volume 2 - Environmental and Social Management Strategy). The purpose of the GWQP is to determine any effects the proposed mining operation has on groundwater quality in the GCP area. The monitoring plan includes the aforementioned baseline monitoring, operational monitoring and post-closure monitoring of groundwater quality in and around the GCP area.

8.11 Modelling of the Planned Water Resources

Modelling by PSM Australia Pty Ltd (Appendix 8.1) of regional and dredge groundwater flows has been combined to estimate make-up water requirements and containment systems to minimise regional impacts.

While dredging during most of the first year of mining is taking place at the natural regional ground water table (RGWT) level, during subsequent mining years the mine path will be periodically adjusted to match the HM content at various depths. This will involve locally raising the water table by up to +6 m to maximise mining grades. The anticipated make-up water for various pond widths, dune heights and water table elevations have been modelled to reflect this.

The combined dredge and regional groundwater model has been developed to:

- Define dredge make-up water requirements in terms of a range of operating parameters, including pond level relative to RGWT, mining width and mining rate.
- Explore alternative upper aquifer recovery water methods.
- Define regional impacts and develop containment strategies.

The PSM report summarises the regional data and field work used to define aquifer extent and hydraulic characteristics, irrigation, extraction and rainfall recharge for the calibration of the MODFLOW regional model. The regional model calibration was conducted by Australian Groundwater & Environmental Consultants Pty Ltd (AGEC, 2009). The groundwater model was developed and calibrated based on 27 years of collated data, to ensure it was capable of replicating historical changes in groundwater levels, prior to being used for predictive simulations of the proposed dredging operations.

8.11.1 Upper Aquifer Water Recovery

Pond make-up water requirements will vary with operating level, dune height and other dredge operational parameters. For the dredge operating at a notional 6 m above RGWT the combined stack and lateral make-up requirement is around 45,000 m^3/day. This would produce a 5.5 mpa rate of water table rise and lead to significant flooding. A large portion of dredge make-up water must therefore be recovered from the upper aquifer. In the PSM study upper aquifer water recovery is via a series of lateral bores as parallel containment lines either side of the dredge path.

The approach proposed by PSM is robust and uses well-proven technology. A high level of recovery will be achievable and therefore flooding risks are manageable in a practical sense. Containment lines were defined in terms of pumping rate and spacing. The capital estimate includes an allowance for 52 fully equipped containment bores, 50 additional cased bore holes and 4 km of 600 mm polyethylene pipe, which will have a series of isolation valves and branches for the supply of water to the active mining pond. As the pond advances, the pipe and pumps will be moved accordingly.

8.11.2 Secondary Water Requirements

While the primary water requirements are those required to maintain the dredge pond, the secondary water requirements are those associated with evaporation loss from the pond and stack and those exported in the HMC pumped to the MSP.

At an assumed evaporation rate of 7 mm/day, the evaporative loss rate has been estimated at 665 m^3/day. Water associated with product losses has been calculated at 3,360 m^3/day. This is a projected maximum total secondary water requirement of 4,000 m^3/day, approximately 10% of the primary water requirement.

As the HMC product water will be returned to the upper aquifer, the true aquifer losses are approximately 1,000 m^3/day, equivalent to 2% of the pond make-up water requirement.

The dredge pond gross make-up water requirement varies with dune height and prescribed operating conditions. Without containment bores, an indicative value is 50,000 m^3/day. With containment lines of bores paralleling the dredge path, net make-up water requirements of 10,000 m^3/day or less are considered practicable. Additional containment bores would be installed adjacent to sensitive areas if deemed necessary.

The containment lines would straddle the full dredge path(s) length. However, as indicated previously, the active pumping length required is about 1,300 m on each side of the active dredge location.

8.11.3 Modelling Results

8.11.3.1 Dredge Operating Parameters

Dredge make-up water comprises water left behind in the tailing stack and that lost laterally from the pond sides when the pond is operated above the regional ground water table (RGWT), and the stack sides.

Dredge make-up water requirements have been modelled as a function of:

- Pond height above RGWT.
- Dredging width.
- Dune height.
- Aquifer saturated thickness.

The modelling results are summarised in Figure 8.5.

Increasing the height of the dredge pond above RGWT increases the water lost from the pond to the aquifer and the total make-up water requirement.

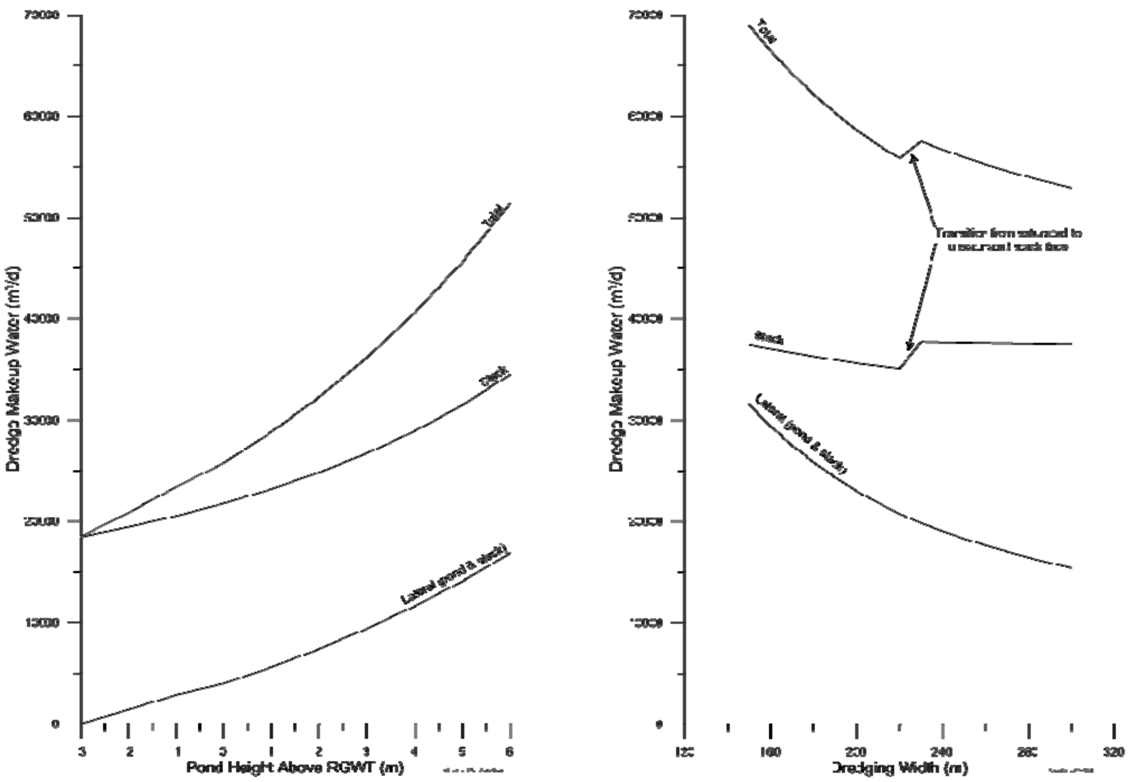
For a given dredge capacity, increasing the dredge pond width reduces the rate of advance such that the pond moves more slowly in “dry” sand and the lateral water loss is less.

For very low dune heights the water requirement is high because the dredge pond is advancing rapidly into “dry” sand. As the dunes increase in height (slower advance) lateral loss from the pond declines but lateral losses from the stack sides and water in the stack both increase.

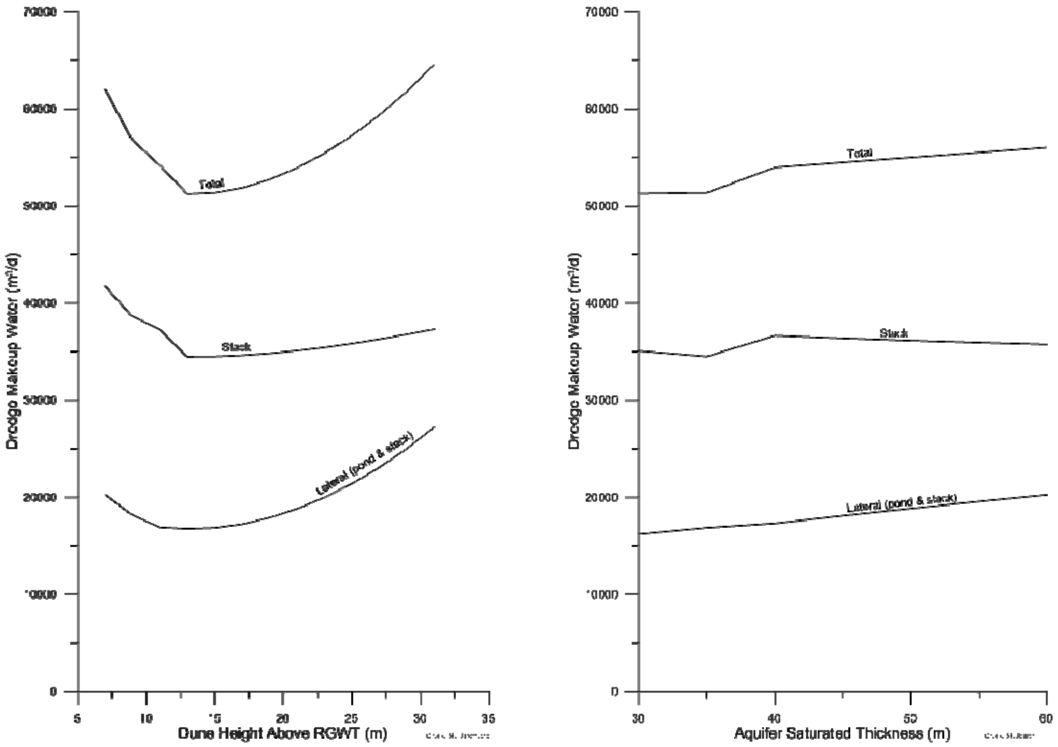
Figure 8.5 Modelling Results Dredge Make-up Water Requirement

As a function of:

(a) Pond Height above RGWT (m) (b) Dredging Width (m)



(c) Dune Height above RGWT (m) (d) Aquifer Saturated Thickness (m)



As aquifer thickness increases, lateral loss from the pond also increases. However, this is mostly compensated by more water in the stack returning to the pond. The net effect is a slight increase in water demand with increasing aquifer saturated thickness.

8.11.3.2 Dredge Path and Upper Aquifer Water Recovery

The dredge path traverses a range of dune heights and includes a range of mining widths. The results can be broadly interpreted irrespective of path locations.

Modelling has been conducted for the dredge pond at the RGWT and +6 m above the RGWT. The results are presented as predicted water table levels and the change in water table. The change in water table provides a good indication of the magnitude and lateral extent of impacts when there is no water recovery implemented. That is, all the make-up water is supplied from an external source.

The areal extent of impacts under various scenarios have been modelled for the following conditions:

- No containment bores.
- Containment bores on the east, or garden/Niayes side of the mining area.
- Containment bores on both sides of the proposed mining area.

With no containment bores, the areal extent of raised RWGT is evident (Figure 8.6 a).

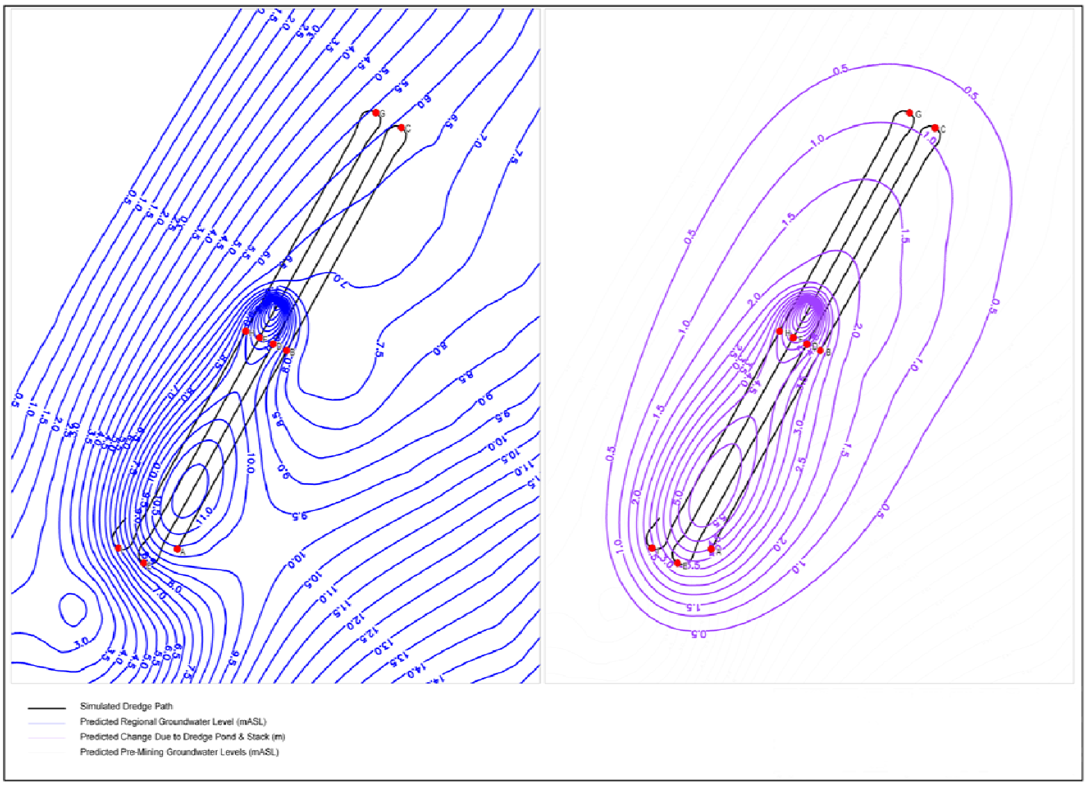
Modelling a line of containment bores paralleling the dredge path on the eastern side, with pumps operated as required to maintain the initial pre-dredging water level, is presented in Figure 8.6(b). This scenario is designed to protect garden areas. This illustrates that a single containment line can effectively protect garden areas. However, this line only recovers about half of the water required to sustain the dredge and pond. The remaining water must be sourced from elsewhere. If it were drawn from the deep bores, then flooding would result.

With containment bores paralleling the dredge path on both eastern and western sides (Figure 8.6(c)), the RGWT is managed at its pre-mining levels. For the wells on the western side the primary purpose is to provide water recovery from the upper aquifer.

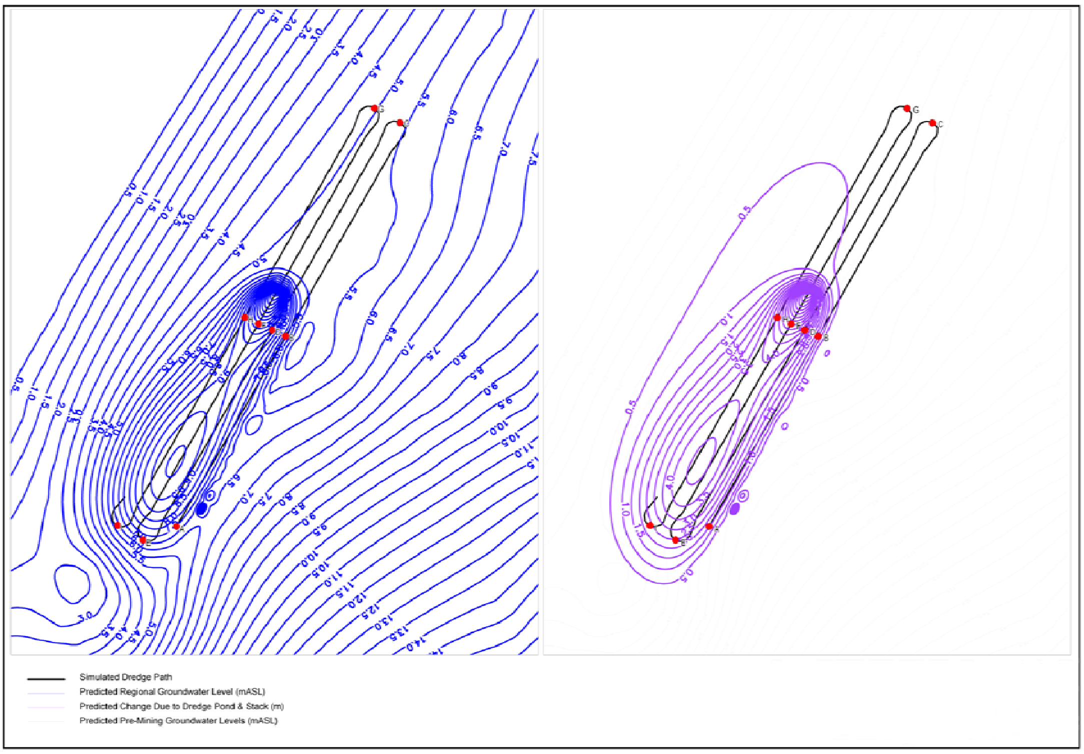
Figure 8.6 Dredge Pond at +6 m

(Left figure, Water Table; right figure, Change in Water Table)

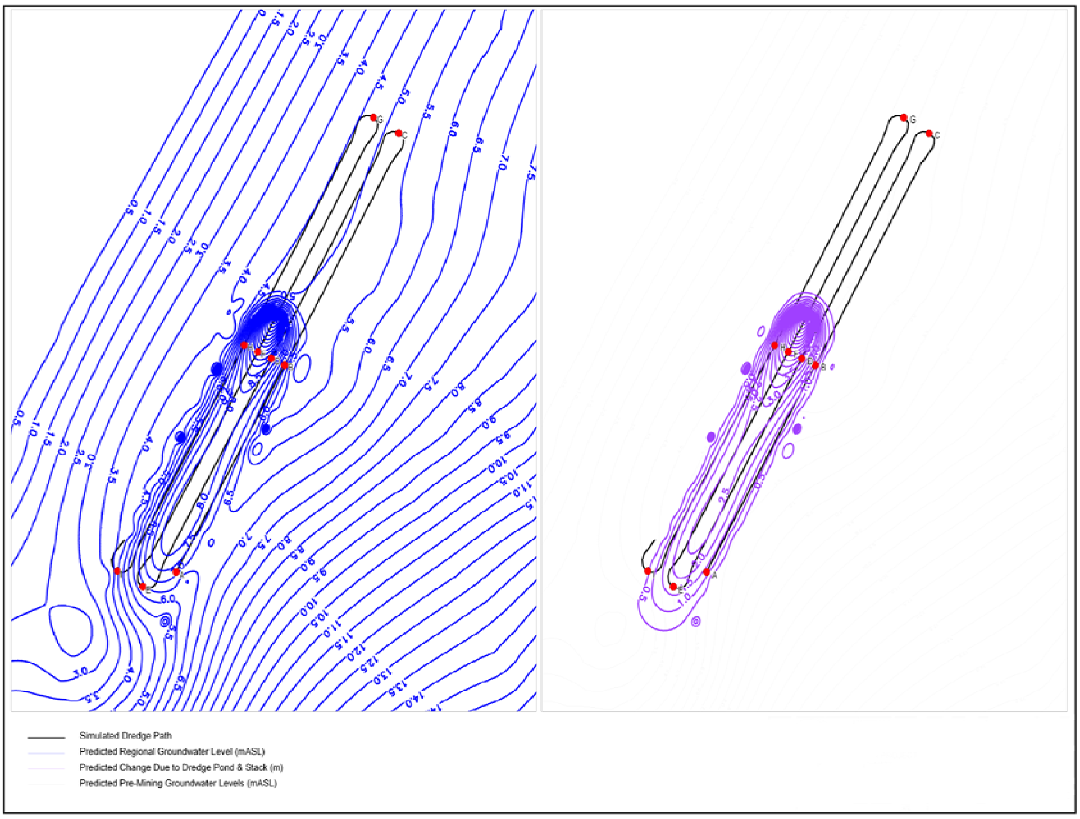
(a) No Containment Bores.



(b) Containment Bores, Eastern Side.



(c) Containment Bores both sides.



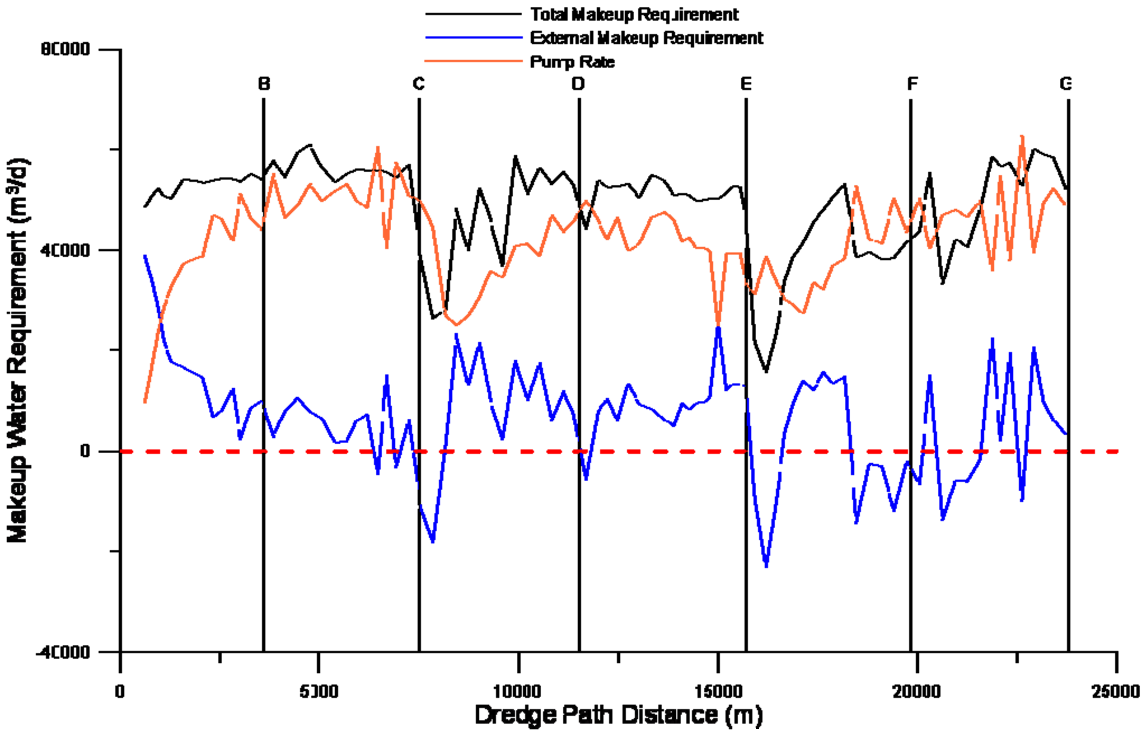
Make-up water requirements corresponding to the areal extents presented above have also been modelled.

Water requirements vary with location on the dredge path: they are smallest immediately after a turn when the dredge is advancing through the mound it has just created, and then gradually increase as the time for groundwater mound dissipation increases.

Figure 8.7 presents the modelling with the dredge at +6 m and containment/recovery bores at 50 m spacing on either side. Apart from the start-up phase (the first 2.5 km of dredge path), only a very small amount of external make-up water is required. During detailed design this spacing should be optimised in conjunction with a small fraction of make-up from the deep bores. Dredge make-up water requirements are shown in Figure 8.7. The three curves in Figure 8.7 can be explained as follows:

- The total make-up water requirement for the dredge pond (black line). This is the water that must be pumped to the pond to maintain the prescribed pond level. It is a function of the current water table level just ahead of the dredge, the dune height being encountered and the dredging width. The water table level just ahead of the dredge is a key factor. Whenever the dredge loops back on itself (e.g. points C and E in Figure 8.77), it encounters the high water table it has just created and the make-up water requirement is temporarily reduced.
- The recovery rate from the containment line bores (red line). The pumping rate is entirely driven by the local water level at the containment line without reference to the current requirements of the dredge pond.
- The difference between the current pond make-up requirements and that supplied by the containment bores (blue line). If the containment lines were 100% effective, this curve would fluctuate about zero. When the curve is above zero external water is required or the containment bores must be over-pumped to sustain the ponds. When negative, there is a surfeit of water from the containment bores that, as already noted, might be pumped to the dunes ahead of the advancing dredge for later use.

Figure 8.7 Dredge Make-up



If the containment scheme was 100% successful, external make-up would only be required to cover evaporation loss and the initial raising of the dredge. A little below the 100% containment, the regional aquifer gets recharged by water pumped from the lower aquifer. If it falls a lot below, then localised flooding may result.

8.11.3.3 Containment Pumping

Modelling of the dredge path in relation to the Niayes gardens and containment pumping lines, with the dredge at +6 m elevation, has been undertaken and is summarised in Figure 8.8 and Figure 8.9. An example of the results at the Garden Area 3 in Figure 8.8 location is presented in Figure 8.9. Key points are:

- Without containment lines, the magnitude of the groundwater level rises in the range 3 m to 4 m, with spikes to 5 m.
- With containment lines both sides of the dredging area, the groundwater rises are negligible.
- Advance rates for the dredge pond are modelled at 10 m/day at the +6 m elevation, which would correspond to 130 days of pumping, or 1,300 m of containment line, largely behind the dredge.
- Modelling the spacing of the containment bores at 10/20/30/40 and 50 m spacing with corresponding flow rates of 10/20/30/40 and 50 litres/s was also undertaken. All produced effective containment, i.e. negligible leakage and therefore negligible flooding. At greater than 50 m spacing, some loss through the containment lines could be expected.

- For 50 litres/s bores at 50 m spacing, 26 bores per line, or 52 active bores overall are required.

Figure 8.8 Location of Modelled Containment Lines and Key Garden Areas

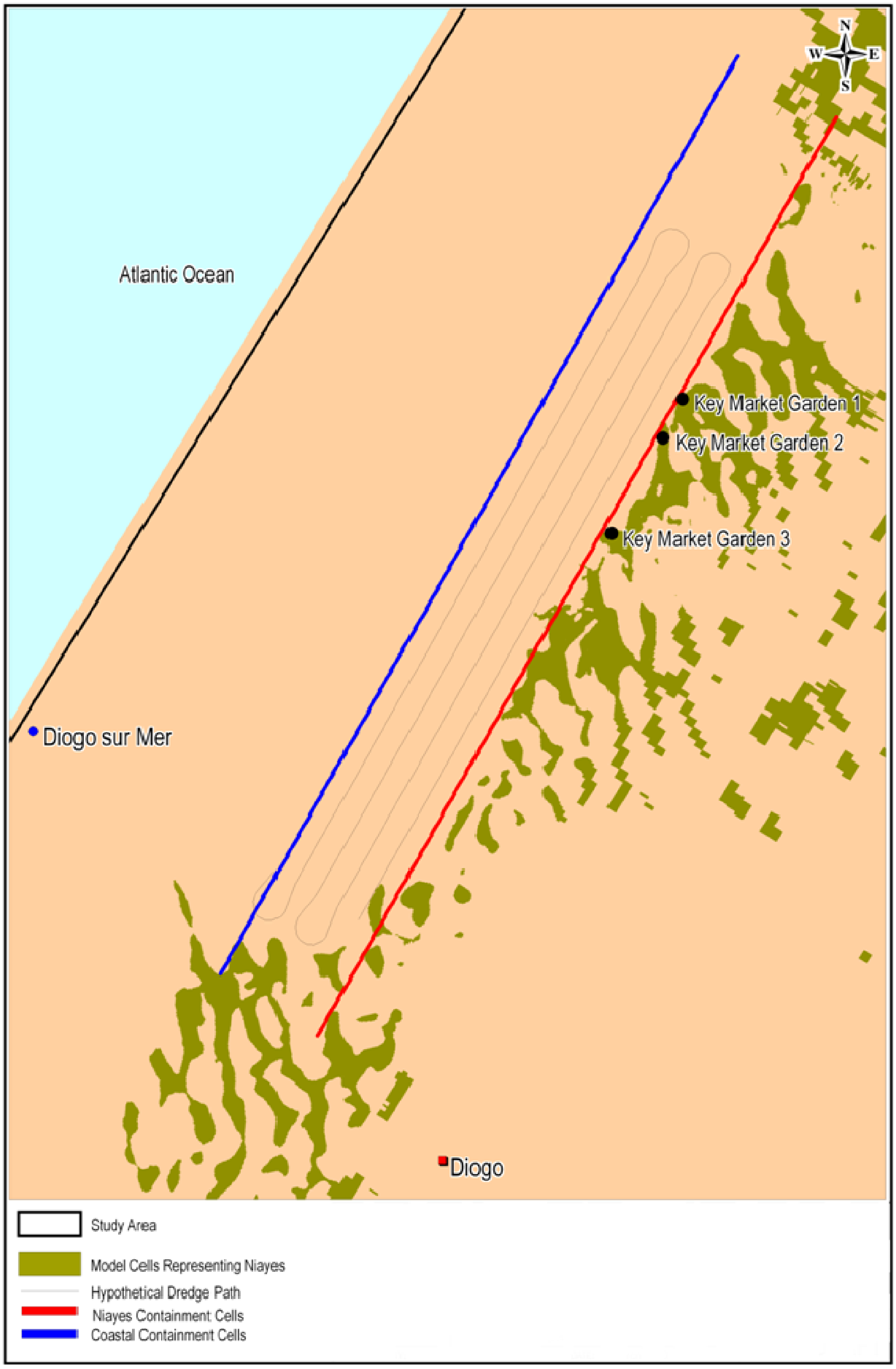
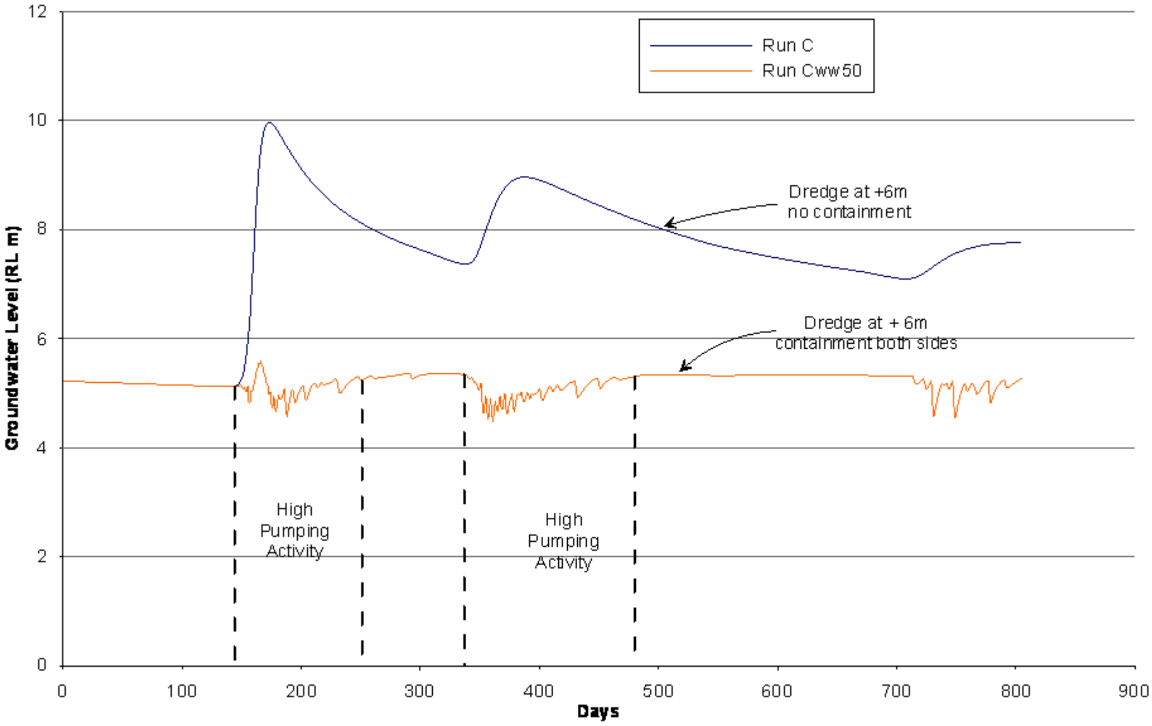


Figure 8.9 Modelling of Local GWT Pumping Activity at Garden Area 3



8.12 Effect of Water Use on Existing or Surrounding Users

The effect of water use on existing and surrounding users is detailed in Volume 2 - Environmental and Social Management Strategy.

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SECTION 9

Infrastructure and Services

Copy 16

AMC CONSULTANTS

CONTENTS

TABLES

FIGURES

9 INFRASTRUCTURE AND SERVICES

9.1 Introduction

Infrastructure and services supporting the development and operation of the dredge mining and mineral processing facilities are described in this section, including:

- Buildings and storage facilities:
  - Mill buildings.
  - Administration offices.
  - Warehouses and lay-down areas.
  - Ancillary buildings and site facilities.
- Refuse and sewage treatment.
- Fuel specifications, supply and storage.
- Power station specifications, design and supply.
- Information and communications technology.
- Transport and logistics:
  - Rail infrastructure.
  - Road infrastructure.
  - Port and harbour facilities.

Water services and reticulation are described separately in Section 8. Details of the construction schedule for the rail, road and port infrastructure are in Section 13. Security requirements, transport of personnel during construction and operational phases and accommodation services are detailed in Section 14. The capital and operating costs associated with the development and operation of the supporting infrastructure and services are detailed in Section 16 and Section 17 respectively.

9.2 Buildings and Storage Facilities

9.2.1 Mill Buildings

The mineral separation plant (MSP) will contain four milling facilities:

- The WHIMS plant.
- The wet mill.
- The zircon dry mill.
- The ilmenite plant.

The zircon dry mill and ilmenite plant buildings are fabricated fully colourbond clad steel structures. The WHIMS building will be a partially clad steel structure. The wet mill building is a combination of fabricated steel structure with a suspended concrete floor and concrete columns at one end of the building, it is partially clad.

Each of the dry mill, wet mill and ilmenite plant buildings have built in control rooms, switch rooms and toilets. The WHIMS plant will be supported by the wet mill control room, switch room and ablutions. Figure 9.1 illustrates the general layout of these buildings.

9.2.2 Administration and Services Buildings

Administration buildings and service offices located at the MSP site include:

- Administration building - including offices, first aid room, lunch room, training room and ablutions.
- Workshop compound.
- Site mess and kitchen.
- Maintenance office and crib building - adjacent to workshop compound.
- Maintenance workshop - a re-engineered copy of the Sabodala workshop.
- Maintenance ablutions - toilets and showers adjacent to workshop.
- Laboratory.

The administration and service buildings will be constructed with standard materials and techniques used in Senegal. The location of these buildings is shown in Figure 9.1.

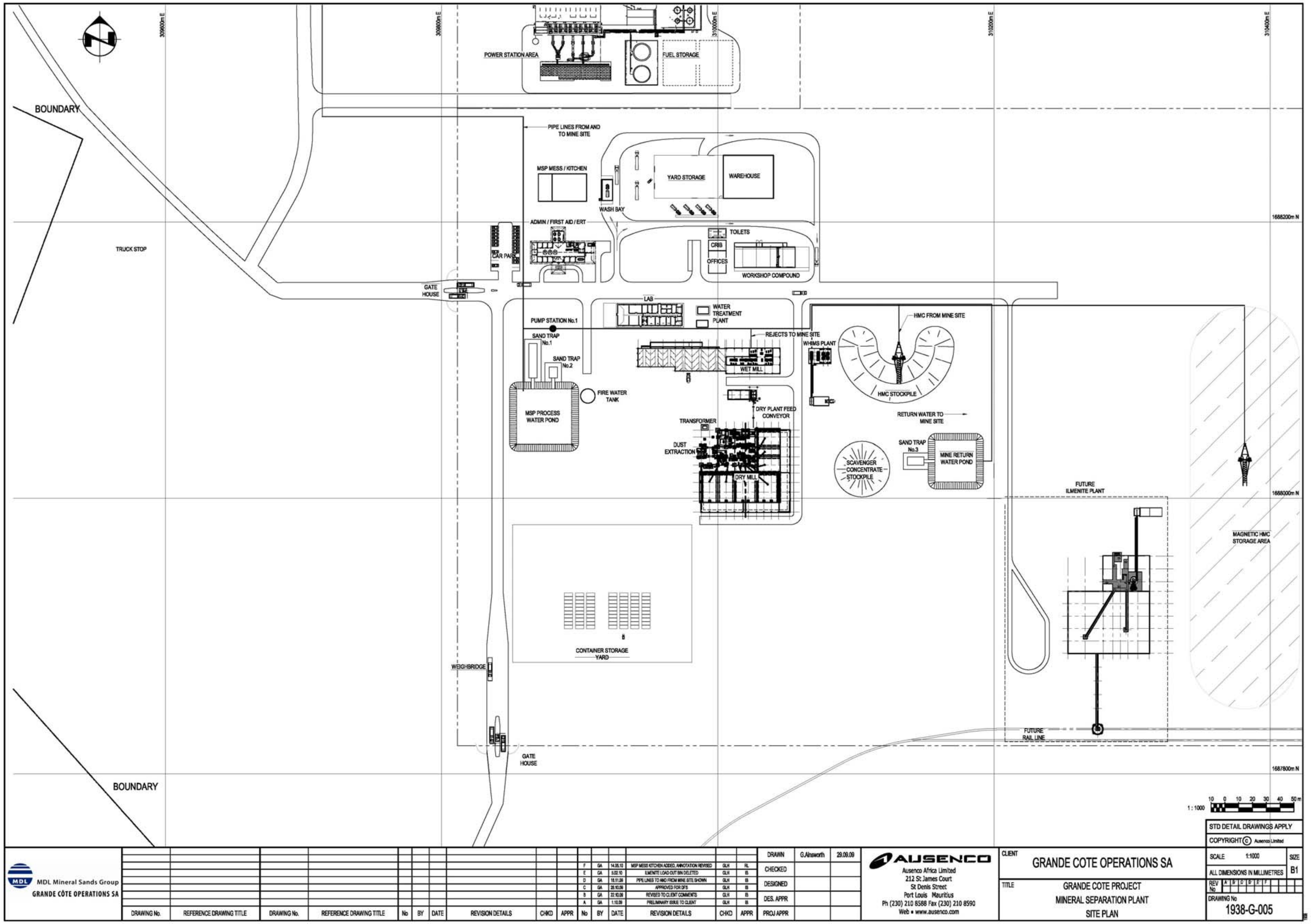
9.2.3 Warehouses and Lay-down Areas

A single warehouse building for storage of consumables and spares will be located at the MSP site. The MSP warehouse will be a modified version of MDL's Sabodala warehouse extended to make a total footprint of 675 m^2.

Other lay-down areas and storage facilities on the site (see Figure 9.1) include:

- Yard storage.
- Container storage.
- Heavy mineral concentrate (HMC) stockpile.
- Magnetic HMC stockpile.
- Mine return water pond.
- MSP process water pond.
- Scavenger concentrate stockpile.
- Fuel Storage at the power station.
- Sand traps (3).

Figure 9.1 General Arrangement of Site Buildings at MSP



9.2.4 Ancillary Buildings and Facilities

Ancillary buildings and facilities at the MSP site include:

- Two gate houses.
- Mess and kitchen.
- Weighbridge.
- Water treatment plant.
- Firewater tank.
- Dust extraction and transformer associated with the dry mill.

The ancillary buildings will consist of slab on ground, sandwich construction. The layout of these facilities is shown in Figure 9.1.

9.3 Refuse and Sewage Treatment

Sewerage systems are required for the dredge, the WCP and MSP.

Both the dredge and WCP sewage systems will be proprietary systems which chemically treat the sewage before automatically discharging it into the dredge pond. Treated sewage will comply with appropriate recycled water quality guidelines.

The MSP Sewage treatment plant (STP) will treat sewage from nine locations around the site. These sites are:

- Maintenance workshop ablutions.
- Administration building ablutions.
- Laboratory building ablutions.
- Power station ablutions.
- Two gate house ablutions.
- Wet mill ablutions.
- Dry mill ablutions.
- Ilmenite plant ablutions.

A sump and sewage pump will be installed at each location from which sewage will be gravity fed to a common sump. From the sumps the sewage will be pumped to a single below-ground lift station located adjacent to the STP. The lift station will pump the sewage to be treated into the STP. The STP will include the following stages of sewage treatment:

- Liquid/solid separation.
- Anaerobic digestion.
- Aerobic digestion.

- Settling.
- Chemical sterilisation.

The treated sewage from the STP will then be discharged into a soakage trench allowing evaporation and/or soakage of any outflow.

9.4 Power Station Specifications, Design and Supply

9.4.1 Power Supply

The GCP will require significant electrical power supply at a location remote from the Senegalese national power grid. MDL's current power supply strategy is similar to that used at the Sabodala operation, whereby GCP will own and operate a stationary dual fuel (natural gas/heavy fuel oil [HFO]) fired power station. Given the long life of the operation, MDL considers this a better economic option when compared to power supply options investigated. The installation of a natural gas compatible power station will provide opportunity for utilisation of a local energy source, with the added benefit of potential carbon credits under the clean development mechanism (CDM).

The estimated total capital cost of the power plant is $45M and this is detailed in Section 16. The estimate and the facility description is largely consistent with the power plant at the Sabodala operation (excepting the dual fuel capability) and includes all earthworks, civil works, concrete, logistics, transport, fuel farm facilities and commissioning.

9.4.2 Power Demand

The maximum demand, as determined by Perth engineering company BEC Engineering, indicates a connected load of 27 MW. The online power demand will be 22 MW and 141,000 MWh of power will be required annually. Details of the equipment loadings and maximum demand assessment are in Appendix 9.1.

9.4.3 Power Distribution

The power station will be at a fixed location near Diogo and adjacent to the MSP, and will generate power at 11 kV. Power supply lines (33 kV) to the dredge and floating plant will be progressively extended as the dredge advances. Power infrastructure consistent with two years of dredge activities will be installed as part of the initial plant construction. Power will also be distributed at 415 V to the MSP and for general distribution to workshops, offices and other facilities, and at 11 kV to the pump stations.

9.4.4 Technical Specifications

A Wartsila power station including power generation equipment and services for a stationary power plant comprising 3 x 8 MW and 1 x 4 MW (dual-fuel) engines with installed total capacity of 28 MW is proposed and costed. The plant will require 0.219 litres of HFO fuel per kWh (or equivalent energy content natural gas) and is consistent with MDL's experience at the Sabodala operation.

The design, power and infrastructure of the Wartsila power plant for the GCP will be similar to that of the Sabodala operation, with key differences being:

- 50% smaller fuel storage capacity due to close proximity to Dakar.
- Dual-fuel capable engines, i.e. engines capable of running on HFO or natural gas.
- Lower installed power of 28 MW rather than 30 MW.
- Roof-mounted radiators due to sand and wind at the GCP.

The power plant includes 3 x 20V34DF and 1 x 9L34DF Wartsila gensets. The Wartsila power plant power output is listed in Table 9.1.

Table 9.1 Output of Proposed Wartsila Power Plant

Station output at generator terminals (HFO)	ISO conditions	Site conditions
Engines: 3 x 20V34DF +1 x 9L34DF	30,078 kWe	28,111 kWe

Detailed technical power plant specifications and general arrangement drawings are provided in Wartsila Proposal “Offer for Grande Côte Project in Senegal” October 2009 (Appendix 9.2).

9.4.5 Site Layout

The total land site area required for the power plant will be 158 m x 105 m, totaling 1.656 ha with building footprint of 0.168 ha. The total area required for the fuel farm will be 1,249m^2. The location of the power plant adjacent to the MSP site is shown in Figure 9.1. The layout of the power station is shown in Figure 9.2.

9.4.6 Delivery, Construction and Commissioning Schedule

The power plant will be built as a turnkey solution by Wartsila but the GCP will remain responsible for:

- Access roads.
- Basic site leveling and supply of laterite for final trim.
- Disposal of soil, construction materials, debris and sludge.
- Lubrication unloading pump unit (for used oil).
- DC system switchyard control system and outdoor switchyard.
- Start-up consumables, including water and electricity during construction.
- Earthworks and substructures and fencing for power transformer and switch yard areas.
- All site works (excluding pavements, roads, and parking, power plant surface covering with gravel, fencing around power plant, pavements, kerbs and rain water drainage).
- Taxes, duties, permits, insurance and remedial road works such as bridge reinforcement, construction of new roads outside site boundaries.

The equipment will be ready for hand over to GCO within 14 months after the starting date as defined by the Wartsila EPC offer.

9.4.7 Operation, Maintenance and Occupational Health and Safety

After construction and handover, the power plant will be owned and operated by GCO. Maintenance and manpower requirements (see Section 14) will be similar to the Sabodala operation. Occupational health and safety standards will be consistent with the Sabodala operation and are outlined in Section 10.

9.4.8 Environmental Compliance

The GCP power plant will comply with local and international environmental regulations for noise and air quality.

9.5 Fuel Specifications, Supply and Storage

Significant quantities of fuel will be required for the operation of the power station and processing drying facilities. The two types of liquid fuel and gas required at the GCP are described below.

9.5.1 Natural Gas

The power station will have dual-fuel capability and will be equipped to allow operation with HFO and natural gas. Natural gas is considered to be the preferred fuel for power generation at the GCP particularly given the potential benefits of carbon credits under CDM. Natural gas is available within 46 km of the plant site and is presently being used to fuel 12 MW of load using Agrekko hire gensets at a nearby cement works. Full natural gas conversion of the cement works existing 24 MW Wartsila power station is scheduled in the next 12 months.

An offer has been provided by natural gas company Fortesa, which on the basis of a five-year contract will:

1. Install 46 km 6" GAS pipeline and associated gas regulation/condensate equipment at no cost to the project to a nominated battery point adjacent to the proposed power station.
2. Supply like-for-like energy quantity natural gas at discount to Senegal Government published rates for 180 Cst HFO delivered to Diogo plant site.

9.5.2 Heavy Fuel Oil (HFO)

The other potential fuel, HFO, has proven to be successful at MDL’s Sabodala project and is 23% cheaper than diesel (gasoil) at current market rates (April 2010). Also, from a supply chain security point of view, HFO is the preferred liquid fuel as it has less “street value” as it cannot be used in standard transport vehicles.

The proposed fuel farm associated with HFO has a storage capacity of 1M litres of fuel, which is sufficient for two weeks supply if straight HFO is used for power generation. If required, additional storage capacity of 2M litres is available at the Port of Dakar for a nominal charge of 3 CFA/litre.

Delivery of HFO requires sufficient trucking capacity. GCO has a relationship with fuel supplier Shell for the Sabodala operation and Shell via its subcontractor Koury organised a new fleet of trucks as part of a five-year supply contract. The GCP is closer to the Dakar fuel depot and GCO anticipates the extension of existing supply contracts.

9.5.3 Gasoil

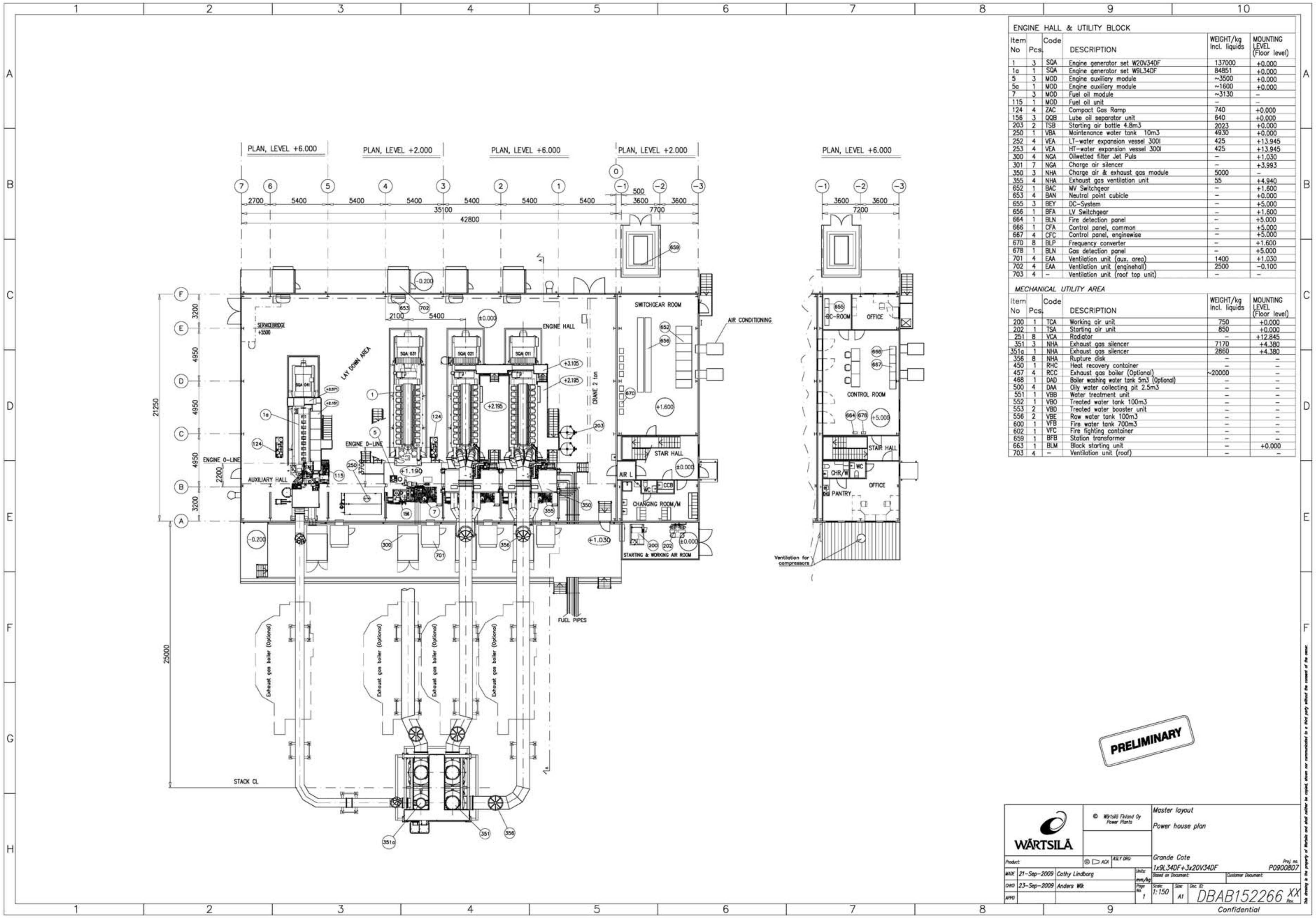
Gasoil is the equivalent of quality diesel and is suitable for use in motor vehicles and mobile plant. Gasoil is also required to fuel the burners on the zircon dry mill and the ilmenite plant heating equipment.

The power station incorporates a gasoil storage tank (100,000 litres). A metered gasoil fuel bowser will be installed at the power station for refueling of vehicles and mobile plant. Two gasoil pumps and the associated filters will be fed from nozzles on the gasoil tank. The pumps will supply the gas oil through a ring main to the dry mill rotary dryer, reheaters and ilmenite plant fluid bed dryer. The ring main will include a pressure relief valve which discharges through a recirculation line back to the gasoil storage tank.

Gasoil is readily available in Senegal at fixed prices and has an established distribution network. Gasoil will be delivered from Dakar by truck.

Fuel pricing and costs are discussed in Section 17.

Figure 9.2 General Arrangement of Power Station



ENGINE HALL & UTILITY BLOCK

Item No	Pcs.	Code	DESCRIPTION	WEIGHT/kg Incl. liquids	MOUNTING LEVEL (Floor level)
1	3	SQA	Engine generator set W20V34DF	137000	+0.000
1a	1	SQA	Engine generator set W9L34DF	84851	+0.000
5	3	MOD	Engine auxiliary module	~3500	+0.000
5a	1	MOD	Engine auxiliary module	~1600	+0.000
7	3	MOD	Fuel oil module	~3130	–
115	1	MOD	Fuel oil unit	–	–
124	4	ZAC	Compact Gas Ramp	740	+0.000
156	3	QQB	Lube oil separator unit	640	+0.000
203	2	TSB	Starting air bottle 4.8m3	2023	+0.000
250	1	VBA	Maintenance water tank 10m3	4930	+0.000
252	4	VEA	LT-water expansion vessel 300l	425	+13.945
253	4	VEA	HT-water expansion vessel 300l	425	+13.945
300	4	NGA	Oilwetted filter Jet Puls	–	+1.030
301	7	NGA	Charge air silencer	–	+3.993
350	3	NHA	Charge air & exhaust gas module	5000	–
355	4	NHA	Exhaust gas ventilation unit	55	+4.940
652	1	BAC	MV Switchgear	–	+1.600
653	4	BAN	Neutral point cubicle	–	+0.000
655	3	BEY	DC-System	–	+5.000
656	1	BFA	LV Switchgear	–	+1.600
664	1	BLN	Fire detection panel	–	+5.000
666	1	CFA	Control panel, common	–	+5.000
667	4	CFC	Control panel, enginewise	–	+5.000
670	8	BLP	Frequency converter	–	+1.600
678	1	BLN	Gas detection panel	–	+5.000
701	4	EAA	Ventilation unit (aux. area)	1400	+1.030
702	4	EAA	Ventilation unit (enginehall)	2500	−0.100
703	4	–	Ventilation unit (roof top unit)	–	–

MECHANICAL UTILITY AREA

Item No	Pcs.	Code	DESCRIPTION	WEIGHT/kg Incl. liquids	MOUNTING LEVEL (Floor level)
200	1	TCA	Working air unit	750	+0.000
202	1	TSA	Starting air unit	850	+0.000
251	8	VCA	Radiator	–	+12.845
351	3	NHA	Exhaust gas silencer	7170	+4.380
351a	1	NHA	Exhaust gas silencer	2860	+4.380
356	8	NHA	Rupture disk	–	–
450	1	RHC	Heat recovery container	–	–
457	4	RCC	Exhaust gas boiler (Optional)	~20000	–
468	1	DAD	Boiler washing water tank 5m3 (Optional)	–	–
500	4	DAA	Oily water collecting pit 2.5m3	–	–
551	1	VBB	Water treatment unit	–	–
552	1	VBO	Treated water tank 100m3	–	–
553	2	VBD	Treated water booster unit	–	–
556	2	VBE	Raw water tank 100m3	–	–
600	1	VFB	Fire water tank 700m3	–	–
602	1	VFC	Fire fighting container	–	–
659	1	BFB	Station transformer	–	–
663	1	BLM	Black starting unit	–	+0.000
703	4	–	Ventilation unit (roof)	–	–

9.6 Information and Communications Technology (ICT)

9.6.1 Background

An integrated and scalable ICT environment was built and deployed across all MDL sites, excluding the Diogo site, from June 2008 to June 2009. The GCP Exploration Camp ICT at Diogo currently includes:

- Very Small Aperture Terminal (VSAT) link provided by Connecteo with a 512 k up/1 MB down link serves data and voice traffic.
- A small number of personal computers (PCs), which use standard software packages and Datamine.
- A Voice over Internet Protocol (VoIP) compatible, Internet Protocol Private Branch telephone Exchange (IPBX). This telephone system is suitable for more than 200 users, is similar to that at Sabodala and caters for the evolving trends in voice and data communications.
- Mobile cell phone communications service provided by TIGO, the largest provider of mobile services in Senegal with coverage extending to Dakar.
- WAN services.

Radio communication services are not currently available; however, VHF radio will be used for local voice communication. LAN facilities will be implemented as part of the project development.

Accounting services are provided by GCO’s Dakar office at present and this will continue until the GCP is operational.

The existing infrastructure will provide the basis for an efficient and economic upgrade during development of the GCP. The key elements will be similar to those of Sabodala and will include:

- ICT and Local Area Network (LAN) infrastructure.
- Wide Area Network (WAN) infrastructure.
- Voice and data communications.
- Accounting and finance software.
- Specialist software requirements.
- Installation and on-site support.
- Security and backup processes.

A detailed assessment of the ICT requirements for the GCP is described in ICT Requirements and Implementation Plan prepared for MDL (Triggs, 2008).

9.6.2 ITC Infrastructure

An integrated approach to network architecture, file sharing, mail server synchronisation, security and authentication across the network will be used. The features of this infrastructure are described below.

9.6.2.1 System Architecture

As the specialist mining software applications will require large capacity and secure file services, three Microsoft Windows servers will be utilised, each with the following functions:

- Hosting the accounting, inventory and warehousing software (Classic) and Advantage databases.
- Providing file and print services, domain services, Internet Information Service (IIS), and POP mail for GCP users.
- Hosting IMS and SQL.

The LAN architecture at each of the major MDL sites including Grand Côte, Sabodala, Melbourne, Dakar and Europe (Figure 9.3) has similar core servers for domain management, file and print facilities. Mail and authentication services will be synchronised with other MDL sites to minimise bandwidth use.

9.6.2.2 Communication

Reliable and effective communications systems will be fundamental to the safe and efficient operation of the GCP, and therefore ITC will be integrated with MDL's global network (WAN), requiring new hardware equipment and expanded software licences.

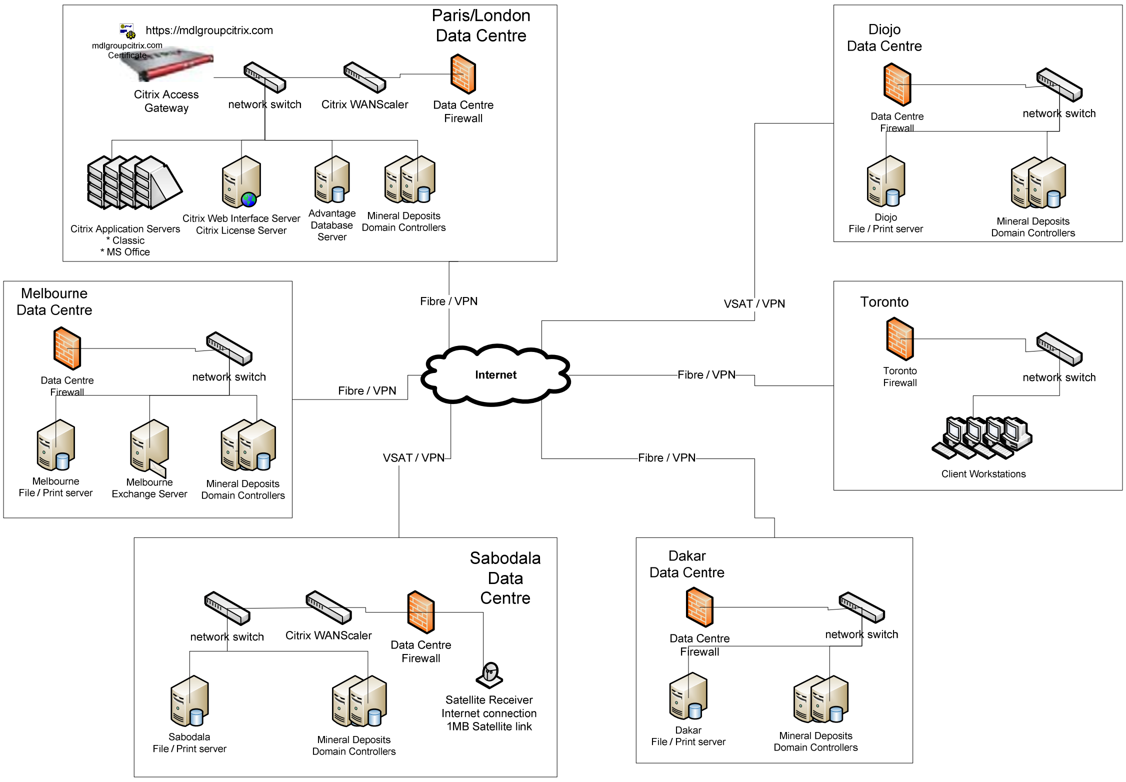
The exchange environment is currently located in Paris with users connecting to Outlook using https://mdlgroupmail.com. The WAN infrastructure will utilise the existing Virtual Private Network (VPN) technology shown in Figure 9.3. Fibre optic cable will be used throughout the site to support the WAN bandwidth using point to point REDLINE high speed wireless transmitters.

During development of the GCP and upgrade of the ICT, the current VSAT dish and associated hardware will be relocated from the exploration camp to the MSP site and bandwidth will be progressively increased to support users and data transfer demand.

The IPBX will have three external gateways:

- An ISDN service to the local Orange/Sonatel network.
- A Groupe Spécial Mobile (GSM) service which connects to TIGO's mobile phone cell at GCP.
- A VoIP and SMS for calls to Melbourne office.

Figure 9.3 WAN Architecture Utilising VPN over Internet



9.6.2.3 Physical Environment

Core server and communication equipment will be housed in a purpose-built clean and secured space within the administration block (Figure 9.1). All servers and desktops will comply with basic MDL standards set out as Standard Operating Environment (SOE) specifications.

Cabling will provide a solid backbone for high-speed LAN connections in and between administration and operational blocks where approximately 50 to 80 personal computers will each support Microsoft Office, Classic, Integrated Management Systems (IMS) and specialised mining software. A dedicated 1 mbps full duplex satellite service will be required to service approximately 50 Classic users. High-resolution screens, printers, plotters and printer display devices will be supplied.

Other communication devices such as switches, routers and interface equipment to satellite services will be located in special dust-free, cool and secured housing in the main office.

9.6.3 Software Applications

The GCP will use a number of specialised mining software applications, shown in Table 9.2 to meet the needs of:

- File and print services.

- Database services – SQL and MS Access.
- Web Services – internet information services.
- Specialised desktop configuration and maintenance (due to IMS).
- Remote and locate access for content management.
- Integration with MDL/GCO and the wider environment.
- Security.

Table 9.2 Software Requirements

Application	Function	Requirements
Classic Information Systems	Accounting and finance, supply and stores, maintenance and payroll.	File and database services backup and security.
Integrated Management System (IMS)	Integrated management system for processes and procedures relating to health, safety and overall mine management.	File and database services, client software, security, backup and intranet and internet publishing. SQL Server, MS Access client. ODBC driver management and other specific desktop maintenance. Remote and local access for content management.
Data Site Enterprise	Publishing of internal processes and procedures.	As above plus Internet Information Services (IIS) to publish the content across the intranet and internet.
Datamine	Management and display of exploration and mining data, mine planning, pit optimisation and scheduling.	File and database services backup and security. MS Access/SQL. High-resolution screen and printer display devices. High-end workstations and licence management.
MineMax	Detailed short-term planning and logistics.	File and database services backup and security.
DataShed	Management of mining and exploration geological data.	File and database services backup and security. SQL Server.
Metallurgical Accounting	Reconciles product grades and values from mine to market.	File and database services backup and security. Desktop maintenance.
Key System	Manages physical security issues.	File and database services backup and security. Desktop maintenance.
Site Administration	Flight and accommodation management.	File and database services backup and security. Desktop maintenance.
Igantt	Short-term task scheduler.	Network connection to Datamine. Desktop maintenance.
MapInfo and Discover	Geographic Information. System (GIS) and mapping.	File and database services backup and security. High-end desktops maintenance. Licence management. High-end graphical screens and printers.

9.6.4 Classic Information Systems

The GCP will use MDL's established Classic Information Systems (Classic) for accounting, finance, supply, maintenance, flight and accommodation management and payroll administration which allows access by all MDL sites at all times.

The software architecture of Classic is shown in Figure 9.4. It is estimated that approximately fifty users will require access to Classic at the GCP, shown in Table 9.3.

Figure 9.4 The Classic Information System Architecture

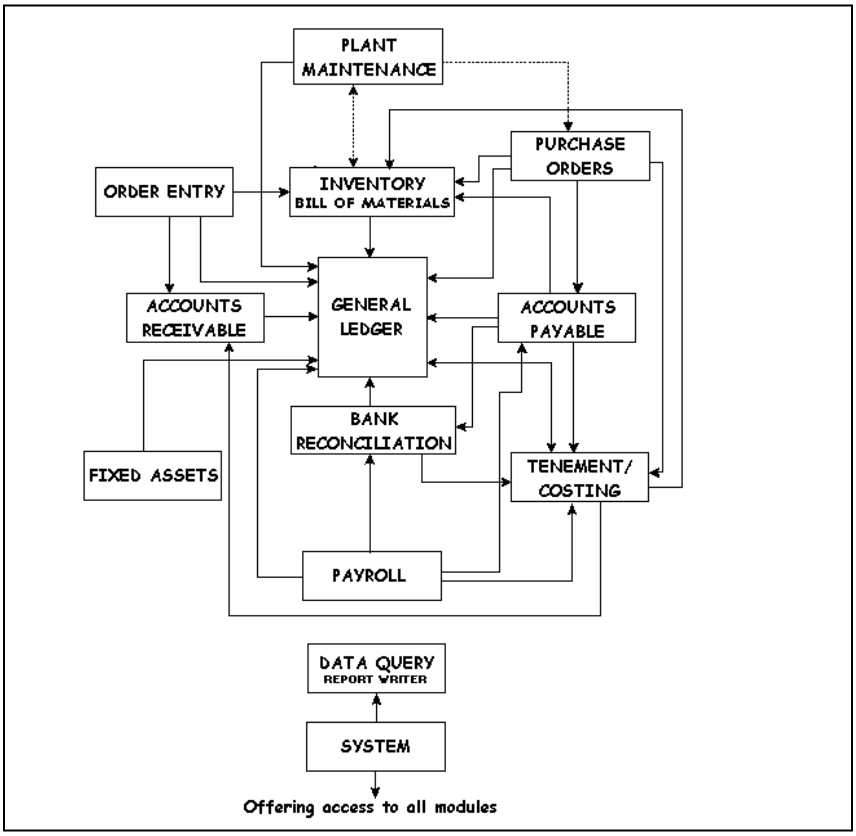


Table 9.3 Estimated GCP Site Classic User Demand

Site	Group	Estimated Users
GCP	Warehouse and purchasing	7
	Accountants	6
	Heads of Departments	10
	Maintenance	27
	Total	**50**

9.6.4.1 Integrated Management System (IMS)

IMS is a suite of software modules supplied from Think Visual Pty Ltd in Perth which enable users to develop customised data management and reporting that can be maintained and published over the Company's intranet.

The modules to be used at the GCP include:

- SecureBase - security management and reporting.
- MediTrac - clinical management and reporting.
- TrainBase - training and development/succession planning management and reporting.
- SafetyBase - incident and accident management and reporting.
- Site Manager - flight and accommodation management.

9.6.4.2 Data Site Enterprise

This product integrates closely with IMS, using IIS to publish Adobe PDF files. The content is developed by GCP staff.

9.6.4.3 Datamine

Datamine is a mine planning system used for the management and display of exploration and mining data, mine planning, pit optimisation and scheduling. It is currently running on some personal computers at the GCP Exploration Camp with dongle licence protection. Datamine generates large data sets to inform mine design, optimal material movement and general economic efficiencies.

9.6.4.4 DataShed

The GCP will use DataShed on desktop personal computers for management of mining and exploration geological data, using the underlying MS Access database engine. There are plans, however, to migrate the underlying database engine to SQL.

9.6.4.5 Metallurgical Accounting

This software provides a mechanism for reconciling all product grades from mine through wet and dry mills to market. The data produced is of high value as it assists in estimating the value of the saleable product/s in the mine.

9.6.4.6 Key System

Key System is a security software system for protection of the network and data storage.

9.6.4.7 MapInfo and Discover

MapInfo is Geographic Information System (GIS) with tailored options for mining and exploration. Spatial environmental and social information will be stored in MapInfo. Discovery is a MapInfo plug-in which allows the publishing of MapInfo maps to a web server.

9.6.5 ITC Installation and Support

GCO's current ITC Managed Services Providers E-Qual will be responsible for the overall network design and the implementation and management of the ICT Services for the GCP. The existing GCP infrastructure would be upgraded over a six month period in line with increasing demand during development of the GCP.

The in-house support requirements will change as the company's ICT architecture and infrastructure evolves but will include the following ITC management functions:

- Alignment of business processes and the deployment and use of information technologies.
- Management of the information systems plan.
- Management of the ITC budget.
- Management and service delivery of major suppliers.
- Processing of invoices from the major suppliers.
- Renegotiation of annual agreements and support contracts.
- Systems and technology standards, policies to support the business.
- Specification and project management of new and refresh technology initiatives.

The GCP intends a "zero touch" approach for maintenance and support, with issues directed to service providers. However, ICT support roles will be required in the remote logistical environment of the GCP. As such, GCO will employ one site ICT technician who will perform the following duties:

- Provide support to GCO staff in person, over the phone or via email and solve their computing problems in a timely manner.
- Monitor ICT equipment at the mine site for errors or stoppages and take remedial action.
- Troubleshoot difficult or unusual situations and, with the approval of the Line Manager, engage external parties to assist with problem resolution.
- Undertake backup and recovery activities and assume responsibility for the secure backup of the company's data at GCP. This includes making arrangements for offsite secure backup and retrieval services.
- Perform routine maintenance and cleaning of equipment.

- Install, configure and maintain network equipment and network operating systems at GCO and liaise with network service providers for assistance with maintenance, and fault resolution.
- Verify accounts from service providers that relate to the GCP.
- Implement and coordinate housekeeping procedures, including user accounts, file and network security.
- Ensure that system access control systems and security levels at GCP are maintained and that the security policies satisfy the requirements of senior management.
- Maintain peripheral devices throughout the mine site such as printers and scanners.
- Document and review processes and procedures for GCP users.
- Attend relevant product and skill courses.
- Provide assistance to other ICT personnel as directed by the line manager.

In addition, a suitably qualified onsite ICT support person will attend to general physical maintenance.

9.6.6 System Security and Backup Processes

Virus and malware security will be managed by Trend Micro Office Scan using a client server model with MDLGCTDC01 acting as the host and a strict firewall will control all packets, in and out.

Backup processes will be established and implemented for the servers and desktops and sufficient spare parts will be stocked to avoid risk of lengthy system downtime. Full data backup will occur nightly on a 2 SET, maintained on rolling basis, with secondary 3 SET monthly backups.

Uninterrupted power supply (UPS) units will be will be used to manage power failure and keep core equipment running long enough to enable controlled shutdowns.

9.7 Transport and Logistics

9.7.1 Transport and Logistics Considerations

In developing the GCP transport and logistics strategy, a number of issues have been considered. These are described below.

9.7.1.1 Location

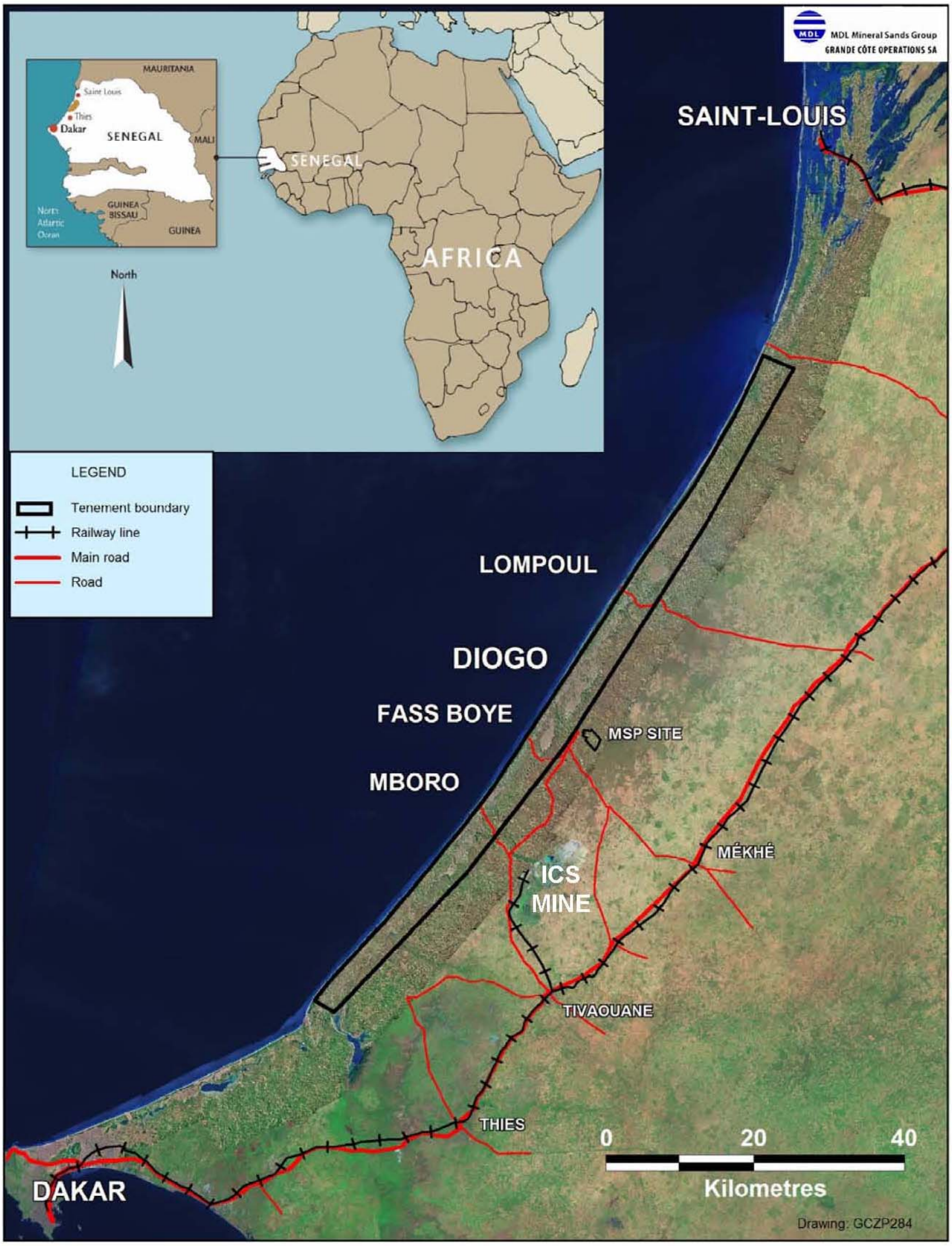
The southern boundary of the GCP is located about 50 km north-east of Dakar and extends more than 100 km north along the coast of Senegal. The GCP MSP is located near Diogo village, approximately midway along the mining lease. The MSP has ready access to nearby infrastructure including major highways, roads, railways and the Port of Dakar (Figure 9.5).

The nearby town of Mboro, 25 km south, is adjacent to the Industrie Chemique Senegal (ICS) phosphate mine, which has a railhead. The main highway between Dakar and Saint Louis to the north is located 20 km east of the MSP.

Ilmenite will be transported in bulk by road to the ICS rail spur whereby it will be loaded into GCO trains using a mobile train-loader and then railed to the Port of Dakar. Zircon, rutile and leucoxene will be transported in shipping containers by road to the Port of Dakar. The port is ideally situated for the shipment of GCP product to nearby markets, particularly Europe and North America.

Of the 125 km of road from the MSP to the Port of Dakar, 25 km is unsealed. However, government funding is in place and work is presently well underway to repair and seal the remaining portion of the road during the first half of 2010.

Figure 9.5 Project Area Road and Rail Infrastructure



9.7.1.2 Transport Scope

Transport will be provided for:

- Plant construction materials and equipment to the mine, MSP and the power station.
- Fuel for the power station and product drying.
- Operating supplies and maintenance components.
- Sales products from the GCP for container shipment and bulk shipment for export.

Table 9.4 illustrates the anticipated breakdown of freight.

Table 9.4 Anticipated Breakdown of Freight for the GCP

Description	Construction	Operations
Mine and MSP	600 x 40' containers; 3,200 t of break bulk items	
Power station	160 x 40' containers; 4 x 110 t engines	
General freight	120-150 containers p.a. est	120–150 containers p.a. est
Fuel (HFO)		26,000 tpa
Gasoil	4,000 tpa	4,000 tpa
Zircon, rutile and leucoxene sales in containers		95,000 tpa
Ilmenite sales in bulk		600,000 tpa

9.7.1.3 Logistics Resources

Until the completion of the construction phase of the Sabodala project, MDL had a logistics team based in Dakar, which handled all of the purchase orders for Sabodala using local staff. This approach was very successful and will be adopted for the GCP.

Dakar is the main West African base for two well-equipped, international freight logistics companies, SDV Senegal and DAMCO Senegal. MDL has successfully used both of these companies during the Sabodala construction.

The Dakar port is currently being expanded, supported by the streamlining of customs administration in Senegal, which reduces time and costs and aspires to a paperless system over the next two and a half years. The electronic connection of pre-clearance (ORBUS) and clearance (GAINDE) systems with the international ports in Europe, Asia and East Africa will enable Senegal's Customs Administration and Port Authority to achieve 24-hour operations by late 2010. Currently MDL clears container freight and break bulk cargo through the port in three to five days.

Airfreight is available through numerous providers, including DHL, and has been used successfully for the Sabodala operation from Australia, South Africa, the US and Belgium.

9.7.1.4 Construction Transport

The EPCM contractor will coordinate construction transport from Senegal. The freight forwarder will utilise one or a combination of the many established Dakar logistics companies to handle road freight from Port to the GCP. System management and tracking will be in place and road survey conducted to identify hazards for “over-dimension” loads.

The EPCM contractor will conduct a detailed transport and logistics study for project construction items, to ensure the timely low-cost delivery of equipment and materials to site. An allowance for this study is included in the capital estimate.

The turnkey power plant will require a heavy-lift ship, with all freight and logistics the responsibility of the provider.

9.7.1.5 Process Materials and Operating Supplies Transport

Fuels (HFO, gasoil) are the most significant operating consumables required to support the power plant, mineral dryers and road vehicles. If natural gas is not available, the fuel provider will be required to deliver 30,000 tpa of HFO by road tanker from Dakar, equivalent to nominally 85 t/day. Gasoil will also be delivered in tankers by road from Dakar.

9.7.1.6 Sales Product Transport

Zircon, rutile and leucoxene will be transported in 20' (6 m) shipping containers with a nominal 20 t payload. These will be transported by road to the Port of Dakar for export. A container handler facility for loading and unloading is to be constructed at the MSP.

The ilmenite transport route to the Port of Dakar will be:

- By road to the Industrie Chemique Senegal (ICS) railhead.
- Then by rail via the ICS owned rail spur to Tivouane.
- Continuing on the ICS concession track from Tivouane to Thies.
- Then on the Transrail concession track to Dakar.

The total road and rail haul length is approximately 130 km.

A detailed rail logistics study was conducted by Sandwell in 2010 (Appendix 9.3).

9.7.2 Road Infrastructure

The MSP is located about 125 km by road from Dakar, via Tivouane and Thies (Figure 9.5).

A new purpose-built road will be established and extended from the mining areas to the MSP. This road will be used for the delivery of supplies and personnel to the mine, and to access the services (power and pipelines) running between the MSP and the mining operation.

A 25 km haul road will be constructed from the MSP to the ICS railhead for haulage of bulk ilmenite. GCO will subcontract the trucking of the bulk ilmenite.

9.7.3 Road Operations

Service offers for road transport have been received from two of the largest freight companies in Dakar. The offers include:

- Dedicated logistics management and export clearance team.
- Continuous replenishment of empty, cleaned containers.
- Dedicated truck fleet for six day per week feed to the port.
- Responsibility for accommodating logistics personnel.
- Container handling and holding storage at or adjacent to the port.
- Export formalities and documentation including container sealing and tracking.

Separate to these offers, a further offer has been received for:

- Dedicated truck fleet for transport of bulk ilmenite to the ICS rail spur.

9.7.4 Rail Infrastructure

The existing rail infrastructure consists of the following sections:

- ICS private 18 km (single track) rail spur from the load-out facility at the Darou plant site to Tivouane. The track structure is in good condition and is shown in Figure 9.6.
- 22 km of rail track (single track) between Tivouane and Thies. This section was solely for the use of ICS as it is a concession held by ICS and the track is in good condition. The track is maintained by Transrail under a contract agreement with ICS (Figure 9.7).
- 65 km of rail track (double track) from Thies to the Port of Dakar. This section of track is part of the Transrail concession for the 1,200 km rail line between the port of Dakar and the Mali capital of Bamako.

GCO has received a running rights offer from Transrail for access to the entire rail section from the ICS railhead to the Port of Dakar. Transrail would pay, on GCO’s behalf, all running rights costs to ICS for their portions of the rail. The offer includes provision of dedicated locomotives for bulk freight with wagons provided by GCO. The operating cost estimate is based on the Transrail running rights offer.

Figure 9.6 Track Condition on the ICS Spur Line

Figure 9.7 Track Condition between Tivouane and Thies

Despite the condition of sections of the Thies to Dakar rail line, the line carries over 550,000 t of containerised freight each year to Mali.

9.7.4.1 Loading at the ICS Railhead

Covered storage and a mobile train loader will be installed at the ICS railhead. An estimate for these facilities is included in the Sandwell report (Appendix 9.3).

9.7.4.2 Railway Operations

The railway design parameters are shown in Table 9.5.

Table 9.5 Railway Design Parameters

Item	Specification
Railway gauge	1.00 m
Axle loads	17 t per axle
Maximum speed on new track	50 km/h
Maximum gradient	1.25% (1 in 80)
Maximum locomotive gross weight	102 t
Maximum wagon gross weight	68 t

Key project issues associated with railway operations are:

- Integration of the ilmenite trains with existing freight and passenger train schedules.
- Bulk materials handling at the Port of Dakar.

For the GCP rail operations it is assumed that:

- The average track speed will be 20 km/h, based on the track condition and existing operating performance.
- Local passenger trains running between Thies and Dakar block all other traffic between 6.00 am and 10.50 am and between 4.30 pm and 8.00 pm daily except Sunday. This will impose fairly rigid daily times for loading and offloading at the ICS facility and the Port of Dakar. Rail scheduling studies by both Sandwell and Transrail indicate that GCP train traffic can be accommodated within the current rail system timetable.
- The total cycle time will be 21 hours, including loading and unloading times.
- GCO will use the communication systems employed by ICS and Transrail.

GCO is at present in negotiation with ICS for rail access in line with the Transrail offer and use of the existing ICS port load-out facilities and port concession. In both cases verbal approval has been given and a detailed formal offer from ICS is anticipated in late 2010.

The capital costs for the rail operation are shown in Section 16 and the operating costs in Section 17.

9.7.4.3 Locomotives and Wagons

Wagons will be purchased by GCO and running rights for their operation on tracks held as concessions by ICS and Transrail are essentially in place. Locomotives will be provided by Transrail as part of the running rights offer. Bottom dump wagons with a capacity of 43 t and a gross rail load of 62 t will be utilised.

Based on the equipment selection above and a maximum annual production of 600,000 t of ilmenite, it is estimated that two train sets of 22 ilmenite hopper wagons, each with one locomotive, achieving one complete cycle per day would meet traffic requirements. Total rail equipment requirements are estimated at two locomotives and 44 ilmenite hoppers, including spares.

9.7.5 Port and Harbour Facilities

9.7.5.1 Port of Dakar

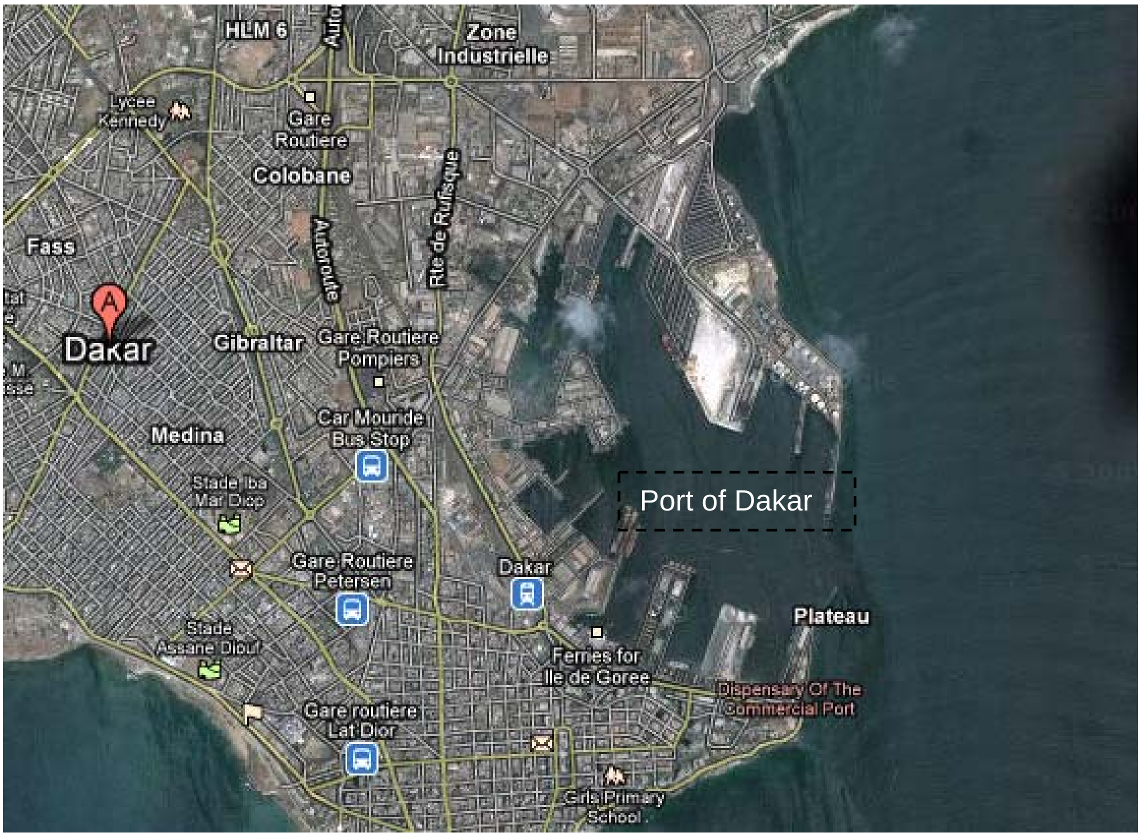
The Port of Dakar has a long history as a major trading port for Senegal and land-locked countries such as Mali and Burkina Faso. It is the largest and most efficient port in West Africa (Figure 9.8). Access to this deep-water port is through a 250 m-wide channel dredged to 11 m depth. Protected by the Island of Goree, the channel is open 24 hours a day and tidal variation at the Port of Dakar is about 1.2 m.

The port has a well-established container terminal and capability to receive major bulk shipments and tankers. Exports currently include phosphoric acid, phosphate, fertilisers, attapulgite, salt and cotton.

The Port of Dakar has two separate zones. The northern zone contains Piers 4, 5, 8, 10, the container terminal and the oil wharfs. The southern zone contains Piers 1, 2, and 3. The piers in the Port of Dakar’s northern zone have depths from 9 m to 10 m, and they specialise in containers, solid bulk, and liquid bulk cargoes. The zone covers almost 76 ha of area, of which 34 ha is dedicated for the container terminal.

The Port of Dakar’s southern zone piers have depths from 8.5 m to 10 m. The southern zone handles general cargo, about 20% of the container traffic, passengers, and vehicles. The southern zone covers about 22.9 ha.

Figure 9.8 Port of Dakar



The Port of Dakar contains 112,500 m^2 of open surface storage, 48,800 m^2 of covered storage space, and 15,000 m^2 of cold stores. In addition, it has 13 ha of surface for storing containers, and capacity to store 290,000 m^3 of hydrocarbons. A total of 300,000 containers of freight was handled through the Port in 2007.

MDL successfully unloaded 800 containers, a 26-piece mobile mining fleet and six 110 tonne engines during the construction phase for the Sabodala mine.

In October 2007, Dubai Ports Worldwide signed a 25-year concession with Port Autonome de Dakar to develop and operate the container terminal. This included a two-stage expansion plan commencing with a plan to duplicate existing facilities by late 2010 (currently nearing completion) with a second stage expansion plan after that to make Dakar the major shipping centre for the region.

In summary, the existing Port of Dakar has the capability of loading all of the shipments required for GCO both during construction and when the mine is in operation.

9.7.5.2 Product Storage and Loading Facilities

GCO products of zircon, rutile and leucoxene will be exported through the Port of Dakar as “bulk in container” utilising general-purpose shipping containers. The Port of Dakar has ample capacity to handle the additional shipping containers from the GCP.

Ilmenite will be transported by road and rail to the Port of Dakar and shipped in bulk. New dedicated facilities will be constructed at the Port of Dakar for unloading bulk ilmenite from trains, for ilmenite storage and for loading ships. The train unloading and ship loading facilities will be based on modular materials handling equipment.

These facilities will be located on a vacant pier at the southern zone of the port. The area is approximately 310 m long x 160 m wide. The infrastructure required at this location would be:

- Approximately 800 m of new track for unloading purposes.
- A shed with a rail wagon dumper.
- A shed with capacity for a 50,000 t stockpile.
- A mobile ship stacker (see Figure 9.9).

Figure 9.9 Mobile Ship Stacker

As an alternative, but unbudgeted option, the existing unused ICS load-out and storage facilities could be refurbished and used by GCO. Negotiations with ICS for the sublease of these facilities are in progress.

9.7.5.3 Product Shipping Logistics

The key markets for the Grande Côte products are Europe and North America, with Dakar ideally located on the most westerly point of Africa to conveniently service these markets (Figure 9.10).

Figure 9.10 Proximity of Senegal to European and American Market

Note: Dots illustrate ports that ship mineral sands products.

These markets are serviced by frequent container services from Dakar, with shipments every seven to 10 days to Europe and every seven to 14 days to North America. Voyage times from Senegal, Australia and South Africa to these markets are shown in Table 9.6.

Table 9.6 Shipment Voyage Times to Markets (Days)

	From Senegal/ Grande Côte	From Australia (East and West Coast plus Murray Basin)	From South Africa (East and West Coast)
To Europe/Mediterranean	6–10	38–50	21–27
To Western Europe	10–13	31–34	25–29
To North America	15–19	38–47	28–35

A detailed discussion of the proximity benefits of the GCP is described in Section 3.

9.7.5.4 Shipping of Equipment and Material during Construction

For the shipping of equipment and materials during construction a combination of vessels will be used. They include:

- Container ships for container-based freight.
- Chartered ships for over-gauge materials.
- A heavy-lift ship for the dredge pump, gearbox and main dredge structure components.

The detailed shipping logistics will be determined as part of the EPCM contractor's scope of work. A key learning from the Sabodala project will be the basing of all logistics management in country using a mixture of expatriate and Senegalese staff.

9.7.5.5 Unloading and Storage Facilities during Construction and Operations

Dakar port container handling facilities will be used for unloading of container-based freight. Over-gauge materials and the power station engines will be unloaded with appropriate cranes. Wherever possible, freight will transported directly by road to site. Where this is not possible, freight will be temporarily stored in the freight operator's lay-down facilities at Dakar port.

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SECTION 10

Health and Safety

AMC CONSULTANTS

Copy 16

CONTENTS

TABLES

FIGURES

10 HEALTH AND SAFETY

10.1 Introduction

The MDL policies - MDL Corporate Code of Ethics and MDL Sustainability Policy Statement - display the company commitment to health and safety and its attitude to implementing strategies to provide a safe workplace. MDL states that the company will comply with the relevant legislation and regulations, implement best practice options, identify employee training needs and promote a culture of personal responsibility for safety.

MDL is committed to developing an integrated management system (IMS) which incorporates health and safety. MDL via its existing operation at Sabodala complies with all appropriate Senegalese and international standards and has established the systems detailed in this section previously at Sabodala.

The implementation of these occupational health and safety standards resulted in the Sabodala project 12 monthly moving average frequency rates during construction and operations shown in Table 10.1.

Table 10.1 Frequency Rates for Sabodala Construction and Operation

Item	30-Apr-09	30-Apr-10
Lost-time injuries	0.29	0.04
Medically treated injuries	1.12	0.54
First aid treatments	6.83	5.25

The safety statistics for the same periods are shown in Table 10.2.

Table 10.2 Safety Statistics

Item	Construction May 2008 to April 2009	Operations March 2009 to April 2010
Hours worked	5,431,369	2,331,641
Lost-time injuries	7	2
Medically treated injuries	28	6
First aid treatments	204	55
Incidents (property, damage, fire and near misses)	133	282
High-potential incidents	7	7

10.2 Statutory Requirements

GCO intends to comply with all relevant Acts and their supporting Regulations and codes of practice as a minimum standard for the operation. This includes the Senegal Mine Safety Code 2003 (Law No2003-36).

In addition, the GCO IMS will incorporate the following safety standards:

- AS/NZS 4801 (2001) Occupational Health and Safety Management Systems - Specification with Guidance for use.
- AS/NZS 4360 (2004) Risk Management.

10.3 Health and Safety Strategy

GCO's strategy for health and safety management will be based on thorough identification of hazards, assessment and control of risks through:

- High engineering and maintenance standards.
- Line management ownership and responsibility for health and safety performance.
- An organisational structure that provides sufficient resources with the required competencies to manage health and safety issues.
- Clear, documented health and safety expectations and objectives for line managers and employees.
- Programs to help people anticipate potential injuries and incidents and to encourage personal action to minimise risks.
- Documentation of safe systems of work in procedures and operating instructions.

The company's strategy will be a balanced application of people, plant and procedural measures to improve health and safety performance and manage the health and safety risks arising from:

- Plant and equipment in the workplace.
- Chemicals and other materials in the workplace.
- The way activities are performed (behaviour).

10.4 Health and Safety Policy

MDL has developed an OHS Policy that has the objective "to provide a safe workplace that enables our people to efficiently carry out their work without injury to themselves or others".

In addition, to achieve MDL's objective GCO will:

- Maintain full compliance with relevant legislation, regulations, codes of practice and standards.
- Set and monitor measurable OHS objectives and targets.
- Provide effective safety induction and training for all employees.
- Establish and insist upon safe work methods and safe practice at all times.
- Provide safe and well maintained equipment fit for purpose.
- Establish mechanisms to ensure effective OHS consultation and communication.

- Maintain and implement procedures to ensure an ongoing program to identify, evaluate and control workplace hazards.
- Implement an OHS audit program involving personnel from all levels.
- Implement incident investigation and OHS reporting procedures to ensure prompt corrective and preventive action.
- Promote a culture of personal responsibility for safety.
- Work together to eliminate all injury.
- Be committed to continuous improvement for all aspects of the operation with consideration given to community expectations and current industry standards.

10.5 OHS Philosophy

GCO's objective is to have the Occupational Health and Safety Management Plan (OHSMP) implemented in an environment of continuous improvement through routine review and revision within a quality system structure. The OHS information within this system will be readily available to all operations personnel.

All work associated with the operation will be guided by Australian Standards. The achievement of operations safety standards will not be compromised by conflicting production, cost or quality objectives.

Consistent with this philosophy, GCO and contractors will make every effort, so far as is reasonably practicable to:

- Provide and maintain systems of operation to ensure safe working conditions.
- Develop a culture within the organisation where good safety performance is seen as a valuable and fundamental principle of business.
- Provide all necessary protective equipment, both personal and mechanical, which is regarded as appropriate to ensure safety and health.
- Ensure buildings, plant, equipment and work areas on the site are in a safe working condition.
- Ensure the correct medical, first aid services and rescue equipment as deemed necessary is available on the site.
- Inform employees and contractors in the methods used to work without risk to their safety and health or that of others in immediate vicinity, and ensuring that they comply with all relevant safety legislation.
- Establish workplace safety representatives and committees.
- Comply with relevant safety legislation.
- Arrange for purchasing, safe use, handling and storage of hazardous substances.
- Establish, implement and monitor safety awareness programs regularly to ensure goals are achieved and target an incident-free working environment.
- Investigate all incidents which cause or have the potential to cause personal injury or damage to plant, buildings and equipment.

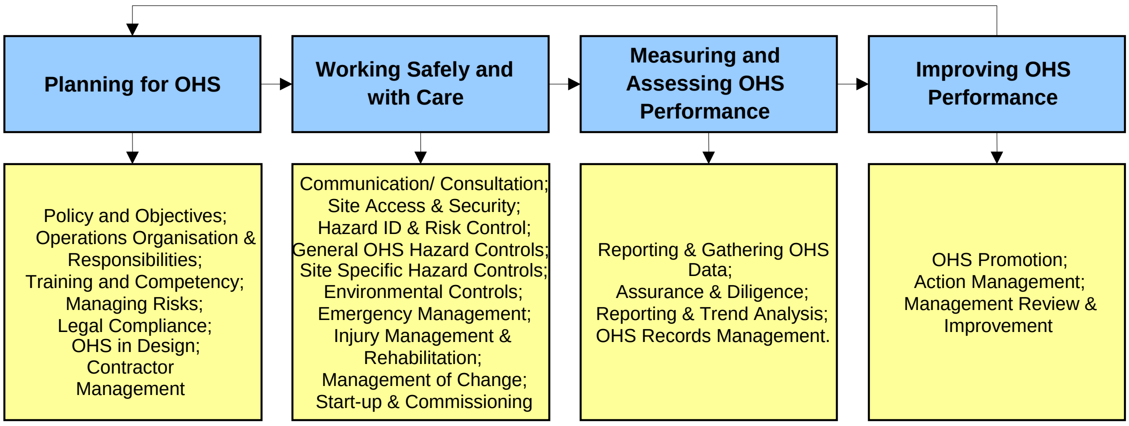
Management's commitment to safety will be active and visible at all levels. All operation participants, including the management team and contractors' personnel will be encouraged to maintain ownership of safety through participation in the management processes.

Through suitable planning and risk management, GCO will aim to eliminate any foreseeable hazards which could result in accidental loss or impacts to the environment. In addition, management and line supervision will have the responsibility to achieve and maintain a well-informed and motivated work force who will effectively contribute to the overall success of the OHS program.

It is recognised that one of the key aspects of successful OHS management is to ensure that operations management and supervision understand OHS expectations and the critical risk controls that must be in place to avoid incidents. The assurance and diligence programs, such as OHS inspection protocols, behaviour observations, personal contacts and system audits will be designed accordingly.

The OHSMP structure is shown in Figure 10.1.

Figure 10.1 MDL OHSMP Structure



10.6 Occupational Health and Safety Management Plan

An OHSMP will be developed for GCO to address all operational OHS aspects and identify the OHS controls necessary to achieve the desired outcomes and specify how these controls are to be applied. The OHSMP will be structured to be consistent with the requirements of ISO 14001 and AS/NZS 4801.

The OHSMP will strive to achieve completion of the operations with zero recordable incidents.

The operations objective will be to protect the health and wellbeing of personnel during operations activities and ensure that OHS is the prime consideration in operations execution. Targets will be set to achieve:

- Zero recordable injuries - zero fatalities; zero lost-time injuries; zero restricted work and zero medical treatment injury cases.
- Zero property damage incidents.
- Zero chemical or hydrocarbon spills to water or land.
- Zero proven complaints from neighbours.
- Zero high-risk potential incidents.

10.7 GCO OHS Core Responsibilities

At GCO, all personnel will be responsible for ensuring that they fulfill their health and safety responsibilities through actively participating in the prescribed activities for their position. The OHS responsibilities of key personnel for the operations are identified below:

- General Manager
  - Responsible for ensuring the development and effective implementation of GCO's OHSMP, including the provision of adequate resources to give effect to obligations imposed by the OHSMP.
  - Monitor and audit compliance with the OHSMP.
  - Responsible for achievement of the GCO's OHS targets.
  - Ensure timely action is taken to mitigate OHS risks.
  - Show visible support for, and commitment to, OHS by participating in various OHS management activities.
  - Inspire and motivate GCO team members to achieve excellent OHS performance.
- Mining and MSP superintendents
  - Responsible for the on-site implementation of the GCO's OHSMP, including the provision of adequate resources to give effect to obligations imposed by the OHSMP.
  - Responsible for achievement of the GCO's OHS targets.
  - Ensure timely action is taken to mitigate OHS risks.
  - Show visible support for and commitment to OHS by participating in various OHS management activities.
  - Inspire and motivate GCO team members to achieve excellent OHS performance.
- Mining and MSP team leaders
  - Responsible for ensuring that appropriate OHS requirements are included in all aspects of the design process.
  - Ensure designs comply with all applicable legislative requirements.
  - Ensure OHS considerations are a mandatory component of design reviews.

- Administration superintendent
  - Responsible for ensuring that appropriate OHS requirements form part of purchasing documentation and that all suppliers comply with these requirements.
  - Responsible for ensuring that appropriate OHS requirements, including the OHSMP, form part of all tender and contract documentation and that all business partners comply with these requirements.
- OHS leader
  - Responsible for overseeing implementation of the GCO's OHSMP and managing the OHS Action Plan.
  - Provide advice to GCO team managers to support the implementation of the OHSMP to meet the OHS objectives of the operations.
  - Responsible for periodic audit of the OHSMP.
  - Responsible for function and maintenance of IMS.
  - Responsible for inspecting and auditing activities to ensure compliance with the GCO's OHSMP.
  - Responsible for the collection and management of safety statistics and records as required by the GCO's OHSMP.
  - Provide OHS advice and support to GCO line management.
- Line supervisors
  - Responsible for ensuring all GCO work is carried out in accordance with established procedures and work practices.
  - Responsible for leading work team safety activities, such as toolbox talks, safety meetings, inspections, job safety analyses and other risk reviews.
- GCO OHS Committee

The GCO OHS Committee will be a management committee comprising the GCO general manager, mining superintendent, security leader, environment superintendent, administration superintendent, OHS superintendent and safety advisers. The committee will be responsible for:

  - Review of the implementation of the OHSMP.
  - Monitoring performance against the plan targets and performance standards.
  - Review and status update of all incidents and corrective actions.

- Elected OHS representatives (from each functional department)
  - Responsible for representing the work team in OHS matters and supporting supervisors and team leaders with respect to OHS in the workplace.

- Contractors

Contractors working on the operations shall be:

  - Responsible for compliance with the requirements of GCO's OHSMP.
  - Responsible for the OHS performance of their own employees and subcontractors.

10.8 Managing OHS Risks

Throughout the duration of the operation, suitable hazard identification techniques will be used. The hazards and risks identified from these techniques will be managed by thoroughly assessing each hazard and the implementation of agreed control measures.

A risk management plan will be formulated for each development phase of the operation. The risk management plan will aim at early identification and management of OHS risks.

In accordance with a proactive approach to OHS, management techniques will be adopted so that potential hazards are identified and evaluated prior to execution, thereby enabling either substitution or adoption of control techniques. These hazards may be identified at any stage of the operations, for example in GCO data, existing drawings, site survey investigations, design stage and constructability reviews, mine development or emerge during construction or commissioning phases associated with any major project.

Once potential hazards are identified, the risk to health and safety must be assessed. The assessment shall characterise the risk in terms of severity and probability.

The risk management plan will include the following as required:

- Risk assessment using a formal process which includes:
  - Development of a safety risk profile for the work.
  - Identification of critical risk controls and competencies required to manage the risk.
  - Implementation of controls.
  - Monitoring of performance.
- Job safety environment analysis (JSEA) will be used by all site personnel for identifying hazards and developing management strategies.
- A personal hazard identification tool (low-level mental JSEA) will be introduced to enhance individual hazard awareness of all personnel. This level applies the hazard management approach to routine activities.
- Hierarchy of risk control: following the risk assessment process, personnel shall determine control measures for the hazard by following the hierarchy of control (elimination, substitution, engineering controls, administrative or personal protective equipment (PPE).

10.8.1 Operations OHS Risk Register

An OHS risk register will be developed for GCO. The GCO OHS risk register will be a live document that describes the nature of the OHS risk exposures. The risk register will be updated as a result of hazards identified during the course of the operations and prior to any major project.

10.9 OHS Standards and Procedures

GCO will develop site-specific standards and procedures for its operations. The standards and procedures will include:

- Traffic management plan.
- Activity procedures.
- Material procedures.
- Equipment procedures.
- Fit for work policy.

10.10 Training and Competency

All staff working at GCO shall be competent in the safe performance of their work. GCO will ensure all personnel employed on the operation have adequate work experience in the task for which they are employed to do and, where required, shall hold the appropriate qualifications and competencies for the position.

Employees of contractors must be suitably qualified and be able to produce evidence of certification prior to mobilisation.

A training matrix will be developed for all positions and the training needs identified. Training of employees will be ongoing and identified according to the operation's needs. This training may include:

- Supervisor Training.
- Health and Safety Representative Training.
- Job Safety Environment Analysis Training.
- Incident Recording System Training.
- Specific Safety Training, such as Confined Spaces; Hazardous Substances; Working at Height.

10.10.1 Site Induction

All personnel intending to work on-site at GCO will attend the GCO general site induction prior to the commencement of any work activity.

10.11 Emergency Response Team

An emergency response team (ERT) will be maintained on site. The ERT organisational structure, equipment, and training will be based on the types of emergency likely to be encountered on site. The team will have a clearly defined role and objectives including control of expected incidents to clearly defined physical damage and loss of income levels. To ensure the team is capable of achieving these objectives a detailed, documented review will be undertaken by GCO prior to commencement of operations. The review will include, but not be limited to, consideration of the following:

- **Team size/qualifications/expertise:** To establish the number of team members, qualifications, and expertise required to provide a credible fire fighting capability, a series of exercises, both tabletop and field, will be completed. The exercises will be based on a range of situations, including fires involving the fuel tanks, the power station (includes engine hall, LV room and inlet filter areas), store, camp mess and floating plant. Tasks will include:
  - Electrical and equipment isolation.
  - Operation of the required number of hydrants (at least 2 hose lines).
  - Radiant heat protection for the fire crews.
  - At least one ERT member assigned to the fire pumps.
  - Mop-up teams using fire hydrants.
  - Command and control activities, plus other required ERT duties.
- **Team leaders:** The ERT on each shift will be led by a Team Leader with appropriate qualifications and experience in control of incidents expected at the location. If this is not feasible then an appropriately trained and qualified team leader will be available to respond to the site within a defined time of an alarm being raised at all times night or day.
- **Team members:** An adequate number of trained members will be on duty at all times. The minimum number required will be based on providing sufficient fire fighting capability to achieve, with a high level of confidence, fire control with an acceptable level of damage and loss of production plus addressing the unique safety issues associated with the floating plant. All team members will be required to pass an appropriate medical check before being assigned to high physical stress tasks.
- **Team equipment:** It is expected at least eight operational sets of equipment (breathing apparatus and turn-out gear) plus two spare sets, plus 10 spare air cylinders will be required for the crew. Foam monitors and foam will be required for oil/fuel-based fires.
- **Team training:** The ERT training program will provide realistic training for all team members on the equipment they are expected to use. The training program will be fully documented.
- **Emergency response plans:** Documented and detailed emergency response plans will be prepared for each major class of expected emergency including fire, explosion and person overboard/in the water at the floating plant.

- **Minimum equipment list and number of team members on duty:** A review will be conducted to establish the minimum personnel and equipment requirements to safely operate the plant. ERT members will be required to log in before commencing work. If less than the minimum number of team members are available, or if the minimum equipment list cannot be met, management procedures will be in place for immediate corrective action (backup staff called in and/or equipment repaired).

The capital estimate included allowances for “specialised” ERT equipment, suitable building, vehicle allowance and training room.

10.12 Contractor Management

GCO recognises that effective management of contractors, including the EPCM contractor, is critical to achieving excellent GCO OHS performance.

To be allowed access to the GCO site potential contractors will require the ability to meet the following:

- GCO’s OHS performance standards.
- GCO’s OHS performance expectations.
- Applicable regulatory requirements.

All contractors will be required to provide an OHSMP specific to the contractor’s scope of work and include details of the strategies the contractor proposes to implement for the management of any subcontractors in relation to OHS matters.

The project will adopt a zero tolerance target for lost-time injuries and educate personnel in safe work practices to achieve the desired target.

Consistent with the project targets, the contractor manager with the assistance of the safety adviser has overall responsibility for safety and personnel welfare on site and the management of the first aid facilities during construction.

The contractor manager will ensure that their supervisor with the assistance of the safety adviser regularly conducts safety audits of the site. The results of the audits will be conveyed to the contractor manager together with proposed actions and time frame within which problems noted will be rectified.

The contractor manager will be responsible for:

- Implementing the safety management plan.
- Ensuring safety records are adequately maintained.
- Investigation of accidents and near misses.
- Chairing of regular safety meetings with all contractors.
- Site responsibility for safety.

The contractor supervisor will be responsible for:

- Undertaking safety audits.
- Attending toolbox meetings on a regular basis.
- Convey safety audit results.
- Addressing all safety concerns raised.

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SECTION 11

Socio-Economic Impact

Copy 16

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CONTENTS

11 SOCIO-ECONOMIC IMPACT

11.1 Introduction

This section summarises the socio-economic impact of the GCP on the local communities. Further details on the socio-economic impact can also be found in Volume 2 of the DFS.

11.2 Legal and Policy

The key legal and policy drivers that shape the social management and compensation processes for the Grande Côte Project are:

- GCO agreements and policies.
- Government of Senegal legislation and regulations.
- World Bank/IFC guidelines and performance standards.
- African Development Bank safeguard policies.

11.2.1 GCO's Policies

GCO is committed to developing a beneficial partnership with the local community that maximises the sustainable benefits of the GCP for all stakeholders, and makes a positive contribution to the development and prosperity of the Senegalese people through employment and training opportunities. The company seeks to win global high regard for social and environmental compliance as well as technical, safety, and human resources excellence.

The core elements of GCO's community relations and development strategy include: a land and asset compensation program; resettlement planning; a livelihood restoration program; a community infrastructure development program; a community awareness and education program and a disclosure and consultation program.

11.2.2 Grande Côte Mining Convention

MDL executed a Mining Convention for the GCP with the Government of Senegal (GRS), which was formally decreed in September 2004. The agreement defines the general, legal, financial, fiscal, economic, administrative and specific corporate conditions under which GCO shall undertake its operations within its mining area. The following is a summary of commitments stipulated in the Mining Convention that are relevant to land occupation and compensation management:

- The State guarantees GCO access, occupation and use of all lands, inside and outside the area necessary for the exploration and mining works on the deposit or deposits which are respectively the object of the mining permit in the context of this agreement and in accordance with the provisions of the Mining Code. (Article 32.3).

- At the request of GCO, the State will proceed with the relocation of residents whose presence on the land impedes the mining works. (Article 32.5).
- GCO shall be required to pay an equitable indemnity to the said residents as well as for all other losses, privations of use or damages that result from its activities. (Article 32.6).
- In the absence of an amicable settlement, the State agrees to undertake as action for public expropriation on behalf of GCO. (Article 32.7).

11.2.3 Government Legislation and Guidelines

Key laws and regulations of the GRS that are relevant to land administration and compensation are listed in Volume 2 of the DFS.

The Mining Code (2003) is the primary legislation regulating the mining industry in Senegal. Sections of the code that are relevant to land administration and compensation include:

- Article 55, 'Equalisation and Support': Ensures that a portion of income from the mining operation is set aside as a fund for the local communities.
- Article 73, 'Land Occupation': Holders of mining titles are required to request authorisation from the mining authorities to occupy lands that are necessary for their mining operations, whether such land is located either inside or outside the perimeter of their mining titles.
- Article 55, 'Equalisation and Support Funds': One part of the fiscal resources perceived from mining operations is deposited in an equalisation fund destined to local communities.

Article 92 of the Mining Code Application Decree, No. 2004-647, states that all mining title holders must duly compensate the appropriate party, such as the land owner or the state, for any loss or damages caused by compulsory acquisition resulting from mining activities being carried out on their land by either the mining company or any contractors working on the mining company's behalf. Article 93 states that compensation is required for two types of land:

- For registered land, agreement is struck between the mining title holder and the land owner.
- For public land, an agreement is struck between the mining title holder and the local government concerned, or in the absence of such an agreement, by a commission comprised of: the prefect of the department concerned; the regional Mines Service; the regional Water Resources and Forestry Service; the Agricultural Service; the regional Land Titles Office; the regional State Lands Department; the Department for the Environment; local government concerned; the mining titleholder.
- If for whatever reason, in six months following the date on which the decree or the administrative order came into force authorising the occupation of the lands, an agreement has not been reached between the holder of the mining title and holders of the land rights or the rural communities concerned, the beneficiary of the authorisation for occupation shall be authorised by the Minister for Mines to

occupy the concerned lands in exchange for the deposit into the account of a public accountant of provisional compensation.

The June 1964 land reform anticipated the creation of the communautés rurales to act as a framework for the application of Law No. 64-45 on the National Domain. On April 19 1972 Law No. 72-75 was passed, establishing the rural institutions responsible for managing public lands. This made rural councils responsible for democratic land management, under the control of the administrative authorities representing the State (governors, préfets and sous-préfets).

11.2.4 World Bank/IFC Guidelines and Performance Standards

IFC Performance Standard 5 - Land Acquisition and Involuntary Resettlement (April 30 2006), applies wherever land, housing or other resources are taken involuntarily from people. It requires the consideration of feasible alternative project designs to avoid or minimise physical or economic displacement while balancing environmental, social and financial costs and benefits.

The overall objectives of the IFC's performance standard on land acquisition and involuntary resettlement are to:

a) Avoid or at least minimise involuntary resettlement where feasible by exploring alternative project designs.

b) Mitigate adverse social and economic impacts from land acquisition or restrictions on affected persons' use of land by: (i) providing compensation for loss of assets at replacement cost; and (ii) ensuring that resettlement activities are implemented with appropriate disclosure of information, consultation, and the informed participation of those affected.

c) Improve or at least restore the livelihoods and standards of living or displaced persons.

d) Improve living conditions among displaced persons through provision of adequate housing with security of tenure at resettlement sites.

General requirements of the performance standard are detailed in Volume 2.

11.2.5 African Development Bank Safeguard Policies

The African Development Bank Group Involuntary Resettlement Policy (November 2003) has been developed to cover involuntary displacement and resettlement of people caused by a project. It applies when a project results in relocation or loss of shelter, assets being lost or livelihoods being affected.

The overall goal of the bank's policy on involuntary resettlement is to ensure that when people must be displaced they are treated equitably, and that they share in the benefits of the project that involves their resettlement.

Guiding principles relevant to the design and implementation of a compensation and resettlement program include:

- Where physical displacement or loss of other economic assets is unavoidable, the borrower should develop a resettlement plan. The plan should ensure that displacement is minimised, and that the displaced persons are provided with assistance prior to, during and following their physical relocation. The aim of the relocation and of the resettlement plan is to improve displaced persons' former living standards, income earning capacity, and production levels. Project planners should work to ensure that affected communities give their demonstrable acceptance to the resettlement plan and the development program, and that any necessary displacement is done in the context of negotiated settlements with affected communities.
- Additionally, displaced persons and host communities should be meaningfully consulted early in the planning process and encouraged to participate in the planning and implementation of the resettlement program.
- Particular attention should be paid to the needs of disadvantaged groups among those displaced, especially those below the poverty line, the landless, the elderly, women and children, and ethnic, religious and linguistic minorities; including those without legal title to assets and female-headed households. Appropriate assistance must be provided to help these disadvantaged groups cope with the dislocation and to improve their status.
- Resettled people should be integrated socially and economically into host communities so that adverse impacts on host communities are minimised.
- Displaced persons should be compensated for their losses at "full replacement" cost prior to their actual move or before taking of land and related assets or commencement of project activities, whichever occurs first.
- The total cost should include the full cost of all resettlement activities, factoring in the loss of livelihood and earning potential among affected peoples. This attempt to calculate the "total economic cost" should also factor the social, health, environmental and psychological impacts of the project and the displacement, which may disrupt productivity and social integration. The resettlement costs should be treated against economic benefits of the project and any net benefits to resettled people should be added to the benefit stream of the project.
- The borrower will be required to prepare a full resettlement plan for any project that involve a significant number of people (200 or more persons) who would need to be displaced with a loss of assets, or access to assets or reduction in their livelihood. For any project involving the resettlement of less than 200 persons, an abbreviated resettlement plan will be released together with the environmental annex of the bank's appraisal report.

11.3 Baseline Study

11.3.1 Introduction

In October 2007, Earth Systems completed a *Land, Asset and Livelihood Baseline Study Report* to assist in the development of a compensation program for the inhabitants of settlements that are contained within, or might access land or water, in the mining area. The 2007 baseline study data was collected over a two-month period commencing March 2007 and subsequently updated in 2010. The scope of the initial work for this study included:

- Consultation with village elders and key community members to obtain an understanding of their livelihood; land administration and use; social organisation, development needs and history. A separate consultation was held for women's groups in the settlements of Foth, Diourmel and Thiakmat.
- Livelihood surveys with 100% of households within the littoral dune and within the mining area. Sample surveys of households residing in the costal and hinterland settlements outside the exploitation area were also completed. The survey totalled 483 households with a population of 4,462 persons.
- Mapping of village level land use inside the exploitation area and buffer zone and identification and classification of gardens, plantations, mobile dunes and remnant vegetation using aerial photography and satellite imagery.
- Field registration of houses, community infrastructure, wells and cemeteries inside the exploitation area and buffer zone using GPS and photographic survey.
- Assessment of land use and ownership within the land area designated for the MSP.
- Preparation of "farm models" to understand the economic return on the market gardens.

Since the completion of the 2007 baseline study the proposed dredge mining path has been modified. The modified path includes some areas outside of the 2007 baseline study.

Earth Systems has presented an updated *Land, Asset and Livelihood Baseline Study Report* for the GCPA dated May 2010. The May 2010 report uses data from the 2007 baseline study report which has been updated using more recent aerial photography from January 2008 and recent ground truthing undertaken by GCO staff under instruction from Earth Systems. The assessment of land, assets and livelihood within the current 10 year mine plan is comprised of:

- A detailed assessment over the areas covered by the 2007 baseline study data (*Land, Asset and Livelihood Baseline Study Report,* May 2010).
- A desktop assessment of areas outside of the 2007 baseline study data (*Land, Asset and Livelihood Baseline Study Report*, May 2010).

11.3.2 People and Place Baseline

The baseline study indicates that settlements within the GCP region can be broadly clustered into three zones:

- Settlements located on the littoral dune, including Foth, Keur Gou Mag and some Diogo, Diourmel and Thiakmat hamlets. Several settlements from Foth, Diogo, Diourmel and Thiakmat are located inside the mining area.
- Coastal settlements located adjacent to the proposed mining area, including Fass Boye, Theni Naar, Litte, Mbetite 2, Diogo Sur Mer, and some Diourmel and Thiakmat hamlets. Of these, several Diourmel and Thiakmat settlements are located inside the mining area. The remaining settlements are outside the mining area but may access land and water resources within the mining area.
- Hinterland settlements located east of the littoral dunes (along the road leading to Diogo) and adjacent to the proposed mining area, including Ngoye Yawatt, Ngoye Beye, Diogo, Ngoye Wade, Ndieul Kougne Dior, Ndangar, Ndieul Kougne Kheub, Darou Fall, Keur Khar Cisse, Ndiligne, Darou Ndoye and Darou Salam. These settlements may access land and water resources within the mining area.

Located primarily on the eastern side of the dunes are arable inter-dune depressions known as ‘niayes’. Many plant species are able to survive in these depressions by tapping into the near-surface groundwater. Agricultural activity within the region is supported through extracting the near-surface ground water.

During the first ten years of mining, the littoral dune settlements of Foth, Diourmel, Diogo and Thiakmat are most affected by the proposed mine development with some housing and agricultural land located inside the proposed mining area. Some small land parcels of coastal and hinterland extend into the buffer zone of the proposed mining area with the potential to be disturbed by project development.

Based on the 2007 baseline study, 159 households, approximately 897 persons, reside inside the current proposed mining area. A further 50 households, approximately 270 persons, were identified inside the 50 m project buffer zone.

The 2007 study indicated that:

- More than 80% of the population were born in the village in which they reside.
- There are two main ethnic populations, the Peul and the Wolof, which tend to have their own villages.
- The Peul are the main inhabitants of the littoral dune area and thus have the potential to be more affected by the GCP.
- The predominant religion is Islam, with the religious leaders maintaining a significant social influence over the Wolof communities.
- The family structure is patrilineal, with the typical extended family being represented by the chief (chef de concession), usually the eldest male, and comprising more than one household. Polygyny is widely practised, with the men in the communities often having more than one wife.

- Households of extended families often live in a common compound (concession) and share resources such as food, access to land, equipment and cash, allowing the concession greater individual security in times of hardship.
- Residential structures comprise huts built from wood, reeds, grass and some from cement with metal roofs. Some construction materials are sourced from within the project development area.
- Access to health and education facilities is a major constraint, with most such facilities in excess of 10 km from the littoral dune settlements of Foth and Diourmel. Health issues include malaria, dengue, dysentery, diarrhoea, parasites, malnutrition and tuberculosis. Education attainment is low, with 29.5% of men and 45% of women inside the proposed mining area and buffer zone describing themselves as illiterate.
- Principal land use and occupations within the project area are horticulture, agro-pastoralism, and timber forest-product harvesting. To overcome shortages in water, land and labour, farmers are introducing mechanised forms of irrigation, recruiting on-farm labour and using increasing quantities of chemicals.
- Groundwater is the principal source of water. A comparison of studies conducted in 1975 and 1994 suggest that groundwater level has been steadily dropping, which is likely to be due to the combined effects of long-term drought and increased groundwater use.
- More than 75% of the households raise cows, small ruminants (goats and sheep) or poultry, aiding in livelihood and security. Market gardening has enabled the intensification of animal raising, as waste crops provide a valuable source of animal feed, and manure as a source of fertiliser. Horses and donkeys are mainly used for traction and transportation.
- A cash income is required for staple and supplementary foods, household items and emergencies such as medical expenses. The average annual household cash income for the settlement clusters on the littoral dune varied from 3M FCFA (~US$6,833) in Foth to 4.2M FCFA (~US$9,567) in Diourmel hamlets. There are few opportunities for off farm employment.

Project affected persons (PAPs) are those persons and families affected or impacted by the GCP. PAPs may have land, assets or derive some portion of their livelihood in those areas to be impacted by the GCP. It is these PAPs who may be entitled to any applicable compensation.

11.3.3 Land and Asset Baseline

The updated land and asset baseline study indicates that:

- In total 38 settlements are located within the proposed mining area and buffer zone.
- It is estimated that a total of 115.5 ha (~5% of proposed mining area) is agricultural land of which at least 89.0 ha belongs to the settlements of Foth, Diogo, Diourmel and Thiakmet. The remainder still requires classification (~26.5 Ha). It is likely that this land will be subject to semi-permanent or temporary loss as a consequence of dredging activities.

- An additional 54.4 ha (~8% of buffer zone) of agricultural land is located in the buffer zone of which 35.3 ha belongs to the settlements of Foth, Diogo, Diourmel and Thiakmet. 19.1 ha still requires classification. This land will potentially be subject to temporary interruption of typical use as a consequence of project development.
- No orchards were identified in the project development area. However, some farmers have established fruit trees and other plantation species adjacent to their agricultural fields; compensation will be required for the loss of such trees.
- Project development under the current 10-year mine plan is likely to result in the loss and subsequent re-establishment of approximately 609 water sources within the proposed mining area of which six are trenches and the remainder wells. A further 283 water sources will be potentially impacted within the buffer zone. Compensation will be required to affected households for the replacement of water sources.
- Project development under the current 10-year mine plan has potential to result in loss or disturbance to approximately 15.0 ha of habitation area; 907 ha of herbaceous, scrub and woodland; and 944 ha of revegetation area within the proposed mining area. The period of loss will depend on the time taken for the rehabilitation and stabilisation of the dune following mine exploitation, including fixation of dunes where these may be prone to wind erosion, the re-establishment of vegetation and the availability of groundwater for agricultural production. Successful rehabilitation may take several years and thus it will be some time before communities can access and use the land as they did previously.
- The project development area comprises numerous revegetation areas (approximately 944 ha) administered by the National Forestry Commission. The principal objective of this revegetation was to fix the mobile littoral dunes and thus minimise the loss of valuable agricultural land in the niayes. This includes up to 381 ha of revegetation areas containing Japan International Cooperation Agency (JICA) plantations.
- Under the first 10 years of project development, one cemetery and one Arabic school belonging to Diogo settlements were identified in the proposed mining area. One cemetery belonging to Diourmel settlements was identified within the buffer zone. No baseline data on community assets is available for Thiakmat. Where feasible, disturbance to cemeteries will be avoided and/or compensation measures developed in close consultation with local communities. Grave sites are likely to require relocation should there be risk of disturbance and compensation provided to affected communities to appease ancestral spirits.

11.4 Impact Assessment

11.4.1 Settlement

Settlement areas and infrastructure within the proposed mining area are expected to be fully impacted. In some circumstances this infrastructure may be able to be moved to nearby areas resulting in reduced impact on the society.

Infrastructure identified inside the proposed mining area for the current 10-year mining period included 134 huts and 37 buildings with metal roofs. 48 other buildings were also identified within the proposed mining area. Infrastructure within the buffer zone comprises 77 huts, 25 buildings with metal roofs and 34 other buildings. Some community infrastructure is also impacted, including a small Arabic school and other cultural sites including cemeteries.

Settlements which will experience the most significant land loss will be those located inside the proposed dredge path, including those belonging to Diogo, Foth, Diourmel, and Thiakmat. This is likely to necessitate the relocation of 27 settlements containing 159 households (approximately 897 persons).

A further 11 settlements containing 50 households and 270 people are located within the 50 m buffer zone on either side for the dredge path.

Agricultural areas likely to be most at risk include the niayes adjoining the littoral dune located along the eastern edge of the dredge path.

Impact outside the mining area and buffer zone is likely to be indirect disturbance of social and cultural associations directly impacted settlements.

All assets and community infrastructure impacted by the GCP will require compensation to enable livelihood restoration.

Persons identified within the project development area will require relocation and, where livelihood can be maintained, to potentially nearby areas within their village lands. Resettlement to new areas is likely to be required if livelihood cannot be maintained. Community and government consultation will be required with all affected parties to identify the preferred strategies for each affected household.

The implementation of a Resettlement Action Plan (RAP) and Social Development Plan (SDP) developed with appropriate community and government consultation prior to construction will reduce the significance of potential livelihood and resettlement impacts.

11.4.2 Land Use

Impacts on land use will primarily be associated with the disturbance of land for mining activities within the proposed mining area and buffer zone. Under the current 10-year mine plan, the GCP has the potential to directly impact approximately 2,222 ha of land within the proposed mining area, including 907 ha of herbaceous, scrub and woodland, 944 ha of revegetated dune areas and 116 ha of agricultural land.

A further 676 ha will potentially be impacted within the 50 m buffer zone, including 282 ha of herbaceous, scrub and woodland, 254 ha of revegetated dune areas and 54 ha of agricultural land.

There is likely to be limited direct impact on land outside of the project development and buffer area assuming no adverse effects to groundwater resources particularly in the niayes adjacent to the dredge path.

Settlements which will experience the most significant land loss will be those located inside the proposed mining area, including those belonging to Diogo, Foth, Diourmel and Thiakmat. There is also potential for hinterland and coastal settlements to own land assets located inside the project development area.

An assessment of land and assets that will potentially be affected by the siting of other project facilities (e.g. proposed roads and railway) will need to be undertaken prior to construction.

Direct impacts on land loss will require mitigation through measures such as providing compensation for or replacement of agricultural land, maximising local employment and alternative livelihood development activities.

Impacts on forest resource use will require mitigation through measures such as progressive rehabilitation of the proposed mining area.

11.4.3 Water Use

Initial groundwater modelling for the passage of the dredge path past adjacent horticultural areas has been completed. This has confirmed that groundwater will not be depleted but will be raised for the operating dredge by using water from a deep aquifer.

Groundwater is of vital importance to the livelihood of the local communities and represents the principal source of water within the project development area. It is extensively used for crop irrigation, stock watering and domestic use.

Groundwater harvested from shallow wells, is used by settlements for agriculture, household consumption (e.g. washing, cooking), and stock watering. Groundwater is usually transported by hand to irrigate adjacent agricultural areas. Mechanically driven boreholes, varying in depth from a few metres to over 20 m can also be found in niayes areas.

Project development will result in the loss of community water sources located within the proposed mining area and potentially within the buffer zone. These will be reinstated or substituted to replace these important impacted assets.

Other potential impacts on water resource use associated with the GCP include potential for changes in the availability of groundwater, risk of surface water and groundwater contamination, potential impacts of changes in groundwater levels on agricultural areas (particularly in the niayes) and the livelihoods of local communities within the GCPDA and in nearby areas.

Implementation of site-specific management and mitigation measures, including installation of a series of groundwater monitoring bores, provision of alternative water sources and appropriate compensation where community assets are impacted are expected to essentially negate the potential impact of the GCP on groundwater and the livelihood of water users.

11.4.4 Economy and Employment

The GCP is likely to be of benefit to the local community through the creation of economic and employment opportunities associated with project development. Employment requirements for the GCP are likely to be largely associated with construction of the GCP and less so with permanent operations. However, rehabilitation activities associated with the project are likely to provide scope for employment of local people, particularly those on the littoral dune.

The broad economic and employment impact is expected to be positive, although ensuring minimal impact on groundwater and agriculture as well as implementation of livelihood restoration measures will be important to ensuring that the GCP has a net beneficial impact on local communities surrounding the GCP.

Monitoring of employment statistics and continuous consultation with local communities will ensure that the potential employment opportunities are realised. Establishment of a Community Development Program designed to support community development initiatives and alternative livelihood opportunities will also help to maximise the social benefits associated with the GCP.

11.4.5 Cultural Values and Heritage

A few cultural sites have been identified inside the proposed mining area under the first ten years of project development. This includes one small Arabic school associated with Diogo hamlet. Implementation of appropriate management and mitigation measures will be required to minimise impacts.

Other important cultural sites associated with settlements within the proposed mining area and buffer zone are primarily located outside the project development area and are not likely to be directly disturbed by dredging activities.

No detailed assessment of cultural values and heritage has as yet been undertaken for the Thiakmat area in years 9 and 10.

11.4.6 Community Health, Safety and Amenity

The primary potential impact on community safety is likely to be from accidents along project supply routes. Uncontrolled crossing of haul roads by people or livestock could result in potentially serious accidents involving vehicles.

Other community health and safety concerns include the potential spillage or release of hazardous materials along supply routes, unauthorised access to project facilities, disease introduction or exacerbation of existing diseases, and increased pressures on food availability due to in-migration. The remote potential risks of exposure to radioactivity above natural background levels associated with mineral products and waste streams are expected to be essentially non-existent.

Potential impacts on the social amenity of local communities from noise and dust emissions as well as disturbance to visual amenity are not likely to be significant provided appropriate management and mitigation measures are successfully implemented.

A variety of education programs and management measures will be required to ensure that risks to community heath and safety due to the GCP are effectively minimised.

11.4.7 Accessibility and Transport

The GCP is likely to result in an increase in the overall traffic volumes along the project's transport routes. The increase in the use of project roads may result in a concomitant minor increase in the risk of road accidents, and increase the risk of spills of hazardous materials such as hydrocarbons. These risks will be minimised through the development of dedicated new access roads, careful management of transport operators and contractors, traffic safety measures, ongoing monitoring and adaptive management of accident rates and vehicle behaviour along all of the project roads, and road safety awareness campaigns in villages.

GCO is considering several options for project-related transport at Diogo to alleviate the traffic congestion and maintain a high level of safety for villagers, including a bypass for Diogo and adjacent villages. Rail transport is expected to reduce the number of trucks transporting product to Dakar.

11.4.8 Population and In-migration

In-migration into the GCP area is likely once construction begins, particularly for hinterland villages such as Diogo, which has more developed public infrastructure and greater commercial activity compared to the settlements located on the dune. In-migration also has the potential to increase pressure on land and water resource use, livelihood and impact on health.

Management of in-migration will require liaison with the government and local community. GCO's recruitment policy will discourage an influx of people to the area and therefore minimise adverse impacts. During closure, a net out-migration may occur as people leave to seek other employment opportunities.

11.4.9 Closure

At the completion of mining, key closure issues that will need to be considered include:

- Careful planning to avoid relocating villagers, replacement land and assets, and undertaking rehabilitation in areas that will potentially be impacted by future dredge passes.
- Minimising any long-term deleterious impacts of the GCP on the livelihoods of the local community.
- Minimising the potential long-term impacts of changes in groundwater levels on agricultural areas and potential changes to groundwater quality.

The development and successful implementation of a site-specific RAP, SDP and rehabilitation plan for the GCP, as well as other management and mitigation measures, is expected to reduce the residual impact of the GCP on the local communities and their land, assets and livelihoods to acceptable levels.

Future details on closure planning are in Section 15.

11.5 Proposed Social Management Strategy

Development of a strategic framework for social management is a key management measure for the GCP and will form the basis for the development and implementation of a detailed RAP and SDP.

The social management strategy includes the identification of procedures and processes at the strategic level to avoid, mitigate and manage the impacts to persons arising from project development and operations as it pertains to the need for physical displacement, and the loss of land, livelihood and assets.

An important initial step will be the development of implementation procedures to ensure that key stakeholders (such as community, government and GCO) are able to effectively refine and deliver the social management strategy.

Preparation and implementation of a well-resourced RAP will outline in detail the procedures and actions that GCO will take to mitigate adverse effects, compensate losses and provide development benefits to persons and communities affected by the GCP. Preparation of a SDP will provide a comprehensive strategy for the re-establishment and security of the livelihood of PAPs.

Social impact monitoring will be required to identify and quantify the direct and indirect impacts of the GCP on the local community. Social monitoring will also ensure that existing management and mitigation measures are effective and will identify the need for improved or additional measures.

11.6 Compensation

State lands fall into four categories: i) urban areas; ii) classified forests, national parks, etc.; iii) community land; and iv) pioneer zones. Land can be accessed through occupation, authorisation, ordinary lease, long-term lease and concession. Locally elected officials in rural communities can allocate land according to customary practices as long as lands are productively used (*mises en valeur*).

Under Article 73 of the Mining Code, GCO as a holder of a mining title can occupy lands that are required for its mining operations without acquiring the property. The right of land occupation is also stated in Article 32.3 of the Grande Côte Mining Convention, which stipulates that the State gives the right for GCO to have access, possess and use all lands which are located either inside or outside its mining concession necessary for prospecting and exploitation. Under Article 76 of the Mining Code the holder of the mining title is required to compensate other land users for any loss or damage sustained by the occupation of land.

The establishment of project compensation policies and entitlements for the GCP will need to be conducted in close consultation with the government and community and in keeping with IFC and Senegalese requirements. Appendix 2.6, Volume 2 outlines principles of compensation as well as a methodology for establishing entitlements and eligibility for compensation.

In summary, four compensation categories have been defined to assist in the understanding of likely compensation scenarios: a) permanent loss; b) semi-permanent loss; c) temporary loss; and d) temporary disturbance.

a) **Permanent loss:** is when lands and/or assets are permanently transformed from their pre-mining use. When permanent loss is agreed, the land and/or asset owner is to be offered either the financial "replacement cost value", a land swap of equal or greater productivity, or assets of equal or greater value at the time that the property is resumed by the project. The financial "replacement cost" will be sufficient to actually replace lost land and assets with land of equal productivity, or assets of equal value/quality/size.

b) **Semi-permanent loss:** may occur when temporary loss of land occurs over a prolonged period such that the transformation of land from its pre-mining state may be considered 'semi-permanent' (such as the proposed mining area). Semi-permanent loss of land for any period greater than three years (and potentially up to 10 years) is likely to provide justification for replacement land to be provided.

   Semi-permanent loss of land has therefore been assessed in the same manner as permanent loss. However, the time period of semi-permanent loss will vary significantly depending on the type of land to be disturbed (for example agricultural, scrub land or revegetation areas). Further definition of the time period of semi-permanent loss will need to take into account the results of rehabilitation trials and the outcomes of community and government consultation.

c) **Temporary loss:** may occur when land is resumed during mine construction, though returned during the mine operational phase. The landowner is offered a "rental (or subsistence) allowance" for the period of loss. The "rental allowance" is equivalent to the lost productive value of the land at the local market value for the year in which the compensation is paid.

d) **Temporary disturbance:** may occur in areas adjacent to construction activities, where the owner will still enjoy access and use of their property, though that access and use may be disturbed by GCP activities. Depending on the severity of disturbance, the land owner may be offered a "disturbance allowance" for the period of disturbance. The "disturbance allowance" would be sufficient to cover the economic loss incurred by the disturbance.

Compensation procedures and entitlements are proposed for disturbance to housing, property assets, agricultural land, water supply, community land, and livelihood restoration.

11.6.1 Resettlement and Compensation

The indicative resettlement and compensation estimate under the current 10-year mine plan is approximately US$3,912,220. This includes settlements and assets within the buffer zone. Compensation costs per household will vary depending on the individual settlement and agricultural assets impacted. They are likely to range from US$5,000 to US$20,000 per household.

These costs are those required for livelihood compensation and restoration, as well as costs for the restoration and revegetation of land surfaces disturbed by mining.

11.6.2 Budget for Social Management and Monitoring

The indicative budget for social management and monitoring for the GCP has been estimated at approximately US$11,812,220, which represents an average operating cost of approximately US$1,128,222 per year over the 10-year mine plan. This includes US$3,912,220 for resettlement, compensation and livelihood restoration costs, US$425,000 for post-funding management plans and studies, US$4,050,000 for management and monitoring and US$3,320,000 for administrative costs of the Community Relations Department.

11.7 Future Social Program

GCO will undertake the following social management activities prior to the commencement of the GCP:

- Update household livelihood surveys undertaken as part of the 2007 Land, Asset and Livelihood Baseline Study.
- Undertake household livelihood surveys of all new settlements located within the project development area since the detailed 2007 Land, Asset and Livelihood Baseline Study.
- Prepare a detailed inventory of all project affected land and assets at the household, village and community level.
- Conduct follow-up consultation with communities to confirm the location, ownership and use of their agricultural and community land and assets.
- Establish a cut-off date for resettlement and compensation eligibility.
- Establish a population census in the township of Diogo, Ngoye Wade and Ndoye Beye in advance of project operations to be used as a baseline for assessing the extent of project related in-migration.
- Establish a health baseline within the project development area, which includes an assessment of the capacity of local authorities to manage health problems, both existing and potential.
- Undertake extensive consultation with government, local authorities and PAPs regarding management and mitigation of potential project impacts, resettlement options and alternatives, livelihood restoration options and development opportunities, and compensation measures.

- Prepare a Resettlement Action Plan (RAP) and a Social Development Plan (SDP) based on the outcomes of stakeholder consultation.
- Prepare a Public Consultation and Disclosure Plan (PCDP), which details the methodology for conducting stakeholder consultation and documents the results of consultation activities.
- Conduct a detailed cultural values and heritage baseline study for the area prior to the commencement of the GCP.

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SECTION 12

Environmental and Social Management Strategy

Copy 16

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CONTENTS

TABLES

12 ENVIRONMENTAL AND SOCIAL MANAGEMENT STRATEGY

12.1 Introduction

The environmental and social issues associated with the development of the GCP and the mitigation measures proposed to minimise the potential impacts of the development are summarised here. Additional detailed information can be sourced in Volume 2.

12.2 MDL Policies

The following MDL policies have been considered in the development of the Environment and Social Management Strategy as they apply to the GCO:

- MDL Corporate Code of Ethics.
- MDL Sustainability Policy Statement.

The Corporate Code of Ethics and Sustainability Policy Statement underpins the company approach to implementing environmental and social management strategies. In June 2004, MDL formally adopted a Code of Ethics, which applies to GCO, to the GCP and to all its employees. The MDL Board reviews and assesses the implementation of the code and the policy each year (see Volume 2 and the MDL website for further details).

GCO is committed to developing and maintaining an integrated management system that incorporates the requirements of the following standards:

- AS/NZS ISO 14001 (2004) Environmental management systems - specification with guidance for use.
- AS/NZS 4801 (2001) Occupational health and safety management systems - specification with guidance for use.
- AS/NZS 4360 (2004) Risk management.
- International Finance Corporation (IFC) Performance Standards.
- Equator Principles.
- African Development Bank Safeguard Policies.

12.3 Environmental and Social Management System Overview

The environmental and social management system (ESMS) being developed for the GCP broadly follows the structure outlined in International Standard ISO 14001. It is based on the identification of environmental and social issues through the environmental and social impact assessment (EIES) process, the assessment of land use and community development and the development of mitigation measures to manage known environmental and social impacts.

The main objectives are:

- To implement a fully functional and effective environmental management system to improve environmental performance and to reduce environmental risk.
- To ensure ownership of the environmental management system at all managerial levels and that employee knowledge and use of the system remains high.
- To prioritise staff and financial resources on the basis of environmental risk.
- To continuously improve the environmental performance of the GCP through annual improvement plans, audits and inspection processes, training programs and effective corrective action systems.

The Environmental and Social Management and Monitoring Plan (ESMMP) (Appendix 2.1, Volume 2), describes the monitoring, mitigation and management measures required during the construction, operation, decommissioning and rehabilitation phases of the GCP. It is based on commitments made in the EIES and on requirements of the GRS and financial institutions involved in the project. The ESMMP provides a framework for ongoing environmental and social management and sets guidelines for development of management plans and standard operating procedures that will be developed as part of the ESMS. The ESMMP is a dynamic document subject to updating and adjustment following biennial review.

12.4 Legal and Other Requirements

12.4.1 Mining Convention and Permit

The Mining Convention between MDL and the GRS was executed on 9 September 2004, formally decreed on 10 September 2004 by Ministerial Arrête 7474, and recorded in the *Government Gazette* (*Journal Officiel*) of 30 October 2004.

Following approval of the EIES for the GCP, a Mining Permit was granted in November 2007. The mining permit is valid for 25 years and is renewable.

The Mining Convention stipulates commitments and requirements relevant to the management of environmental and social issues associated with exploration and mining at the GCP. For a detailed list of commitments see Volume 2.

12.4.2 Certificate of Environmental Compliance

In February 2008, the Ministry for the Environment, Protection of Nature, Water Retention Basins and Artificial Lakes issued the Certificate of Environmental Compliance for the GCP, which applies to the EIES and its management plan. This certificate requires implementation of the management plan, including consultation with committees specified for each section of the management plan.

The Certificate of Environmental Compliance also requires that the further studies must be completed in order to clarify the ESMMP.

In particular, the outstanding studies concern the environmental and social impacts of:

- The power plant and fuel storage facility.
- The tracks and roads to be used for access and transport.
- The MSP and ancillary structures.

The locations of these features were unknown at the time of the original EIES, but have since been identified.

12.4.3 National Legislation and Regulations

Thirty-two laws and regulations of GRS that are relevant to the environmental and social management of the GCP are listed in Volume 2. The relevance of these laws and regulations will be reviewed periodically to determine if there has been any change of status.

12.4.4 National Action Plan for the Environment

The *National Action Plan for the Environment* (1993) (PNAE) provides a strategic framework for environmental planning. The PNAE also presents actions for protection of the littoral belts and the area of the Niayes, including stabilising the dunes and protection of the basins from sand encroachment. To date, it is estimated that 1,016 ha has been rehabilitated.

12.4.5 Environment Code

The *Environment Code* (2001), Senegal's principal environment law, aims to establish a set of fundamental principles designed to manage and protect the environment against all possible forms of degradation arising from the economic, social and cultural development of Senegal. The code defines procedures for environmental impact assessment, including community consultation. The code also defines key environmental terms and sets out the government's environmental policies.

The following sections are particularly relevant to the mining industry:

- Title I, Chapter 3 "Instruments for the Protection of the Environment".
- Title II, "Prevention and Fight against Pollution and Noise".
- Title III, "Protection and Enhancement of Receiving Environments".
- Title IV, Chapter I "Penal Sanctions".

12.4.6 Mining Code

The Mining Code (2003) is the primary legislation regulating the mining industry in Senegal, covering both exploration and mining activities. Sections of the code that are relevant to environmental and social management of the GCP are detailed in Volume 2.

12.4.7 Water Quality, Air Quality and Noise Guidelines

To develop an environmental and social management and monitoring program, five applicable guidelines for water quality, air quality and noise are required to be assessed. Further detail of the relevant guidelines is contained in Volume 2.

12.4.8 Land and Water Ownership

Land legislation consists of a series of legal texts and regulations based upon the 1964 National Domain Law (64-46) and the 1972 Rural Communities Act (72-75). Under Article 73 of the Mining Code, GCO as a holder of a mining title can occupy lands that are required for their mining operations without acquiring the property. Under Article 76 of the Mining Code the holder of the mining title is required to compensate other land users for any loss or damage sustained by the occupation of land. Land administration is detailed in Volume 2.

12.4.9 International Conventions

International conventions ratified by GRS relevant to the mining project are identified in the EIES. They are listed in Volume 2, along with comments on the implications of these conventions for the GCP and potential requirements for project operations.

12.4.10 World Bank/IFC Guidelines and Performance Standards

World Bank Environmental Health and Safety (EHS) Guidelines are technical reference documents that address IFC's expectations regarding the industrial pollution management performance of projects financed by the IFC. Banks subscribing to the Equator Principles also apply these guidelines to projects they finance. The guidelines are designed to assist managers and decision makers with relevant technical information to support actions aimed at avoiding, minimising and controlling EHS impacts during the life of a project.

IFC performance standards that are potentially relevant to the environmental and social management of the GCP as listed and discussed in Volume 2. In addition to the performance standards there are a number of guideline documents prepared by the IFC that may be applicable to the GCP (refer Volume 2).

12.4.11 Equator Principles

The Equator Principles provide a framework for financial institutions to determine, assess and manage environmental and social risk in project financing. Adherence to the principles ensures that projects are developed in a manner that is socially responsible and reflects sound environmental practices. In order to keep all options open with respect to financial backing for this project, GCO has elected to comply with the Equator Principles.

A complete statement of the principles is available from http://www.equator-principles.com. A summary is contained Volume 2.

12.4.12 African Development Bank Safeguard Policies

The African Development Bank Group Involuntary Resettlement Policy (November 2003) has been developed to cover involuntary displacement and resettlement of people as a result of bank-financed projects. It applies when a project results in relocation or loss of shelter by the persons residing in the project area, assets being lost or livelihoods being affected.

Details of the guiding principles are provided in Appendix 2.2 – Land, Asset and Livelihood Baseline Study of Volume 2.

12.5 Environmental and Social Context

12.5.1 Environment Context

The GCP lies within the area of the Niayes, an area of sand dunes with arable inter-dune depressions known as “niayes”. The niayes are situated mainly on the eastern side of the dunes in the hinterland areas and will generally not be impacted directly by the proposed mining operation, except during construction of the initial dredge pond. Also, during the first three years of operations, while the dredge moves along the eastern margin of the littoral sand dunes adjacent to the niayes, temporary changes to the water table in the vicinity of the dredge pond may occur. These changes may lead to temporary flooding of the niayes, while the dredge pond is nearby although every effort is being made to limit this effect via the inclusion of a lateral borefield adjacent to the active mining area as detailed in Section 8. Some of the agricultural areas on the littoral dunes, which are also in depressions and often more marginal than those in niayes, are likely to be impacted under the current year mine plan.

Three types of soils are present in the project area:

- Soils of white dune depressions.
- Soils of yellow dune depressions.
- Soils of red dune depressions.

These sandy soils are essentially young, have minimal organic matter and very low nitrogen content. To farm these soils it is necessary to enrich the soil with animal manure and/or organic and chemical fertilisers. This practice may already be causing nitrate pollution of groundwater (Sall & Vanclooster 2009), for example, 6 of 28 monitoring sites observed around the proposed project site on 13 January 2010 had groundwater nitrate concentrations in excess of the WHO recommended standard for drinking water of 50 mg/L.

Vegetation in the dunes within the proposed mining area is generally sparse. Several areas have been planted with eucalypts and casuarinas in an effort to stabilise the dunes and protect market gardens from encroachment by mobile sand dunes. Towards the eastern side of the exploration area, several native species, including cashews and *Parinari macrophylla,* provide forest fruits for local communities. Various endemic species and species on the IUCN Red List of Threatened Species occur in the general exploration area. Eleven threatened flora species and eight endemic flora species have been identified in the exploration permit area (Tropica 2005, Table 10.1). Detailed vegetation mapping will be conducted on the mine path and on the areas to be disturbed for infrastructure development prior to construction, to determine whether threatened, endemic or significant flora species are present.

The Niayes area is considered poor in wildlife, especially terrestrial animals. The only endangered species recorded for the area by Tropica (2005) are marine turtles, which use the beaches of the Grande Côte for nesting. No mining will take place in their nesting habitat.

Most rainfall infiltrates the sand dunes and recharges the groundwater. Some depressions between the dunes become swampy during the wet season due to rising water tables. Over the past 30 years rainfall has generally decreased and rainfall at the levels required to adequately replenish the groundwater system in the sand sheet aquifer has not occurred for many years.

Groundwater is accessed from wells and pits, which vary from a few metres to over 20 m deep. Groundwater is used for potable water, farm irrigation and watering stock. The groundwater table is approximately 11 m above sea level at Diogo, grading to 1 m above sea level close to the coast.

GCO has established an extensive piezometer field (in excess of 300 piezometers as of December 2009) across the entire exploration drilling area and commenced monitoring groundwater levels in April 2006. Results to date indicate a declining trend in groundwater levels in many piezometers, confirming the declining trends identified in earlier studies of the groundwater in this area (BRGM 1983).

Basement for the sand sheet aquifer is Eocene limestone. Underlying the Eocene limestone, at depths of more than 400 m, is an aquifer of Maestrichtian age, which will be used to supply water for mining, mineral processing and for potable applications.

In an effort to manage the available groundwater sustainably, the PAEP (Program of Support for Farmers' Entrepreneurship) has recommended a maximum net extraction rate of 15 m^3ph for groundwater from the sand sheet aquifer.

12.5.2 Social Context

Senegal has an estimated population of approximately 13.7 million people (July 2009, www.cia.gov). Nationally, the population density is 50 people per km^2. The majority of the population are Muslim (94%) with a Christian minority (5%) and the remainder following indigenous beliefs.

Thies, with an estimated population of 1.36 million people is one of the most populated regions (Ministere de l'Economie et Finances 2005) with 208 people per km^2. In the Rural Community of Darou Khoudoss, the region where mining will begin, the population was estimated at 39,683 in 2003 with an average population of density 76 people per km^2 (CR Darou Khoudoss 2004).

Principal ethnic groups are Wolof (86%) and Peul (13%). The Wolof and Peul in the project area share similar livelihood and social structures but the Peul have less secure access to land, community facilities (schools, health centres and roads), speak a minority language and are likely to have less representation in political structures.

The main occupation in the project area is agriculture, with the majority of adult men (92%) and women (58%) in the 2007 baseline survey area identifying agriculture as their principal occupation. Other occupations include fishing, fish processing, housekeeping, labouring, trades, and only 1% of men identified themselves as being unemployed or retired. Households within the project area are heavily reliant on cash income sourced from horticultural activities for the purchase of staple foods, supplementary foodstuffs, household items, and to manage emergencies such as medical expenses.

Life expectancy in Senegal is relatively low at 56 years. Infant mortality and under-five mortality rates are 78 and 137 (per 1,000 live births) respectively (UNDP 2006). Access to health facilities is a major constraint to the population of the Rural Community of Darou Khoudoss. Within the project area, health posts were identified in Darou Fall, Fass Boye and Lompoul (CR Darou Khoudoss 2004). Common health issues in the project area include malaria, dysentery, diarrhoea, parasites, malnutrition and tuberculosis (CR Darou Khoudoss 2004).

In 2006, the average French language illiteracy rate in Senegal was 41% (ANSD 2006). Based on interviews with heads of household from the project area, 28% of males and 42% of females described themselves as illiterate. Only 10% of men and 8% of women have attended primary school. Within the project area, French language primary schools are located in Darou Fall, Fass Boye and Lompoul (CR Darou Khoudoss 2004). All of these facilities are located more than 10 km from the dune settlements of Foth and Diourmel. The closest secondary school to the project area is in Mboro, a further 17 km south of Diogo. GCO has recently constructed a kindergarten in the village of Diogo.

12.5.3 Climate

Senegal is located in the Sahel, the arid semi-desert or savannah region that forms a broad band across Africa between the Sahara desert to the north and forested areas to the south. The Grande Côte has a tropical climate with distinct wet and dry seasons. The wet season is from June to October, with most rain falling in August and September. In the southern end of the exploration area around Mboro, average annual rainfall is approximately 425 mm. Further north, around the Lompoul area, average annual rainfall is approximately 350 mm.

In Dakar, average maximum daytime temperatures are around 24°C from January to March and between 25°C and 27°C in April, May and December. From June to October, temperatures rise to around 30°C.

12.6 Environmental and Social Aspects and Impacts

The Environmental and Social Impact Assessment for the GCP (EIES) was completed by Tropica Environmental Consultants in November 2005 (Appendix 2.3, Volume 2), prior to final decisions on the locations of various infrastructure items.

The current proposed mine path extends further north than the originally proposed mine path. The environmental and social impacts for the current mine path are expected to be similar to those identified in the EIES in 2005.

The EIES included an environmental and social management program (Plan de Gestion Environmentale et Sociale [PGES]), which proposed measures to mitigate the potential impacts of the GCP, as well as a system for supervising the implementation of the mitigation and monitoring measures. The PGES consisted of three plans:

- A Natural Resources Management Plan (Plan de Gestion des Ressources Naturelles [PGRN]).
- A Social Management Plan (Plan de Gestion Sociale [PGS]).
- A Hygiene–Health–Safety Management Plan (Plan Hygiène–Santé–Sécurité [PHSS]).

The EIES proposed that GCO would undertake consultation on each plan with an external technical committee. The external technical committees will be informed of the likely mitigation measures to be implemented and will be asked to advise on the impacts of the mitigation measures being implemented.

The environmental and social management programs proposed in the EIES have been updated and are summarised in Tables 12.1 to 12.8.

Table 12.1 Natural Resources Management Plan - Flora and Fauna

Potential Negative Impacts	Mitigation Measures	Implementation Methods	Time Frame for Implementation	People Involved	Key Performance Indicator
Loss of vegetation (both local species and plantation species) in the dredging path, around MSP	Replace recent plantations Revegetate degraded land and older plantations Revegetate around MSP on closure Give cleared vegetation to local people via defined process/procedure	Define clearing program Undertake planting trials Prepare a rehabilitation program Scale up production at local tree nurseries Produce seedlings Plant and maintain	Before the start of operations Before the start of operations Before the start of operations Before the start of operations At the start of operations During operations	GCO, Forestry Commission PRL CR Committee of local people (Forest Union, GIE intercompany management syndicate, men, women, etc.)	Mapping Success of planting trials Complete Logging Plan Complete Rehabilitation Plan Progress in planting program
Removal of individual trees of local species	Replace removed trees	Set up a Logging Plan and a process to identify key examples of local trees to be specifically replaced Awareness	Before mining starts	GCO Forestry Commission	Numbers of removed/replaced trees
Habitat destruction	Rehabilitation process for mined areas Community conservation zones Managed faunal reintroduction	Prevention measures Identify appropriate habitats Long-term faunal reintroduction program	Following mining	GCO Forestry Commission CR Local people	Habitat condition
Encroachment on the Community Nature Reserves (Réserves Naturelles Communautaire – RNC)	No measures proposed – no RNC in project area				
Loss of vegetation outside dredge path (e.g. around tracks)	Use existing tracks and roads where possible to minimise vegetation loss	Identify and use existing tracks and roads	Before the start of operations	GCO	Mapping of tracks and roads

Potential Negative Impacts	Mitigation Measures	Implementation Methods	Time Frame for Implementation	People Involved	Key Performance Indicator
Illegal logging	Surveillance of clearing Anti-poaching measures	Signs prohibiting tree clearance/logging Anti-clearing regulations for project site Verbal briefings on anti-clearing regulations	At the start of operations During operations	GCO Forestry Commission CR	Regulations handbook Conduct verbal briefings on regulations
Risks of delay in the process of rehabilitation (depending on the season, by comparison with the speed of mining)	Careful timing of rehabilitation	Prepare a Rehabilitation and Closure Plan (tree nurseries, planting, etc.)	At the start of operations	GCO Forestry Commission CR Local People Heads of villages	Project plan Observation
Risk that best adapted local species are excluded	Nurseries use known local species	Good control of sylviculture for targeted species	Before the start of operations	Forestry Commission Local People Heads of villages	Condition of nurseries
Lack of maintenance of plantations	Produce an integrated planting and maintenance plan	Implement maintenance regime, identifying participants and their roles	At the start of operations	GCO National Forestry Commission CR Heads of villages	Report plantation maintenance activities Monitor development and outcomes for plantations

Table 12.2 Natural Resources Management Plan - Landscapes

Potential Negative Impacts	Mitigation Measures	Implementation Methods	Time Frame for Implementation	Person(s) in Charge	Key Performance Indicator
Visual impact of introduced buildings/infrastructure	Remove infrastructure at the end of the project Design and Construct camp using easily removed buildings/ infrastructure	Dismantle and remove introduced buildings/infrastructure at end of project Consider these issues in project specifications	End of the project At the start of the project	GCO/local community GCO	All introduced buildings/infrastructure removed from project site Include in project specifications
Waste discharge	See Hygiene–Health–Safety Plan				
Risk of disturbance of archaeological sites	Train dredge operators to recognise shelly masses on the surface Raise awareness with dredge operators of the possibility of finding shelly masses Inform the authorities when possible archaeological sites are discovered	Train dredge operators to recognise shelly masses on the surface	Before start of mining activities	GCO	Numbers of training sessions for mine operators to recognise shelly masses
Soil compaction and subsidence	Establish direct transport routes and avoid productive land (avoid multiple tracks)	Research land use and the role of local authorities	At the start of the project	GCO and the local authorities	Project site layout plan
Existing land uses within the mining area will be halted temporarily while mining proceeds (agriculture, forestry,	Mined areas will be rehabilitated to pre-existing uses at the end of the project, or will be planned in a suitable	Dialogue with appropriate authorities/grower representatives/ GCO	At the start of the project	GCO and the local authorities	Agreed Rehabilitation and Closure Plan

Potential Negative Impacts	Mitigation Measures	Implementation Methods	Time Frame for Implementation	Person(s) in Charge	Key Performance Indicator
tourism, etc.)	manner for specific uses				
Destruction of soil structure and reduction in fertility	Drivers trained to use designated tracks	Driver training courses	At the start of the project	GCO	Number of driver training courses providing information and raising awareness
Risk of dune erosion being increased by the wind	Minimise the time between clearing and rehabilitation of the dunes in the mine path	Immediate rehabilitation of the mined dunes	For whole project life	GCO	Constant rate of rehabilitation
Risk of accidental or systemic hydrocarbon contamination of the soil	Secure hydrocarbon storage	Impermeable retention system	At the start of the project	GCO	Layout plan for production site
Risk of soil contamination from accidental or systemic discharge of liquid or solid wastes from domestic or mechanical sources	See Hygiene–Health–Safety Plan				

Table 12.3 Natural Resources Management Plan - Groundwater

Potential Negative Impacts	Mitigation Measures	Implementation Methods	Time Frame for Implementation	Person(s) in Charge	Key Performance Indicators
The MSP will use groundwater for domestic and production purposes	Groundwater for project use will be pumped from the deeper aquifer, not from the sand sheet aquifer	Inform pumping personnel about pump discharge limits	From the start of project	GCO DGPRE	Pump meter readings
Liquid effluents from MSP may contaminate groundwater	See Hygiene–Health–Safety Plan				
Accidental or systemic pollution of groundwater by hydrocarbons	Store hydrocarbons in accordance with standard practice Train and raise awareness among personnel responsible for refuelling machines Conduct refuelling in impermeable areas using trained personnel, aware of the risks	Establish impermeable retention system Organise training courses Monthly sampling of the groundwater for laboratory analysis	Before the start of project	GCO Specialised company for disposal of hydrocarbon contaminated wastes	Enter into contract with hydrocarbon specialist Number of training and awareness sessions for targeted personnel Monthly hydrochemical analysis
Risk of groundwater drawdown in the project area due to: • Dredge pond intake • Evaporation • Pumping	Install piezometer network to monitor water table fluctuations on three monthly basis	Undertake subsequent work to plot three monthly water table fluctuations	Throughout the project	GCO DGPRE	Quarterly report on water table variations
If water table in dredge pond was lowered, the cone of depression could potentially affect other activities using groundwater (agriculture	Operate dredge pond at an elevated level by providing make-up water	Make-up water provided from deep bore	Throughout the mining operation	GCO DGPRE	Groundwater levels

Potential Negative Impacts	Mitigation Measures	Implementation Methods	Time Frame for Implementation	Person(s) in Charge	Key Performance Indicators
areas, etc.). This could reduce groundwater available in nearby wells.					
The dredge pond exposes the water table, making it vulnerable to various sources of pollution, for example lubricants and hydrocarbons from the dredge motors	Daily visual checking of potential sources of hydrocarbon or oil discharges from motors in the dredge pond The project will not use any chemical products	Regular inspection of tank integrity where potential pollutants are found in motors, including gear-case, tanks, etc.	Every week	GCO	Motor inspection reports
The dredging activities could accidentally damage the impermeable substrate of the layer	None required. The depth to the impermeable substrate is known to be below the maximum dredging depth	None required			
Working through the sand unit and removing of fines could potentially modify the hydraulic parameters of the aquifer (permeability, coefficient of storage, transmissivity)	The hydraulic parameters of the aquifer will be recalculated following mining. If the assumptions about aquifer modification are confirmed, a new appropriate discharge limit for the groundwater will be calculated and the DGPRE will be informed	Conduct pumping tests	At halfway At the end of the project	GCO DGPRE	Hydraulic parameters updated

Table 12.4 Social Management Plan

Potential Negative Impacts	Mitigation Measures	Implementation Methods	Time Frame for Implementation	Person(s) in Charge	Key Performance Indicators
Encroaching on fields	Government mandated compensation provided	Official compensation rate/ livelihood restoration	Before the beginning of the activity that will affect people	Local communities GCO Administration Affected people	Number of cases settled Level of satisfaction of affected people
Conflicts with community concerning their lack of involvement	Favour local labour Tell the local population about the project and its activities	Continuous consultation	Before the start of activity	Local communities GCO Populations	Number and percentage of the local people employed
Occupancy of the pasture zones	Government mandated compensation provided to affected livestock producers	Map land use Provide support for domestic animals by providing new grazing or by providing animal feed	Before the beginning of activities that will affect people	Local communities GCO Technical services of State Affected people	Number of settled cases Level of satisfaction of the affected people
Disruption of commerce and trade (weekly markets)	New road to be constructed to bypass the village	Support the market by providing a parking area Construct new road	Before the start of activity	Head of the village Local communities assisted by GCO	Status of market organisation Level of satisfaction of affected people
Moving of occupants or activities	Government mandated compensation provided	Official compensation rate/ livelihood restoration	Before the start of activities that are a source of impact	Local communities GCO Administration Affected people	Number of settled compensation cases Level of satisfaction of the affected people
Risk of market gardening activities being disturbed	Government mandated compensation provided	Official compensation rate/livelihood restoration	Before the start of all the activities that are a source of impact	Local communities GCO Technical services of State Concerned people	Number of settled compensation cases Level of satisfaction of the affected people

Table 12.5 HHSMP* - Risk of Impacts on Hygiene, Health and Living Environment

Potential Negative Impacts	Mitigation Measures	Implementation Methods	Time Frame for Implementation	Person(s) in Charge	Key Performance Indicators
Discharge of solid waste	Effective management: collection, treatment, and removal Organising and regulating land use around the MSP to ensure a healthy living environment Raise awareness among workers and MSP operators	Composting and/or burning of organic waste Removal of the remainder to landfill Separation and recycling of inorganic waste Raise awareness among workers about sorting wastes Make a person within GCO responsible for maintaining hygiene Establish rules for the management of waste and provide these for workers and MSP operators	At commencement of construction	GCO, through the person responsible for hygiene Recycling organisations (local crafts for instance)	State of living environment
Discharge of liquid wastes: sewage	A sewage treatment plant is being installed	Secure septic tank for toilets. Drain and close when decommissioned Install portable toilets on the dredge	At setting up	GCO with the help of a sanitation specialist	Operational condition of sanitation system
Discharge of waste oil	Collection of waste oil and delivery to a centre specialising in the disposal of these products	Seek advice and support from a fuel and lubricant supplier	At the start	GCO with support of a specialist	Quantity of used oils collected and treated compared to that used (proportion collected and treated)

**Hygiene-Health-Safety Management Plan*

Table 12.6 HHSMP -Sanitary Impacts

Potential Negative Impacts	Mitigation Measures	Implementation Methods	Time Frame for Implementation	Person(s) in Charge	Key Performance Indicators
Respiratory diseases caused by dust inhalation	Wear masks (workers) Raise awareness among communities Plant trees, where necessary, along major roads and tracks used by mine vehicles Support for local health systems Road watering	Include these diseases in workplace disease prevention planning Design and implement tree plantings Collaborate with local health agencies	Design at the start Implement immediately	GCO With support of DEFCCS and with the collaboration of local people	Occurrence of respiratory disease Assessment of local communities
Potential spread of STDs/AIDS (MST/SIDA)	Raise awareness among staff and local communities about the risks of STDs/AIDS Organise and regulate the MSP surroundings to reduce risky social behaviour	Collaborate with the local Health District (DS) in which the site is situated	At the start and throughout the entire project	GCO Affected Health District (DS)	Number of awareness-raising meetings
Other diseases (for example, malaria where standing water is found)	Monitor vectors Raise awareness of workers and local communities about these diseases and measures for their prevention	Implement prevention and control measures if necessary	When dredge pond established	GCO Affected Health District (DS)	Occurrence of disease

**Hygiene-Health-Safety Management Plan*

Table 12.7 HHSMP - Safety Risks

Potential Negative Impacts	Mitigation Measures	Implementation Methods	Time Frame for Implementation	Person(s) in Charge	Key Performance Indicators
Risks of accidents involving local people	Road/track markings Implement speed bumps Raise awareness among drivers Provide alternate/dedicated roads for site access	Define rules/standards to be followed by all drivers working on the project Bypass for markets	At the start	GCO	Number of accidents
Fire hazard or explosion	Implement a functional fire management system where hydrocarbons are handled and stored	Design and implement a fire risk management system Include safety clauses in contractor specifications	At the start	GCO with the assistance of a specialist when needed Contractors	Number of incidents
Risk of industrial accident	Wear life jackets when on the dredge pond Specific safety plan for each part of the project	Develop and implement a comprehensive safety plan for workers Adopt safe working practices in the various work places	At the start	GCO	Number of industrial accidents

**Hygiene-Health-Safety Management Plan*

Table 12.8 HHSMP – Risk of Impacts on Hygiene, Health and Living Environment

Potential Impacts on the Environment	Mitigation Measures	Implementation Methods	Time Frame for Implementation	Persons in Charge	Key Performance Indicators
Air pollution	Choose generators with low emission levels Conform to current accepted Senegal emission standards Burn natural gas	Assess generators, considering their impacts on the environment Monitor pollution and air quality Identify remedial measures and implement when necessary		GCO with the support of a specialist	Levels of the following parameters (CO_2, NO_x, SO_x, etc.)
Nuisance caused by sand raised by vehicles	Limit vehicle speed through villages Protect dwellings Collaborate with local health agencies	Raise awareness and direct drivers if needed Collaborate with local health agencies	Design at the start Implement immediately	GCO with the support of DEFCCS in collaboration with local communities	Occurrence Assessment of local communities
Noise pollution (noise from vehicles and motors)	Prevent through vehicle choice Attenuate through traffic schedules	Apply this principle within GCO and require contractors to undertake as well Reduce traffic during resting hours	At the start	GCO	Assessment of local communities

**Hygiene-Health-Safety Management Plan*

12.7 Environmental and Community Objectives and Targets

Details of environmental and community objectives and targets are provided in Volume 2 and a detailed list is contained in ESMMP (Appendix 2.1, Volume 2).

The environmental and community objectives and targets incorporate:

- Groundwater.
- Tailings management.
- Erosion and sediment management.
- General waste management.
- Hazardous materials management.
- Biodiversity conservation.
- Revegetation and rehabilitation.
- Noise.
- Air quality.
- Archaeology and cultural heritage.
- Traffic management.
- Community relations and development.
- Radiation.

12.8 Environmental and Community Programs and Management Plans

The following environmental and community programs and management plans will be developed for the GCO:

- Rehabilitation and Closure Plan, including:
  - Topsoil Recovery, Stockpiling and Re-Spreading Plan.
  - Seed Sourcing and Growing Plan.
- Revegetation Maintenance and Monitoring Plan.
- Acid Sulphate Soil Management Plan (if necessary).
- Groundwater Quality Monitoring Plan (proposal developed by Umwelt 2010).
- Groundwater Table Monitoring Plan.
- Wind Erosion Monitoring Plan.
- General Waste Management Plan.
- Logging Plan.
- Radiation Management Plan.
- Public Consultation and Disclosure Plan.
- Resettlement Action Plan/Social Development Plan.

- Social Development Plan.

12.9 Implementation and Operation

12.9.1 Structure and Responsibilities

The structure of the Environmental Management System (EMS) and its associated supporting documents is shown in Figure 5.1, Volume 2. The Environmental and Social Impact Assessment (EIES) (Appendix 2.3, Volume 2), the Environmental and Social Management and Monitoring Plan (ESMMP) (Appendix 2.1, Volume 2), the Environmental and Social Monitoring Manual (ESMM) (Appendix 2.4, Volume 2), the Emergency Response Plan - Environment (ERP-E) (Appendix 2.5, Volume 2), and the Conceptual Closure Plan (to be developed) are all essential parts of the EMS. As environmental procedures and plans are developed to manage or mitigate potential environmental impacts, they will be incorporated into the EMS.

The implementation, day-to-day management and continued improvement of the EMS for the GCP will be the responsibility of the environmental superintendent, who will report directly to the General Manager. The environmental superintendent will also be responsible for maintenance of the risk register for the GCP, which will be used to prioritise allocation of staff and financial resources in line with the site operational and business plans.

12.9.2 Training, Awareness and Competence

GCO will recruit appropriately experienced and qualified personnel to ensure that the requisite knowledge and skills are available on site to achieve environmental and community relations policies, objectives and targets.

For the GCP, GCO will employ as many Senegalese personnel as is feasible. GCO will develop and implement a training program to increase the proportion of Senegalese staff working for the company. A competency-based training scheme will be implemented and used as the benchmark for local people to progress and work towards higher levels of competence in their field.

All new employees and contractors will be required to complete a structured site induction, detailed in Volume 2. All staff will receive an Induction Manual, which summarises the site induction program.

Training will be ongoing to improve the environmental and social understanding, capabilities and performance of personnel and contractors. In addition, specific training will be provided to personnel involved in:

- Maintaining and operating pollution control and radiation monitoring equipment.
- Storing and handling hydrocarbons and other hazardous materials.
- Responding to environmental incidents and emergencies.
- Work that involves potential or actual significant environmental risk.

Cross-cultural awareness will be a key emphasis of induction and training programs.

Records will be retained of all persons inducted. All employees and contractors will be required to undertake a re-induction every two years.

12.9.3 Communication

12.9.3.1 Internal Communication

Effective internal communication aims to raise general awareness of environmental and social issues in the workforce.

Approximately 80% of the Senegal population speak Wolof as a first or second language. About 20% of men and about 2% of women understand French. In Senegal about 50% of men and 30% of women are literate.

Internal communication on GCP sites will take place in Wolof, in French and in English. Written notices placed on noticeboards will be in English. Verbal notices will be used in Wolof and in French to ensure illiterate employees can also receive information.

Results from the environmental and social monitoring program will be presented internally at monthly or quarterly management meetings, unless there is cause for more rapid consultation.

12.9.3.2 Incident Reporting

An environmental or social incident is defined as any uncontrolled event that impacts on, or may potentially impact on the environment or community, or any activity resulting in regulatory non-compliance or the breach of company policies, standards or commitments. It also includes community complaints.

Incidents will be risk assessed and ranked and then classified according to their environmental/social impact. A written environmental and social incident report will be submitted to the mining superintendent within 24 hours of the incident occurring, and presented to the mine operations manager at the first management meeting following the incident, unless the severity of the incident requires immediate notification as in the case of major and critical incidents.

Information to be included in the incident report is listed in the ESMMP (Appendix 2.1, Volume 2).

12.9.3.3 Reporting

The environmental superintendent will report on the progress of ESMMP implementation and performance against the Continuous Improvement Targets as part of routine reporting to the mining superintendent.

At the end of every calendar year, GCO will prepare an Annual Environmental and Social Report for the GCP.

12.9.3.4 External Communication

Monthly meetings with local authorities will be held and will continue to be held between GCO and key marabouts, village chiefs, president of rural council, and sous-prefect. These meetings will continue throughout the life of the GCP.

Quarterly reports on environmental management will be submitted to the Department of Mines and Geology (Direction des Mines et de la Géologie), within the Ministry of Energy and Mines (Ministère de l'Energie et des Mines) in Dakar and the Department of Environment (Direction de l'Environnement et des Etablissements Classés), within the Ministry of Environment and Nature Conservation (Ministère de l'Environnement et de la Protection de la Nature).

For the first two years of mining, a six-monthly report on groundwater quality and groundwater levels will be submitted to the Division of Management and Planning of Water Resources (Division de Gestion et de Planification des Resources en Eaux). If, after two years, the division is satisfied with the results for groundwater quality and groundwater levels, then GCO will provide subsequent reports on an annual basis.

12.9.4 Operational Control

As part of its EMS, GCO will develop and document procedures to deal with significant environmental aspects of its operations. These procedures will aim to ensure that the operations are conducted in a manner that will control or reduce the adverse environmental impacts associated with them.

All environmental issues identified since the production of the EIES are shown in Table 12.9.

Table 12.9 Environmental Issues Identified for Grande Côte Project

Environmental Issue	Relevant Section of Volume 2	Environmental Issue	Relevant Section of Volume 2
Groundwater Quality	5.6.1	General Waste Management	5.6.11
Groundwater Quantity	5.6.2	Hazardous Materials Management	5.6.12
Surface Water	5.6.3	Radiation	5.6.13
Erosion and Land Stability	5.6.4	Transport and Traffic Safety	5.6.14
Revegetation and Rehabilitation	5.6.5	Biodiversity and Conservation	5.6.15
Mine Path Tailings	5.6.6	Archaeology and Cultural Heritage	5.6.16
Mineral Separation Plant Tailings	5.6.7	Energy and Emissions	5.6.17
Noise	5.6.8	Visual Aspects	5.6.18
Wind-blown Dust and Sand	5.6.9	Cumulative Impacts Assessment	5.6.19
Air Quality	5.6.10	Rehabilitation and Closure	5.6.20

Each environmental issue is discussed in detail in Volume 2 and the mitigation measures proposed to manage its impacts are outlined. A summary of the environmental issues is shown below.

12.9.4.1 Groundwater Quality

Groundwater quality in the sand sheet aquifer may potentially be affected through discharge from point sources such as fuel tanks, lubricant stores or human waste disposal systems, as well as through diffuse discharge from the use of agrochemicals and fertilisers used in revegetation.

An issue for consideration is the potential impact of acid sulphate soil oxidation. Although the Grande Côte or body is a very low-sulphur system, and no evidence of pyrite has been noted in the sands or the humic material (peat), any potential acid sulphate soil identified in the dredge path will be treated as noted in the following paragraphs.

It should be noted that some high values of specific contaminants have already been measured in the existing groundwater monitoring and are detailed in Volume 2.

Fuel, Lubricants and Reagents

Refuelling of vehicles may cause contamination of the ground. The background level of hydrocarbons in groundwater will be monitored prior to the project commencing. Vehicle and plant operators will be trained in refuelling procedures and in spills management.

Fuel tanks will be established in an impermeable and bunded retention system to provide secure hydrocarbon storage. Lubricants will be stored in open-sided sheds constructed with concrete bunded floors.

Hydrocarbons and reagents will be handled according to industry leading practice guidelines. The use of hydrocarbons on the dredge will occur directly over the groundwater body. To minimise the potential for hydrocarbon contamination, potential sources of contamination on the dredge will be checked regularly.

The concentration of hydrocarbons will be monitored in groundwater sampling undertaken around substantial fuel stores, around fuel handling areas and in the dredge pond water.

Fertiliser, Agrochemicals

During the revegetation phase of the project, agricultural fertilisers and agrochemicals will be used to encourage the re-establishment of trees and other vegetation following the passing of the dredge.

Existing fertiliser and agrochemical use is likely to be found around the project site. The background level of nitrates (a derivative of fertilisers) and organophosphates will be monitored prior to the project commencing. Fertilisers and agrochemicals (if used) will be applied at a rate that minimises their discharge to groundwater.

The concentration of nitrates and the concentration of organophosphates in groundwater will be monitored as part of the groundwater monitoring program.

Sewage Systems, Pit Toilets

The sewage system will collect, transfer and treat human waste in a manner that minimises discharges to groundwater and minimises impacts on the environment.

Existing private toilets and animal dung are likely to have contaminated groundwater, particularly around niayes, where the water table is close to the surface. The background level of faecal coliforms will be monitored prior to the project commencing.

The concentration of faecal coliforms in groundwater will be monitored as part of the ongoing groundwater monitoring program.

Potential Acid Sulphate Soil

There is potential for acid sulphate to be generated when humic or acid forming material is excavated during dredging and placed in a position where it can be oxidised (e.g. in the tailings).

If it takes place, acid sulphate generation is most likely to occur within the dredge tailings pile in the months following dredging. The maximum rate of acid sulphate generation is likely to occur within a few years of the tailings being stacked in air. The rate of acid sulphate generation is likely to decline in the years following the maximum generation rate, as the material remaining to be oxidised decreases in volume.

The potential for acid sulphate generation will be minimised by identifying, where feasible, high humic content materials and placing them below the water table as the dredge moves forward. This will prevent oxidation of any sulphides present.

Where, despite this mitigation measure, there is a significant potential for acid sulphate drainage to be generated, it may be mitigated by incorporating lime into the tailings as they are stacked.

If acid sulphate is generated despite these mitigation measures, it will be detected by the groundwater quality monitoring program. In this situation, mitigation measures will be developed to prevent groundwater of inadequate quality being used for irrigation, for stock watering or for human consumption.

12.9.4.2 Groundwater Quantity

Water used from the surficial groundwater body will include water drawn into the dredge pond from surrounding groundwater (when mining at the water table), water for dredge operation, and losses to evaporation. Groundwater used from the surficial sand aquifer will be replaced by groundwater obtained from the deeper Maestrichtian aquifer.

Processing at the mineral separation plant (MSP) will require approximately 50 m^3ph. Following processing, wet tailings will be returned to the dredge pond from the MSP by pipeline.

A deep water bore adjacent to the MSP will be used to supply process water and potable water for the MSP and water for rehabilitation nurseries. Several deep water bores spaced along the dredge path will be used to supply make-up water for the dredge pond.

The deep water bores will obtain water from the deep Maestrichtian aquifer, which is not connected to the surficial sand aquifer in which the dredge is operating. There will be a net gain of groundwater volume in the surficial sand aquifer. Further details on water and the overall site water balance are described in Section 8.

Existing water table levels are being monitored prior to the commencement of the project. During the project, water table levels will be monitored around the dredge pond and throughout the exploration area.

12.9.4.3 Surface Water

The only surface water present in the project area is the water contained in small ponds in the niayes, where trenches have been dug by farmers to intersect the groundwater body (groundwater trenches) and to provide water for irrigation. No flowing streams are found in the GCP area.

Where the dredge pond is close to niayes, and the groundwater is raised, there is potential to temporarily flood the niayes. This flooding will be short-lived, subsiding as soon as the dredge has passed by. The impacts of this flooding will be minimised through installation and pumping of a two lines of containment bores, one each side of the dredge path. The bores will be spaced at 50 m intervals, and installed to 30 m depth. Compensation will be provided for individuals farming flooded niayes for the period that their crops are affected.

12.9.4.4 Erosion and Land Stability

Vegetation will be left intact on road verges and batters where possible and silt fences may be installed where wind-blown sand is obstructing the road. Any erosion and sediment control structures will be inspected following major rainfall events (>50 mm in a day), following maintenance and repairs and at the end of each wet season. Documented procedures will be developed for maintaining and repairing erosion and sediment control structures.

12.9.4.5 Rehabilitation and Revegetation

About 10% of the existing dunes within the 10-year dredge path are active and not vegetated. The remaining 90% of dunes currently vegetated have a range of different land covers, including gardens, scrubland, savannah, woodland and plantation forest.

The EIES listed 11 threatened plant species in the Niayes area. It is understood that these species occur in the depressions, not on the dunes, and therefore, not in the mine path. However, threatened plant species may occur at the dredge construction site. Baseline vegetation surveys will be conducted in proposed construction and mining areas to identify threatened plant species and to assist in planning revegetation strategies.

Despite these difficulties, plantations of filao (casuarina) and eucalypt have been established successfully on parts of the dunes, under a Japanese aid (JICA) project and by the Forestry Department in sustain campaigns.

GCO intends to consult with local communities on vegetation clearance. This consultation will include consideration of how to manage the disposal of firewood and timber from areas cleared of vegetation in a manner that benefits local populations.

GCO will develop and maintain a database to record the consultation undertaken on vegetation clearing. This will be part of the Revegetation Procedures Plan to be developed as part of the EMS.

Consultation with local communities who farm small areas on top of the dunes will be necessary to ensure that they are fully informed of the proposed mining and potential impacts on their farms. Communities identified within the proposed mine path during the Land Asset and Livelihood Baseline Survey (Earth Systems 2009) will be consulted further once the final mine path is determined. Their system of organic enrichment of topsoil within dune depressions will be implemented following mining, to restore land suitable for future farming purposes.

In consultation with stakeholders, GCO will develop a rehabilitation strategy for the GCP that will define the final site rehabilitation objectives, and establish quantifiable criteria to help determine rehabilitation success.

As part of the Annual Mining Operations Plan, a vegetation survey of the proposed dredge path will be conducted and authorisation sought from the Forestry Commission for clearing. Impacts on protected species will be managed by avoiding them, by replacement planting, or by offset planting.

Rehabilitation trials will be conducted prior to the start of mining. Rehabilitation trials and baseline surveys will be used to determine what general categories of land use will be rehabilitated and where this rehabilitation will take place.

The winds in Senegal are from the northern quadrants, with north-easterly and north-westerly components dominating. The highest wind speeds occur in the period February to May. Dry sand grains move along the surface of a dune (by hopping) when wind speeds reach about 0.8 m/s. When wind speeds reach about 2 m/s, medium-size sand can be carried in suspension in the wind. The sand dunes at the project site are naturally migrating towards the south-west.

Sand is not expected to be blown by the wind during the period when the sand dunes are being reformed with the tailings elevator due to the water content of the tailings. Following dredging, barren tailings sand has the potential to be transported at rates higher than occurred prior to the dredge's passing.

To restrict wind erosion of the tailings, long-term dune stabilisation methods will be required. In areas where dune erosion will not affect any surrounding land, it may be appropriate to allow wind erosion to continue for a short period, allowing some flexibility in the timing of dune stabilisation. However, where dune erosion has the potential to affect market gardens or settlements, and the area was vegetated prior to mining, dune stabilisation by revegetation should begin shortly after the dredge has passed through the area.

The dunes may need to be stabilised in the short term, to allow plants adequate time to grow. Methods available for dune stabilisation include windbreaks made from natural materials, as is the current practice of the Senegalese Forestry Department, and/or options such as include planting of a cover crop such as oats or sorghum; the use of Terolas (bitumen emulsion); the placement of mulch; or installing brush matting.

Dune stabilisation may only be required for long-term rehabilitation on steep slopes (more than 15%). However, prior to vegetation re-establishing, dune stabilisation may be required on all slopes if sand is blown at a significant rate from the bare dunes.

The dredge tailings will be shaped mostly by the tailings elevator into landforms that approximate the original dune landforms. Where necessary, the tailings may also be shaped mechanically.

Any soil or surface humic material present in the dune systems will be retained separately as the dredge passes through the dunes. This material will be replaced on the rehabilitated dunes, to offer a seed and nutrient source for replanting.

The perimeter of buildings associated with the project will be planted with local plant species to establish a visual barrier and to assist in stabilising the area.

There are two main existing types of vegetation cover that may be re-created by revegetation:

- Plantations of exotic species such as casuarinas (filao) or eucalypts. Eucalypts consume significant quantities of water to sustain their rapid growth. This rate of water consumption could be detrimental to the availability of groundwater for other uses.
- Revegetation with native species may provide a more sustainable alternative if local forest fruit species, fodder species, species of pharmaceutical interest and species capable of fertilising the soil.

Native and plantation plant production will be undertaken at either a nursery established for the purpose at the mineral separation plant site or via a partnership with the community and/or the Forestry Department's nursery at Lompoul.

GCO will develop a Rehabilitation and Closure Plan and release criteria in consultation with appropriate government and community organisations.

Further details of the revegetation strategy are provided in the ESMMP (Appendix 2.1, Volume 2).

12.9.4.6 Mine Path Tailings

A minor amount of humic material occurs as lenses within the sand body. Mining of humic materials from below the water table may lead to oxidation of sulphur and generation of acid in the tailings following mining.

An acid-sulphate soil contingency management plan will be developed prior to mining if tests indicate there is potential for acid generation. Further details of this strategy are provided in the ESMMP.

A detailed topographic plan of the mine path is available to guide post-mining landforms. Groundwater entrained in the tailings will gradually percolate downwards to the groundwater table. Revegetation will be undertaken on those mined areas that were vegetated prior to mining.

12.9.4.7 Mineral Separation Plant Tailings

Processing of the non-magnetic mineral concentrate at the MSP will produce approximately 90,000 tpa of tailings, which will be pumped continuously back to the dredge location and incorporated in the reformed dunes as a tailings stream. Continuous return of the tailings stream will avoid stockpiling of tailings at the MSP site.

All mineral sands are considered to be naturally occurring radioactive materials (NORM), due to the presence of thorium and uranium in the mineral grains. As a rule, the elements of the ^{232}Th and ^{238}U decay chains are present in the minerals in a state of secular equilibrium (Calytrix Consulting 2008). Analyses of the tailings produced at the MSP will be conducted to establish likely dose rates for workers exposed to the tailings. Exposure is, however, expected to be negligible given that tailings will not be stored at the MSP before being pumped back to the mine for incorporation in the reformed dunes. Dust suppression measures will be implemented whenever necessary to minimise inhalation of tailings or products. Workers potentially exposed to applicable areas/concentrated mineral products will wear a personal radiation exposure badge to measure their annual exposure rate. Further details on radiation exposure monitoring are provided in the ESMMP.

12.9.4.8 Noise

Noise emissions are expected to be generated during both construction and operation phases of the GCP. The closest dwelling to the proposed initial mine site is a farming labour camp, some 780 metres away to the south.

It is anticipated that the distance from the power plant to the closest dwelling will not change during the project. The MSP site is not expected to attract settlement close by as there is no water supply on this sand dune area. The MSP site will be fenced and security will be provided. GCO will maintain close liaison with the village chief and the sous prefect in regard to dealing with the possibility of people settling close to the MSP site.

Noise emissions will be managed to meet established site-specific environmental noise quality objectives. Article R84 of the Environment Code's Application Decree states that maximum noise levels should be 55 dB during the day and 40 dB during the night at the nearest residential receiver.

A noise assessment will be made for each construction site, based on the equipment to be used, proximity to the nearest residences, topography and proposed hours of operation. After commissioning of the MSP and in conjunction with consultation with all relevant stakeholders per the EMS, a noise model may be developed to determine what, if any, additional noise control measures are required to ensure compliance with the Environment Code noise levels.

In accordance with the noise assessments, the following noise control measures may need to be implemented to reduce noise emissions from the sites:

- Noise generated from reversing alarms may need to be regulated to reduce intrusiveness, particularly at night. For example, alarms may be set at 10 dB(A) above the ambient noise level.
- If necessary, vehicles operating at the MSP may be fitted with smart reversing alarms rather than tonal reversing alarms.
- Where appropriate, sound barriers, such as bund walls, will be used to minimise noise transmission from operational areas.
- Temporary acoustic shielding may be necessary to shield machinery noise during construction of the initial mine site and MSP.

The following steps will be taken to minimise noise emissions from mine traffic:

- Truck exhaust systems will be maintained regularly to minimise noise.

- Exhaust braking within the vicinity of villages will be limited.
- Truck movements through villages north of Diogo may be restricted to daylight hours to minimise potential noise impacts and avoid sleep disturbance. It is likely that a parallel by-pass road will be constructed by GCO to provide an alternative transport route between the MSP site and Darou Khoudoss, thereby avoiding approximately 16 villages.

Noise produced by the ongoing operation of the dredge may impact on residents living within close proximity to the proposed mine path. The potential for noise disturbance will be assessed once the sound power levels of all equipment on the dredge are known. GCO if necessary will develop a compensation assessment program and will provide temporary disturbance compensation if required.

12.9.4.9 Wind-blown Dust and Sand

High levels of wind-blown dust and sand occur naturally in Senegal. Strong Harmattan winds frequently blow dust from the Sahara and sub-Saharan regions as far west as North America.

The two generally dominant wind directions in the Grande Côte are north-easterlies during November to April and westerlies/north-westerlies from May to October. The north-easterlies may bring fine dust from the Sahara. Winds capable of moving larger sand particles can be experienced at any time of year but are more likely during the dry season from January to April.

The potential for dust generation will be reduced during the wet season from July to October. However, dust generation may be a significant issue during the dry season, when dust suppression on haul roads and gravel transport routes may be required.

The mitigation measures to be used to reduce dust generated by road transport include low-speed driving in villages with unsealed roads, possible use of a water truck and dust suppressants on unsealed roads, and the construction of specific access tracks to project sites to avoid multiple tracks being used.

The sand dunes will be cleared prior to mining to allow the dredge to work. The extent of this clearance will be kept to a minimum to reduce the potential for wind-blown sand being entrained. Following the passage of the dredge, the dunes will be re-formed and revegetated, as soon as practicable.

Any concentrate stockpiles will be kept damp using spray systems, to reduce the potential for the wind to blow material from the stockpiles. Product stockpiles at the MSP will be stored undercover and will not be exposed to winds. Products (other than ilmenite) awaiting shipment at the port of Dakar will be stored in shipping containers to avoid dust being generated. Ilmenite will be stored undercover at the port in a bulk materials despatch warehouse, where it will be protected from wind and contamination.

12.9.4.10 Air Quality

The air quality objectives for the GCP are to prevent dust nuisance, ensure the health and safety of the community and minimise impacts on the natural environment.

Engine exhaust emissions from plant and equipment are the other main source of air pollution from the GCP. These emissions will be monitored to ensure that they meet Senegal standards for air quality. Emissions of sulphur dioxide from the power station will be dependent on the composition of the heavy fuel oil or natural gas provided by the supplier(s). Emissions monitoring will be undertaken and an air dispersion model generated (if necessary) to determine whether there is likely to be any impact on nearby communities and the need for mitigation measures as a result of fuel sulphur content.

12.9.4.11 General Waste Management

The waste management approach recommended is: reduce, re-use, recycle, and finally dispose. For example, waste production will be reduced by procuring supplies that produce less waste because of the way they are packaged or consumed; and installing equipment that minimises energy and water consumption and thereby produces less waste.

Recycling and re-use will be practised wherever possible. Although recycling and re-use opportunities are relatively limited in Senegal, scrap metal, timber and used oils and lubricants can all be recycled and/or re-used and these practices/processes have been established at MDL's Sabodala operation. Any non-hazardous waste that cannot be reused or recycled will be disposed of to an appropriate landfill facility established on site.

Hazardous waste disposal will be completed in a manner that minimises any long-term risk to employees, contractors, the local community and the environment. GCO will return hazardous waste items to the suppliers, where possible. If on-site hazardous waste disposal is unavoidable, it will be completed in accordance with relevant material data safety sheets. If hazardous waste requires burial, it will be in a specifically designated landfill, constructed with a synthetic or compacted basal clay liner to minimise the long-term risk of contaminant escape.

All waste management facilities, both active and decommissioned, will be marked on project site maps to assist with site rehabilitation and closure planning. The maps will identify the area, volume and type of waste stored in each facility and will include facilities developed during exploration and construction as well as operation phases of the GCP. Further details on landfill sites are provided in the ESMMP.

12.9.4.12 Hazardous Materials Management

Oil and hydrocarbons (such as heavy fuel oil, diesel, lubricants, and grease) are the only hazardous materials expected to be present on site. These materials are potential pollutants for the local soils and groundwater and require effective management to limit the possibility of spills or systemic leakage.

Hydrocarbons will be stored in tanks located in bunded, impermeable storage areas capable of containing 110% of the volume of the largest storage tank. Regular audits of hydrocarbon use and storage will be conducted to detect any unseen leakage. Operators will be trained in the appropriate handling, storage and use of hydrocarbons and provided with appropriate personal protective equipment. Vehicle maintenance bays, equipment lay-down areas and refuelling stations will be constructed on impervious surfaces and any potentially oily runoff from these areas will be contained by perimeter bunding or interception drains. Oily wastes will be removed from site and destroyed per applicable world standards as part of the fuel and lubricant contract for the site. This is currently the practice at MDL's operation in Senegal.

12.9.4.13 Radiation

The radioactive elements uranium and thorium can occur within the crystalline structure of heavy minerals such as zircon, rutile, ilmenite and monazite. The presence of these radioactive elements results in naturally occurring radioactivity, with levels depending on the quantity of radioactive elements present in the minerals.

Analyses of Senegal zircon indicate that levels of its radioactive elements are comparable with other key producers in world market (Table 5.5, Volume 2). Australian Nuclear Science and Technology Organisation (ANSTO) results show that the rutile and ilmenite products have less than 1 Bq/g of radioactivity from head-of-chain uranium or thorium, and are therefore considered inherently safe. Zircon and leucoxene products and the tailings all have head-of-chain uranium or thorium radioactivity in excess of 1 Bq/g. Workers exposed to these materials will be required to wear dose recording badges as part of their personal protective clothing as is standard practice in all operations of this nature.

The *Code of Practice and Safety Guide for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing* (ARPANSA 2005) generally applies to mining operations where doses to workers are expected to exceed the public limit of one millisievert (mSv) per year, and doses to the critical group are likely to exceed some tens of microsieverts (µSv). The International Commission for Radiological Protection (ICRP) recommends that the additional dose above natural background and excluding medical exposure should be limited to 20 mSv per year averaged over five consecutive calendar years for radiation workers who are required to work under closely monitored conditions.

As a precautionary measure, workers in the MSP who are routinely exposed to potentially radioactive mineral products will be required to wear a badge that monitors their exposure to radiation. The badges will be assessed every three months and records of employees' exposure to radiation will be kept readily available for five years. After five years, the employee radiation exposure records will be archived in a secure location for a further 25 years, as these records need to be held for a minimum of 30 years. Following future analyses of products and waste streams, GCO will develop radiation management plans to ensure that appropriate measures are taken to protect the health and safety of employees and visitors to the project facilities.

12.9.4.14 Transport and Traffic Safety

Transport of materials from Dakar to the dredge and MSP construction sites will be via Thies and Tivaouane, along 110 km of sealed road followed by approximately 20 km of gravel road, which passes through several villages between Darou Khoudoss and Diogo. The same route will be used for truck transport of mineral products from the MSP to Dakar for export. Traffic associated with the GCP will increase the overall traffic volumes along these roads. The road through Diogo and nearby villages is often congested with traffic due to loading of market-garden produce onto trucks for transport to markets. In addition, local markets occur along the road, adding to traffic congestion.

In order to alleviate the traffic congestion and maintain a high level of safety for villagers, GCO is considering several options for transport associated with the construction and mining operations at Diogo, including: a bypass for Diogo and adjacent villages, provision of an off-road hardstand area for delivery of garden produce by carts and loading of trucks for transport to market, installation of speed humps, establishing signals and raising awareness of villagers.

A site for the proposed hardstand area has been selected in consultation with the Diogo community. The ultimate choice of preferred transport options will depend on thorough analysis of the route and consultation with the affected community at Diogo.

Prior to the movement of special loads (i.e. oversize loads) along public roads, the relevant government authorities will be notified. All reasonable and practical measures required by the authorised government body will be implemented to minimise the risk of harm to the community and environment during transportation of special loads.

Hazardous materials such as hydrocarbons will be transported by a suitably licensed carrier, who will be responsible for management of risk associated with transport of hazardous materials for example, ownership transfer will occur at GCO’s site. Furthermore, emergency response for spills or accidents during transport will be managed by the licensed carrier.

Movement of mine vehicles and other traffic on the MSP site will be confined as practical to designated access roads. Movement of vehicles outside this network will be limited.

Movement of haulage trucks and other mine vehicles will be confined to a single designated access route between the mine site and the MSP. If the access route intersects tracks or roads used by the public, guardians will be put in place to manage the traffic crossings and speed limits enforced to minimise the risk of accidents.

12.9.4.15 Biodiversity and Conservation

Niayes region has been the site of various revegetation or reforestation projects since the 1940s. These projects aim to stabilise dune sands and thereby to protect the niayes.

Approximately 50% of the project area consists of savannah (native grassland with scattered and isolated shrubs and trees), while approximately 31% consists of plantations of casuarinas and eucalyptus. Approximately 17% of the project area consists of active dunes and the remaining 2% consists of gardens and habitation areas (Earth Systems, 2007).

Native vegetation is used by local communities to provide foraging for stock, while plantations and native shrubs and trees are sources of wood for fuel and construction purposes. Some native trees, such as cashews and *Parinari macrophylla* provide forest fruits for human consumption.

Eleven threatened flora species and eight endemic flora species have been identified in the exploration permit area (Tropica 2005). However, detailed vegetation surveys are yet to be conducted on areas affected by the GCP to determine whether or not threatened flora species will be disturbed. If such species are present in the areas affected by GCP operations, the Rehabilitation and Closure Plan will include provisions for re-establishing such species.

Where possible, GCO will locate infrastructure (including roads) away from potential areas of conservation value to ensure that overall impacts to vegetation and fauna habitat are minimised. GCO will work with the GRS to develop an appropriate management strategy for protecting any threatened flora species living within the GCP area. Vegetation clearing will be kept to the minimum required for efficient operations. Where protected species and established trees are identified, GCO will endeavour to divert works (such as roads) to other areas that will have lower impact. However, this will not be possible on the MSP site, dredge construction site or the dredge path. In these areas, re-establishing protected species will be part of the Rehabilitation and Closure Plan, where required.

To reduce the possibility of vehicle collisions with wildlife, GCO will limit vehicle speeds and night-time traffic.

12.9.4.16 Archaeology and Cultural Heritage

The only known cultural heritage material mapped within the Exploration Permit Area, is a “shelly heap”. It occurs close to the coast in the approximate vicinity of Fass Boye (Tropica 2005). This site is outside the proposed mining area but its occurrence raises the possibility of chance finds of archaeological material during the dredging operation.

GCO will develop a chance find procedure (CFP) to deal appropriately with any cultural heritage material that may be discovered during the dredging operation. The CFP will comply with both GRS and international guidelines and will outline the procedure for dealing with any cultural heritage material found during the mining operation.

12.9.4.17 Energy and Emissions

Senegal is a party to the Kyoto Protocol, which came into force in Senegal on 16 February 2005. Senegal does not have binding emission reduction targets for the first period (2008 to 2012) of the Kyoto Protocol because it is a Non-Annex I country.

Greenhouse gas (GHG) emissions from the proposed power station will be approximately 90,000 t CO_2-equivalent (CO_2e) per year if heavy fuel oil is used or approximately 66,000 t CO_2e if natural gas is used. If the project produces more than 100,000 t CO_2.e per year, then annual quantification and monitoring of greenhouse gas emissions may be necessary if the intent is to satisfy IFC Performance Standard 3, Clauses 10 and 11.

A secondary source of GHG emissions is the short-term clearing of vegetation for the purposes of dredging. Emissions from vegetation clearance will be offset by CO_2 sequestered by revegetation of the dunes, which will replace any vegetation removed prior to dredging.

The GHG emissions expected to be produced by the project will be refined following final design of the power generation plant.

When the vegetation clearance and revegetation schemes are more fully developed, the amount of CO_2e likely to be released then sequestered by the vegetation will be assessed.

If the net CO_2e emissions are likely to be less than 100,000 tpa, then no reporting of GHG emissions will be undertaken.

12.9.4.18 Visual Aspects

The MSP, power station and associated buildings will be constructed approximately 1.3 km east-south-east of the closest dwellings belonging to Diogo village.

Community consultation indicates it is likely that these new buildings will cause little concern for most of the community, because they see the potential employment of the development as a positive opportunity.

The potential visual impact of night lighting for the MSP will be minimised by using directional lighting and installing lights according to Australian Standards. Lighting on the dredge will be hidden from direct view by the sand dunes surrounding the dredge site.

12.9.4.19 Cumulative Impact Assessment

A cumulative impact on the environment is one that results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions. Issues with potential to have a cumulative impact due to the GCP are groundwater quality and quantity, noise, dust generation, and vegetation clearing.

Management plans for all of these potential impacts have been discussed in further detail in Volume 2.

12.9.4.20 Rehabilitation and Closure

Rehabilitation and closure of the mine site will take place in two stages:

1) As the dredge progresses through the sand dunes, the landscape will be reformed and revegetated behind it. This is ongoing closure.
2) When the dredge has finished working in the project area a program of activities for final closure will be undertaken.

More detail about ongoing closure can be found in Section 15 and in Volume 2.

12.10 Emergency Preparedness and Response

An Emergency Response Plan - Environment (Appendix 2.5, Volume 2), has been prepared for the GCP focussing primarily on hydrocarbons. As the project develops, GCO will undertake regular environmental risk assessments to identify potential environmental emergency situations that may arise and that need to be included in the Emergency Response Plan.

12.11 Measurement and Evaluation

An Environmental Management System (EMS) will be written to identify the processes that require measurement and evaluation and to decide on appropriate mitigation measures for environmental and social impacts from the GCO.

12.11.1 Environmental Monitoring and Measurement

Environmental monitoring for the GCP is documented in the Environmental and Social Monitoring Manual (ESMM) (Appendix 2.4, Volume 2). Baseline monitoring will be conducted prior to construction to establish existing environmental values. During construction and operation of the project, regular monitoring will detect any adverse changes that require action. Following cessation of mining, monitoring of various aspects will be continued for at least 12 months post-mining as part of the requirements for mine closure.

Groundwater table monitoring is being conducted in a comprehensive suite of piezometers established as part of the exploration drilling program. Baseline monitoring of the groundwater table for the GCP since April 2006 has shown an average decline of approximately 20 cm per year in some areas, while there is apparently no decline in other areas. Groundwater table monitoring will continue during the mining project and for at least 12 months after mining has ceased.

Groundwater quality monitoring, to establish baseline groundwater quality and to monitor changes in groundwater quality, will be conducted at the dredge pond construction site, in the dredge pond, in monitoring bores alongside and within the dredge path, in a monitoring bore beside the fuel storage facility, in two monitoring bores up-gradient and down-gradient of the landfill site, and in a monitoring bore located approximately 50 m down-gradient of the discharge point for the sewage treatment plant. Inlet and outlet water from the sewage treatment plant will be monitored monthly.

Groundwater quality in wells and bores used by the community in the vicinity of the dredge path is being monitored prior to construction to establish baseline groundwater quality. Details of parameters to be monitored are included in the ESMM.

A proposed program for the baseline monitoring, production monitoring and post-closure monitoring of groundwater quality has been developed.

The groundwater quality monitoring will occur in four stages:

1) Baseline monitoring will be designed to understand the pre-project groundwater quality.
2) Production monitoring will be designed to provide early detection of any changes in groundwater quality during the operation of the project.
3) Closure monitoring will be designed to provide a snapshot of the groundwater quality at the time the mine closes.
4) Post-closure monitoring will be designed to provide an ongoing record of groundwater quality when the project has been completed.

A surface radioactivity survey will be conducted to ensure that the radioactivity at one metre above the ground surface does not exceed background radioactivity levels once the naturally occurring radioactive minerals have been reformed into the landscape.

Workers exposed to heavy minerals at the MSP will wear radiation monitoring badges to measure their exposure to radiation at all times. Although the radiation levels are expected to be within acceptable limits, regular assessment of the radiation monitoring badges will be necessary to ensure that workers are not exposed to unacceptable radiation levels.

The topography of the proposed mining area has been mapped using aerial photography. This mapping provides accurate topographic contours that can be compared with the post-mining landform to ensure that it approximates the pre-mining topography.

A waste inventory will be compiled and monitored. Quantities of oil brought to the site and used oil retained for recycling will be monitored to ensure that the maximum possible amount of used oil is recycled.

The Rehabilitation and Closure Plan for the GCP will include a comprehensive monitoring system to ensure that timely replanting, weed control and maintenance are conducted. General parameters to be monitored may include area of progressive revegetation, seedling survival rate, annual plant growth, vegetation diversity and areas of weed infestation. Photo-points will be established to record vegetation pre-mining and to monitor progress with revegetation post-mining. Anticipated monitoring regimes are documented in the ESMM.

Baseline noise monitoring will be conducted as part of the noise assessment required to develop a noise model for the MSP. If community complaints indicate that noise emissions from the construction or operation of the GCP are causing nuisance or health impacts, GCO will undertake noise monitoring and investigate ways in which noise emissions can be reduced to ameliorate adverse noise impacts.

Dust raised by traffic at the MSP and on transport routes will be monitored by visual inspection and dust-control measures will be implemented when necessary. Any records of community concerns about dust will provide another means of monitoring dust nuisance.

All emissions from the MSP will pass through a bag house to ensure that particulate matter is trapped and emissions to the air meet Senegal's air emission standards for particulate matter. Stack emissions will be monitored for particulate matter every three months or at a frequency linked to the life of the bags in the bag house.

Baseline air quality measurements and dispersion modelling will be undertaken to estimate potential ground level concentrations of sulphur dioxide in the vicinity of the power station, and assess whether or not the emissions from the power station will have a significant impact on the ambient air quality. Emissions from the power station will be monitored at start-up, then on an annual basis.

12.11.2 Inspections

GCO will inspect all project facilities on a monthly basis, and review environmental and social performance against the Continuous Improvement Targets listed in the ESMMP on a quarterly basis. Key performance indicators will be developed over time as the operation matures to enable environmental and social performance to be assessed objectively and quantitatively. Indicators will likely be developed in the following broad areas:

- Groundwater management.
- Transport management.
- Control of erosion (wind erosion).
- Management of tailings.
- General waste management.
- Dust and noise management.
- Radiation management.
- Rehabilitation and revegetation success.
- Socio-economic status and health/nutrition in the local community.

Summary results of the inspections and performance reviews will be compiled in the quarterly and annual reports, submitted to the Department of Mines and Geology (Direction des Mines et de la Géologie) in Dakar.

12.11.3 Audits

GCO will regularly commission routine internal and independent external audits of the EMS. Audits will investigate:

- The appropriateness of the ESMMP to the current development stage and operating practices of the project.
- Workforce awareness of the ESMMP and associated plans.
- The performance of managers and operators in implementing and maintaining the ESMMP strategies.
- Whether sufficient time, resources and expertise are available to implement the ESMMP.
- The effectiveness of the operation's EMS in improving environmental performance and reducing environmental risk.

12.11.4 Evaluation of Compliance

Evaluation of compliance with guidelines and legal requirements will be undertaken as part of the annual reporting to the government departments.

12.11.4.1 Record Keeping

A range of information to support the EMS will be developed specifically for the GCP and once the project commences, this material will be available on site. This information includes the reports prepared as part of the environmental and social impact assessment (EIES) process.

A library of hard copies of data and background information, including the EIES and all supporting reports, will be maintained in the environment department on site.

The site environment department will also maintain computer-based databases that include the following:

- Environmental legislation, standards and guidelines.
- Groundwater monitoring information.
- Corrective action database.
- Results of environmental/social investigations and trials.
- Site materials inventory - quantities, locations and types of materials (such as stockpiles of tailings, slimes or topsoil) for environmental management and rehabilitation purposes.
- Pre-mining vegetation mapping, including:
  - Details of threatened species identified in areas to be cleared.
  - Nursery inventory - the amounts and species of seeds and seedlings available for revegetation and anticipated rehabilitation requirements.

- Rehabilitation undertaken and status.
- Incident reporting (including community complaints) and response records.

The databases will be readily accessible to relevant personnel to allow timely and informed decisions to be made. The administration superintendent will be responsible for maintaining a database of personnel induction and training records.

12.12 Review and Continual Improvement

The environmental management system will be reviewed by senior GCO management at regular intervals. The review will encompass:

- Results of internal audits and evaluations of compliance with guidelines and legal requirements.
- Results of external audits.
- Complaints.
- The extent to which environmental objectives and targets have been met.
- The status of corrective and preventive actions.
- Any follow-up actions from previous reviews.
- Changes to legal or other requirements relating to environmental aspects of the operation.
- Recommendations for improvement.

As a result of the review, management will document decisions and actions related to possible changes to environmental policy, objectives, targets and other elements of the environmental management system, consistent with the commitment to continual improvement.

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SECTION 13

Project Execution

Copy 16

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CONTENTS

TABLES

FIGURES

13 PROJECT EXECUTION

13.1 Project Development Strategy

GCO proposes to construct the project using a single contract for engineering, procurement and construction management (EPCM) with an internationally recognised and experienced engineering company.

MDL adopted this strategy for the development of Sabodala and it provided the following benefits:

- Experienced project engineering with respect to vendor package tender, logistics and purchasing systems.
- Experienced construction personnel at all levels.
- Established design, purchasing, construction and commissioning management systems and controls.
- Engineering support throughout the construction process.
- Experienced commissioning personnel.

Details of the EPCM strategy are described below and include:

- Procurement.
- Expediting.
- Logistics and transport.
- Detailed engineering.
- Construction.
- Project controls.

A total of 198,000 hours have been included in the capital estimate for EPCM activities during the project execution phase.

Owners' activities to support the development of the project and the EPCM contractor include:

- Government approvals and access agreements.
- Occupational health and safety systems.
- EPCM preliminaries such as tendering, evaluation and engineering.
- Market development and sales establishment.
- Hydrology.
- Power supply establishment and service negotiations.
- Rail preliminaries such as geotechnical and equipment purchase.
- Socio-economic, such as local consultation and finalising baseline.
- Rehabilitation, such as nursery establishment and trials.

- Infrastructure upgrades.
- Services, supply and manning establishment.

13.2 Procurement Strategy

13.2.1 Introduction

The key procurement aims and objectives for the GCP are to:

- Contribute to achieving the project objectives of earliest possible completion, cost-effective execution, quality workmanship and a high degree of safety from suppliers.
- Adhere to the project plan, aims and schedule.
- Ensure that commercial and schedule risks are at acceptable levels.
- Provide a purchasing environment that minimises claims and protracted disputes.
- Provide a procurement arrangement that encourages suppliers to be innovative and efficient.
- Carry out the procurement function for the project in an ethical and professional manner.

Key success factors are to:

- Meet or exceed expectations for health and safety requirements.
- Meet or better the project schedule.
- Meet or better the project budget.
- Meet project quality objectives.

As a part of the re-estimate of the GCP capital cost Ausenco have used tenders to source >80% of the equipment requirements (see Section 16). Current pricing for those equipment items is shown in Appendix 13.1.

Key operations tender packages to be developed include:

- Fuel and lubricants (likely extension to existing contract in place for Sabodala).
- Dakar port access (commenced).
- Logistics - bulk sea freight.
- Logistics - road/container movement in Senegal (commenced).
- Logistics - rail access (commenced).

Tender and award of these service/supply contracts will be an owner-driven activity.

Outstanding construction tender packages to be developed are detailed in Section 16.

13.2.2 Tender Enquiry Process for Construction and Remaining Procurement Packages

The procurement manager, in conjunction with the project engineering manager and scheduler, will establish a tender enquiry summary which will reflect the order in which packages are to be offered for tender. Information required for the tender enquiry summary includes the package description, lead time for supply of goods and/or services, and dates required on site.

In addition to the above, the tender enquiry summary will detail the timing required for preparation of invitation to tender packages, tender period, tender commercial and technical evaluation, recommendation for award, approval by GCO and issue of the purchase order or contract. The tender enquiry summary is a subset of the overall project schedule.

The procurement manager (with assistance from the engineering manager and GCO) will develop an approved list of tenderers for each package. Goods and services for the project will be sourced from the approved list of tenderers.

Table 13.1 shows the guidelines for package approval as defined in the tender enquiry summary schedule.

Table 13.1 Tender Package Types

Package Type	Tender/Award Document
Equipment/fabrication supply – >$100,000	AS4911:2003 General Conditions of Contract
Equipment/fabrication supply – <$100,000	Engineer's Standard Conditions for Purchase
Bulk materials supply	Engineer's Standard Conditions for Purchase
Consultancy agreements	Engineer's Standard Consultancy Agreement

Following is a brief description of the package types.

Major equipment packages are defined as those that meet one or more of the following criteria:

- Greater than $100,000 in forecast budget cost.
- Performance guarantees are required.
- Process risk is involved.
- Delivery timing is critical to project success.

Appropriate consideration will be given to process guarantees, liquidated damages (for late delivery of certified information and/or late delivery of equipment), warranties and defects liability period and performance and defects liability period securities.

Minor equipment supply and fabrication packages are defined as those that meet one or more of the following criteria:

- Forecast budget cost is <$100,000 in value.
- Either standard proprietary items or small fabricated components.
- No process risk involved nor process guarantees required.
- Low overall risk to project.

Appropriate consideration will be given to manufacturers' warranties.

Bulk materials supply will be subject to a blanket purchase order with a number of discrete releases for supply issued over the life of the project. Bulk materials generally have a relatively short lead time for delivery and present a low risk commercially and technically. Appropriate consideration will be given to liquidated damages (late delivery of materials), warranties and defects liability period.

A consultancy agreement will be used as required to solicit external specialist assistance to the project. Generally, consultancy agreements will not require a formal tender process to be established.

Project risk assessments will be carried out in accordance with the project execution plan. The project manager in conjunction with the procurement manager will determine, where required, the appropriate risk mitigation measures for each enquiry package to be included in the invitation to tender documentation.

Once approved, the invitation to tender documentation will only be issued to companies on the approved tenderers list noting the close date and time of the tender.

13.2.3 Tender Evaluation and Award

The purpose of the evaluation is to determine the technical and commercial suitability of the tenders submitted. Tenders will be evaluated against project requirements in the following areas:

- Budget amount for the package.
- Technical compliance with the invitation to tender package.
- Commercial compliance with the invitation to tender package.
- Compliance with project schedule.
- Quality assurance (including ISO 9000 certification).
- Health and safety management (mandatory for site works).
- Environmental management (mandatory for site works).
- Industrial relations compliance (mandatory for site works).
- Proposed resources.

The technical and commercial evaluations will be carried out concurrently. Commercial and engineering will use the project standard for evaluation of requirements.

All non-conformance and clarifications (NCCRs) will be captured and recorded throughout the tender evaluation period. These NCCRs may be resolved in several ways, including:

- Tenderer modifies tender submission to comply (may be at additional cost).
- GCO accepts tenderer's initial non-compliance or subsequent revised non-compliance.

On completion of the technical and commercial evaluation and receipt of the completed MRP from engineering, a recommendation for award (RFA) will be produced by the project procurement officer. This will be submitted to GCO's representative for review and approval of the recommended supplier.

On receipt of a duly approved recommendation for award, a notice of award will be prepared and issued to the successful tenderer. Depending on the size and type of package a formal instrument of agreement contract or purchase order will be issued.

13.2.4 Quality Assurance

QA/QC will be carried out in accordance with the engineer's project quality plan. The project quality manager will be responsible to establish the level of quality surveillance in conjunction with the responsible engineer for each equipment package to be incorporated into the invitation to tender document.

Where required by the quality manager, suppliers will be required to submit an inspection and test plan (ITP) and a copy of their quality plan with the tender. Product certification and traceability requirements may also be required and will be stated in the technical specification and scope of works.

An audit and surveillance program may be undertaken randomly on suppliers, based on the status of their QA/QC certification, the importance of the product that they are supplying and previous performance history.

13.3 Expediting

Expediting will be proactive, aiming to pre-empt issues rather than to solve them after the event. The senior expeditor will plan and control expediting activities in consultation with procurement, establishing material status reports and ensuring suppliers comply with agreed delivery of drawings, data, materials and equipment. The post-award responsibility for the purchase order is vested with expediting; however, commercial responsibility stays with the purchasing officer. Expeditors will anticipate and act at the earliest possible stage to eliminate or reduce delays which may impact on the project schedule.

Manufacturing and delivery progress will be monitored and reported to the project via expediting status reports. Status reports will verify the milestones reported. Exceptions will be reported to management. These reports will detail actions being taken to resolve any issues causing concern.

Regardless of where the project is controlled from, the senior expeditor will utilise global support offices of a worldwide expediting third party provider if necessary, to achieve the project schedule.

13.4 Logistics and Transport

13.4.1 Logistics

For the GCP it will be the engineer's responsibility to manage the consignment of equipment and materials to the project site. A proven international project freight forwarding group with a global network will be appointed early in the project to provide logistics support services and to aid in the preparation of the transport and logistics plan. the focus will be on the most cost effective solution for delivery to site of equipment and materials to meet the construction schedule.

The logistics specialist will develop a transport plan to be used to manage the sea, road and airfreight costs to budget. Land transport into the project site will form a significant component of the transport plan. Selected land transport subcontractors will be required to display the necessary capabilities and dedicated management that will ensure equipment is suitable and operators take every precaution to meet the project safety and quality requirements.

Transport plans will be prepared for all equipment based on maximum project transport envelopes. The review of the bulk steel supply will contribute to the plan.

The plan will include, but not be limited to:

- Functional requirements of an inbound logistics system.
- Assessment of existing transport nodes and linkages (ports, roads and rail).
- Maximum load length, width, height and weight restrictions.
- Specialist heavy-lift and over-dimensional transport requirements at port, for example, liaison with statutory authorities and utilities, permitting, road closures, escorts.
- The requirement for "holding facilities" at port to manage the storage of equipment, materials and bulk steel pending transport to site.
- The movement of the pontoons and other over-size steel components to site.
- Assessment of site conditions.
- Identification of alternative operational models; methodologies, constraints and risks.
- The identification and management of shipping container and other demurrage costs.

The freight forwarder (or an independent consultant) will specifically review the movement of the bulk steel supply from place of manufacture to project site. This is required because the bulk steel supply estimate has been prepared by Ausenco on the basis that all items will fit within the Dakar Port freight envelope sizing (20 m long x 6 m wide x 4.5 m high above truck trailer tray). However, there are some items that exceed the freight envelope criteria. Oversize bulk freight components will require an engineering review to enable physical passage through Dakar, or an alternate route to project site.

Options for the delivery of bulk steel, which is primarily used for the pontoons, include:

- The currently preferred and costed construction option to deliver the pontoons to site pre-assembled.
- Having the pontoon steel-plate cut and supplied, with fabrication occurring on-site. This would minimise transport and logistics costs but add to site construction costs.
- To float and “beach” the pontoons at Diogo (or an alternative nearby location) using tug boat(s) and/or barge(s). Initial discussions with SDV and a South African company (A-Cubed Consulting) indicate that this option may have potential.
- To have the pontoons cut and stacked to allow container shipping and road transport.
- A bolt-together option.

In discussions with NMT International (Australia) Pty Ltd, consideration has been given to the option of chartering a vessel to transport the bulk steel requirements to Senegal. Significant freight cost reductions may be achievable.

The capital cost estimate prepared by Ausenco (Section 16) includes an allowance for a comprehensive review of the freight and logistics requirements for the movement of the bulk steel supply component.

13.5 Detailed Engineering

Detailed engineering and drafting will be carried out by the EPCM contractor using a multi-disciplined team under the direction of an engineering manager. This detailed engineering and drafting will be based upon the drawings and documents which were produced during the DFS phase. The detailed engineering will be carried out in accordance with the project execution plan.

An estimate of the percentage complete of the detailed engineering is contained in the Ausenco basis of estimate document (Appendix 13.1).

13.6 Construction Strategy

13.6.1 Introduction

The Grande Côte Project includes the construction of a wet concentrator plant (WCP) and dredge, mineral separation plant (MSP) and associated infrastructure at the project site at Diogo near Dakar in Senegal, West Africa. Construction items are generally outlined in the project execution plan (Appendix 13.2).

Given the location of the project and the limited availability of skilled workers, there is a general expectation and understanding that the construction work will require a higher level of supervision and additional support of contractors. This was the required on the Sabodala project and is consistent with other African project experiences.

Further detailed analysis of construction methodologies, including opportunities for alternatives, particularly in respect of the wet concentrator plant, will be explored during the execution phase of the project. Furthermore, GCO may consider purchasing some plant and equipment items to avoid hire costs during the construction period.

The construction activities for the project will be managed by the EPCM contractor's construction management team located at the project site. This team will be led by a construction manager with site offices at both the MSP and the initial mine area.

13.6.2 Site Facilities and Construction Labour

The site contractors will be responsible for the provision of their own construction site facilities, construction consumables and construction power.

The construction site will operate 10 hours per day on a seven days per week basis. Public holidays will be worked. Contractors will be responsible for managing their own industrial relations. The construction manager will be responsible for liaison between contractors to resolve industrial relations matters affecting the whole site.

Contractors will be requested, wherever practical, to employ local labour. The mix of labour will vary according to the contract scope of work and the skill of the individual, and ultimately will be the responsibility of the contractors.

The contractors will be responsible for transportation of their workforce to and from the site and for the transport of all equipment and materials to the construction area on the site.

The provision of cranes and trucks for movement of equipment and materials around the construction site will be the responsibility of the respective contractors. Heavy-lift cranes, including rigging gear and operators, will be provided by GCO.

13.6.3 Site Contract Management

The construction manager will be responsible for:

- Ensuring the quality control for site construction is maintained and recorded in accordance with specifications.
- Construction site safety.
- Contractor performance.
- Construction schedule.
- Construction budget.

All instructions to contractors which affect cost, time, safety or progress will be via a site instruction signed by the construction manager and a representative of the contractor.

The initial assessment of a variation claim will be by the construction manager and forwarded to the project engineer. If variations involve cost implications, the contractor will be asked to submit a fixed price prior to the issue of the site instruction. If a fixed price is not possible or is deemed to be unacceptably high, then the variation will be estimated and the estimated price noted on the site instruction form.

The construction manager will be limited in the value of variations that can be authorised and variation amounts greater than this limit will be referred to the project manager and if required to GCO for approval prior to an instruction being given.

Contractors will be required to submit time and material sheets for all estimated variations. Time sheets will be approved daily by the discipline supervisor and the construction manager and materials costs will be supported by supplier's invoices.

13.6.4 Contracting Strategy

In general, contractors will be used to perform the works but, as mentioned above, additional supervision and support will need to be provided to ensure adequate productivity and quality. To this end, additional supervision by experienced expatriates or third-country nationals in the form of working leading hands has been provided for in the project capital estimate.

Experience from Sabodala has been that some local contractors struggled to honour their contractual obligations and often fall short on adherence to any schedule. For the above reasons, the general expectation is that the construction work will be a mix of contracted work; sole sourced work on agreed unit rates to known well-performing contractors used at Sabodala and self-performed activities.

13.6.5 Construction Methodology

13.6.5.1 Wet Concentrator

The wet concentrator plant components will be constructed in a wet-style construction using a filled construction pond. However, alternate (dry-style) construction will be investigated prior to construction commencing for the purposes of cost and time reduction.

For wet construction, the pond will contain one piled and shored wall to allow close crane access alongside for floating plant construction. A pontoon assembly area will be required as well as appropriate lay-down areas.

In general, the wet concentrator pontoon sections will arrive at site pre-fabricated in transportable modules and will be assembled and joined on site before being lifted into the pond using a heavy lift crane. The surge bin for the wet concentrator will be installed in sections and welded in situ.

The wet concentrator construction includes a number of heavy lifts for which a large pin jib lattice boom crane will be hired. In addition to a number of mobile cranes, there is a maintenance crane (tower crane) that will be set up initially for the construction period adjacent to the construction pond and used during the construction period before being transferred to the surge bin floating module.

13.6.5.2 Dredge

The dredge will be fabricated, pre-assembled and pre-modularised (as far as possible) off-site into transportable segments using a suitably qualified and experienced dredge fabrication contractor. This off-site work will include trial assembly of as many components as possible prior to being dismantled and packed for transport to site.

Site assembly and construction for the dredge will be undertaken using a dry dock located adjacent to the construction pond or as part of the main pond if dry construction approach is adopted. The dredge ladder and associated components will be shipped direct to site fully assembled for installation.

13.6.5.3 MSP

The construction of the MSP facilities and the infrastructure will be undertaken concurrently with the wet concentrator construction. The construction of the MSP is relatively simple and standard construction methodologies will be employed.

13.7 Project Controls

13.7.1 Introduction

An effective project controls plan is essential for the success of any project. The project controls plan for the Grande Côte Project will include a proven set of procedures to provide effective:

- Planning and scheduling.
- Estimating.
- Cost control.
- Progress monitoring.
- Project reporting.

These procedures should allow for reporting structures to satisfy the engineer's corporate reporting, the owner's requirements, project analysis and status reports.

The engineer should use a proactive approach to highlight trends in cost and schedule, thus allowing the management team to make informed decisions regarding changes affecting either the project cost or schedule. The project controls plan should reflect the need for effective interfaces through engineering, procurement and construction and consequently the systems and procedures to support this philosophy.

13.7.2 Systems

Recognising the importance of project controls for the overall success of the project and using established reporting procedures and project control systems, the project should be monitored at all times from the cost and scheduling viewpoints.

Some of the project controls team should be resident on the site at all times during the project.

Software systems required for project controls are as follows:

- Estimating.
- Planning/scheduling.
- Capital cost control.
- Change management.
- Services cost control.
- Engineering progress.
- Construction progress.

13.7.3 Control Base

An overall control base should be established for the Grande Côte Project. The project should be continuously monitored against this control base, which consists of an approved scope of work, budget, schedule and execution plan. Only approved scope changes (variations) can revise this control base, as set out in a change management procedure. The approved project baseline schedule will be the control base for all scheduling activities and progress measurement.

The plan will put in place the structure necessary to achieve the following objectives:

- To complete the project within budget and schedule.
- To provide an accurate and timely measurement of status and cost.
- To provide the forecasting and analysis necessary for effective decision making by management.
- To monitor and report the trend of cost and progress rapidly and proactively to avoid surprises.

13.7.4 Scheduling/Planning

The project schedule should be prepared in the form of a critical path method (CPM) schedule. Once approved as the baseline schedule, it should be used as the target schedule for the project against which progress will be measured. The overall project schedule should incorporate activities relating to relevant owner activities and be set out as per the agreed work breakdown structure (WBS).

The project schedules will be updated and issued in accordance with the reporting calendar to reflect approved scope changes; progress achieved and forecast work sequencing.

The project baseline schedule will be established after project commencement to provide a control basis for determining project progress. As the project progresses, it may become necessary to revise the baseline as a result of changes in scope, timing or other influences outside the control of the project team.

13.7.5 Cost Reporting and Forecasting

A cost management system will be used for all reporting, consolidation, analysis and forecasting of costs for the project. Analysis and updating of forecast costs will be carried out on a progressive basis in the cost management system throughout each period to avoid excessive workload at period end.

13.7.6 Change Management

Identifying, communicating and managing change on the project will be the responsibility of all team members. The change management process will give the project management team an opportunity to minimise or negate the impact of a potential change.

A trend/change register will be maintained for all approved trends, budget shifts, change notices, design developments and scope changes. Project management approval will be required before any costs are incurred on variations to the scope of work.

13.7.7 Progress and Performance

Engineering progress measurement should be calculated using the cost management system. Each discipline will list the deliverables and tasks required and assign budget hours for each deliverable or task. Each deliverable will have progress earned based on predetermined milestones as they are achieved. Procurement activities should have progress earned through the entire procurement cycle in the same way as engineering.

The estimated construction hours, which are included in the control estimate, form the basis for the construction progress measurement. The man hours should be assigned to each construction package as appropriate to correspond with discrete activities in the schedule or from contractor’s provided progress.

These hours should be spread over the duration of the activities to calculate a planned progress percentage for each activity. This spread should be accumulated by groups of activities to roll up to planned progress “S-curves” by discipline or contract, showing early and late schedule boundaries.

The earned value method should be used for establishing and reporting overall construction progress. Progress will be measured on individual activities based on the actual quantities installed or the achievement of predefined progress milestones. Progress should be measured and recorded weekly and formally reported on a monthly basis.

Total project progress should include the four major phases of the project: engineering, procurement, construction and commissioning. The estimated relative weighting for reporting total project progress should be determined by the man hours or dollars allocated to each phase in the budget.

Productivity will be measured each period and reported both cumulatively and incrementally. Productivity will be calculated as earned hours divided by spent hours.

13.7.8 Monthly Progress Report

A monthly progress report should be prepared with input from subcontractors, where required, to produce a uniform format for reporting project expenditure, forecast, progress and performance.

13.8 Project Development Schedule

A high-level project development schedule Figure 13.1 has been developed by Ausenco and GCO. The project schedule includes the activities undertaken by the EPCM contractor and the GCO owners' team.

Key owners' team activities include:

- Government approvals, access agreements for ICS, Dakar, Transrail and establishing project financing.
- Development of occupational health and safety systems.
- Management of additional consultant studies including the social baseline study, value engineering study, a break bulk logistics review, road and rail geotechnical study.
- EPCM preliminaries such as tendering and evaluation of the EPCM contract, engineering and management of the EPCM contractor, establishing a logistics shipping agent.
- Market development and sales contract establishment.
- Hydrology, such as establishment of the borefield and borefield drilling.
- Power supply establishment, including tendering and evaluation of the power station contract and service negotiations.
- Rail preliminaries such as geotechnical studies, equipment purchase, negotiations with ICS for rail access and with Dakar Port and Transrail.
- Socio-economic, such as local consultation, finalising baseline, verifying and initiating compensation.
- Rehabilitation, such as nursery equipment, establishment and trials.
- Infrastructure upgrades, including the camp and ICT system.
- Services and supply such as the purchase of mobile equipment and transfer of equipment from Sabodala, establishing Dakar logistics, visa and airport services, camp catering, medical and workshop services, road preparation, sewer upgrade, scaffolding and consumables.
- Manning establishment including recruitment and training of operational workforce, establishment of operational management systems and workforce housing.

Key activities for the EPCM contractor include:

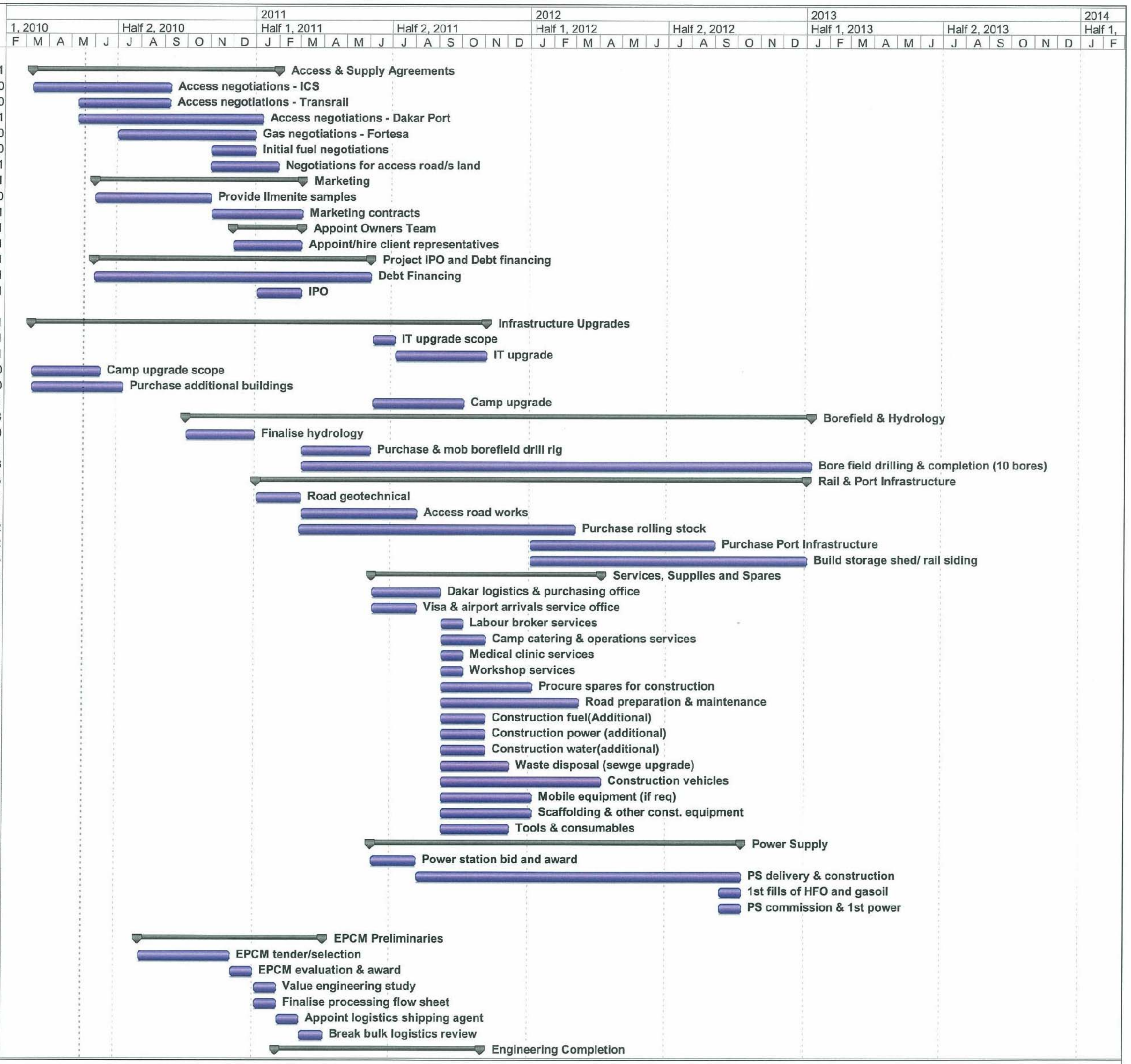
- Detailed design of equipment for mining, the wet concentrator, mineral separation plant, temporary facilities, mining infrastructure, mineral separation plant infrastructure, off-site infrastructure.
- Tender and evaluation of individual works packages.
- Procurement and expediting of equipment and materials.
- Construction management of the dredge, wet concentrator, MSP, rail facilities and associated infrastructure.
- Commissioning of the dredge, wet concentrator and MSP.

The project execution schedule assumes that equity financing via an IPO will be completed by early 2011 and the debt financing will be secured by the middle of 2011. The EPCM contract will be awarded after the equity has been raised in early in 2011. Site mobilisation for the ECPM contractor would commence late in quarter three of 2011. The schedule indicates a completion data for C1 and C2 commissioning by the middle of 2013. The first HMC is scheduled to be produced by early June 2013 and the first zircon shipped in late June 2013.

The schedule is high-level at this stage and will require further detailing as a part of the development of the project management plan. The schedule does not include any float for unscheduled delays.

Figure 13.1 Project Development Schedule

ID	Task Name	Duration	Start	Finish
1				
2	**Access & Supply Agreements**	**10.64 mo**	**Wed 10/03/10**	**Mon 31/01/11**
3	Access negotiations - ICS	6 mo	Wed 10/03/10	Thu 9/09/10
4	Access negotiations - Transrail	4 mo	Mon 10/05/10	Wed 8/09/10
5	Access negotiations - Dakar Port	8 mo	Mon 10/05/10	Mon 10/01/11
6	Gas negotiations - Fortesa	6 mo	Thu 1/07/10	Fri 31/12/10
7	Initial fuel negotiations	2 mo	Tue 2/11/10	Fri 31/12/10
8	Negotiations for access road/s land	3 mo	Mon 1/11/10	Mon 31/01/11
9	**Marketing**	**9 mo**	**Wed 2/06/10**	**Fri 4/03/11**
10	Provide Ilmenite samples	5 mo	Wed 2/06/10	Tue 2/11/10
11	Marketing contracts	4 mo	Wed 3/11/10	Fri 4/03/11
12	**Appoint Owners Team**	**3 mo**	**Thu 2/12/10**	**Thu 3/03/11**
13	Appoint/hire client representatives	3 mo	Thu 2/12/10	Thu 3/03/11
14	**Project IPO and Debt financing**	**12 mo**	**Tue 1/06/10**	**Fri 3/06/11**
15	Debt Financing	12 mo	Tue 1/06/10	Fri 3/06/11
16	IPO	2 mo	Mon 3/01/11	Thu 3/03/11
17				
18	**Infrastructure Upgrades**	**19.68 mo**	**Wed 10/03/10**	**Fri 4/11/11**
19	IT upgrade scope	1 mo	Mon 6/06/11	Tue 5/07/11
20	IT upgrade	4 mo	Wed 6/07/11	Fri 4/11/11
21	Camp upgrade scope	3 mo	Wed 10/03/10	Wed 9/06/10
22	Purchase additional buildings	4 mo	Wed 10/03/10	Fri 9/07/10
23	Camp upgrade	4 mo	Mon 6/06/11	Wed 5/10/11
24	**Borefield & Hydrology**	**27 mo**	**Fri 1/10/10**	**Wed 9/01/13**
25	Finalise hydrology	3 mo	Fri 1/10/10	Fri 31/12/10
26	Purchase & mob borefield drill rig	3 mo	Fri 4/03/11	Fri 3/06/11
27	Bore field drilling & completion (10 bore	22 mo	Fri 4/03/11	Wed 9/01/13
28	**Rail & Port Infrastructure**	**23.82 mo**	**Mon 3/01/11**	**Thu 3/01/13**
29	Road geotechnical	2 mo	Mon 3/01/11	Thu 3/03/11
30	Access road works	5 mo	Fri 4/03/11	Thu 4/08/11
31	Purchase rolling stock	12 mo	Tue 1/03/11	Fri 2/03/12
32	Purchase Port Infrastructure	8 mo	Mon 2/01/12	Mon 3/09/12
33	Build storage shed/ rail siding	12 mo	Mon 2/01/12	Thu 3/01/13
34	**Services, Supplies and Spares**	**10 mo**	**Mon 6/06/11**	**Fri 6/04/12**
35	Dakar logistics & purchasing office	3 mo	Mon 6/06/11	Mon 5/09/11
36	Visa & airport arrivals service office	2 mo	Mon 6/06/11	Thu 4/08/11
37	Labour broker services	1 mo	Tue 6/09/11	Wed 5/10/11
38	Camp catering & operations services	2 mo	Tue 6/09/11	Fri 4/11/11
39	Medical clinic services	1 mo	Tue 6/09/11	Wed 5/10/11
40	Workshop services	1 mo	Tue 6/09/11	Wed 5/10/11
41	Procure spares for construction	4 mo	Tue 6/09/11	Thu 5/01/12
42	Road preparation & maintenance	6 mo	Tue 6/09/11	Wed 7/03/12
43	Construction fuel(Additional)	2 mo	Tue 6/09/11	Fri 4/11/11
44	Construction power (additional)	2 mo	Tue 6/09/11	Fri 4/11/11
45	Construction water(additional)	2 mo	Tue 6/09/11	Fri 4/11/11
46	Waste disposal (sewge upgrade)	3 mo	Tue 6/09/11	Tue 6/12/11
47	Construction vehicles	7 mo	Tue 6/09/11	Fri 6/04/12
48	Mobile equipment (if req)	4 mo	Tue 6/09/11	Thu 5/01/12
49	Scaffolding & other const. equipment	4 mo	Tue 6/09/11	Thu 5/01/12
50	Tools & consumables	3 mo	Tue 6/09/11	Tue 6/12/11
51	**Power Supply**	**16 mo**	**Mon 6/06/11**	**Tue 9/10/12**
52	Power station bid and award	2 mo	Mon 6/06/11	Thu 4/08/11
53	PS delivery & construction	14 mo	Fri 5/08/11	Tue 9/10/12
54	1st fills of HFO and gasoil	1 mo	Mon 10/09/12	Tue 9/10/12
55	PS commission & 1st power	1 mo	Mon 10/09/12	Tue 9/10/12
56				
57	**EPCM Preliminaries**	**8 mo**	**Mon 2/08/10**	**Mon 4/04/11**
58	EPCM tender/selection	4 mo	Mon 2/08/10	Wed 1/12/10
59	EPCM evaluation & award	1 mo	Thu 2/12/10	Fri 31/12/10
60	Value engineering study	1 mo	Mon 3/01/11	Tue 1/02/11
61	Finalise processing flow sheet	1 mo	Mon 3/01/11	Tue 1/02/11
62	Appoint logistics shipping agent	1 mo	Wed 2/02/11	Thu 3/03/11
63	Break bulk logistics review	1 mo	Fri 4/03/11	Mon 4/04/11
64	**Engineering Completion**	**8.86 mo**	**Tue 1/02/11**	**Mon 31/10/11**



Project: Project execution 10-05-16-AS
Date: Tue 18/05/10

Task · Progress · Milestone · Summary · Rolled Up Task · Rolled Up Milestone · Rolled Up Progress · Split · External Tasks · Project Summary · Group By Summary · Deadline

Page 1

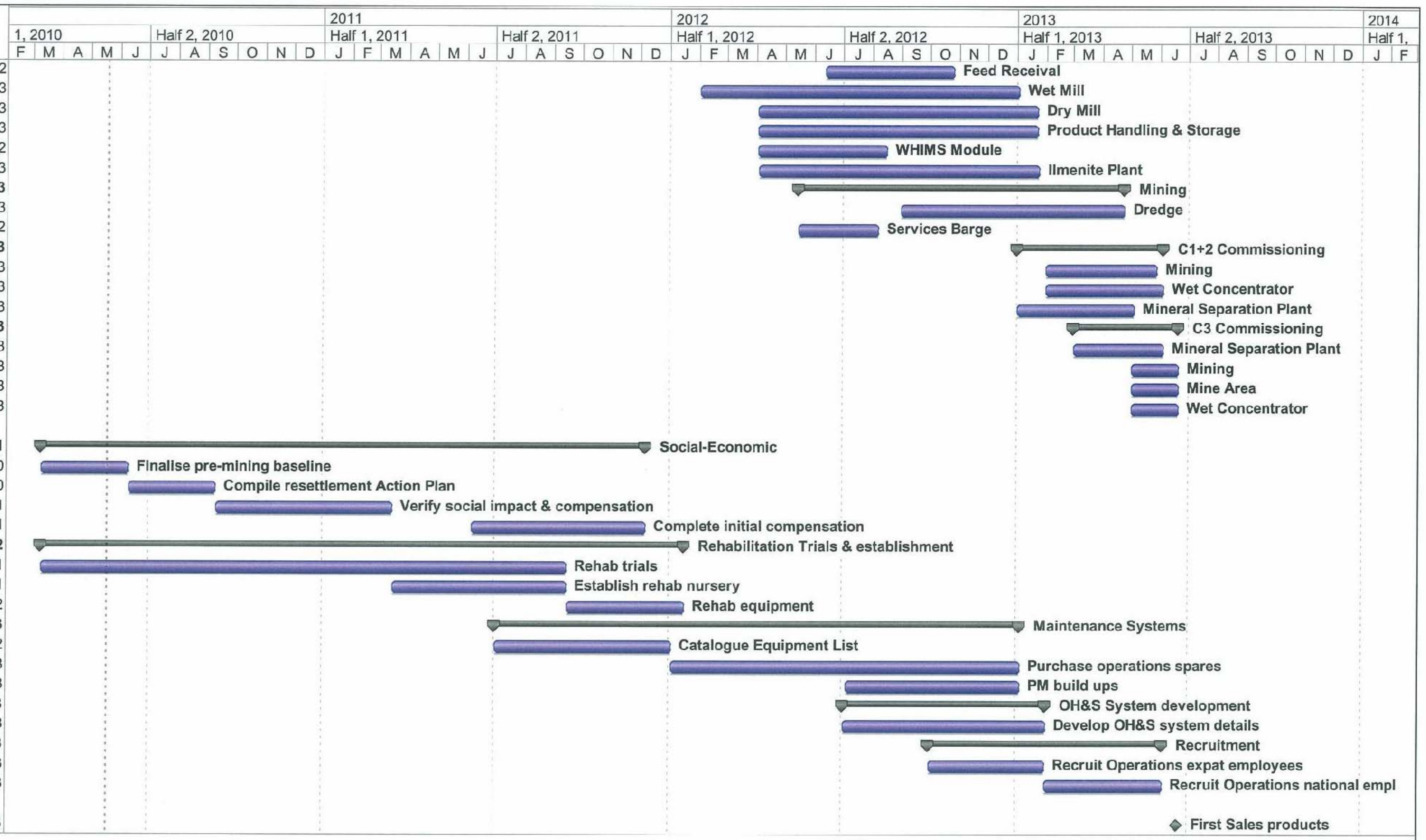
ID	Task Name	Duration	Start	Finish
65	**Mining**	**5.45 mo**	**Tue 1/02/11**	**Mon 18/07/11**
66	Dredge	5.45 mo	Tue 1/02/11	Mon 18/07/11
67	Services Barge	30 days	Fri 1/04/11	Thu 12/05/11
68	**Wet Concentrator**	**7.91 mo**	**Tue 1/02/11**	**Fri 30/09/11**
69	Surge Bin Module	145 days	Tue 1/02/11	Mon 22/08/11
70	Spiral Concentrator Module	174 days	Tue 1/02/11	Fri 30/09/11
71	Tailings Stacker Module	74 days	Tue 3/05/11	Fri 12/08/11
72	Product Handling	150 days	Tue 1/02/11	Mon 29/08/11
73	**Off Site Infrastructure**	**7.05 mo**	**Tue 1/03/11**	**Mon 3/10/11**
74	Road - MSP to Mine	50 days	Tue 1/03/11	Mon 9/05/11
75	Rail + Rollingstock	155 days	Tue 1/03/11	Mon 3/10/11
76	**Mineral Separation Plant**	**7.95 mo**	**Tue 1/03/11**	**Mon 31/10/11**
77	Feed Receival	30 days	Tue 1/03/11	Mon 11/04/11
78	Wet Mill	66 days	Tue 1/03/11	Tue 31/05/11
79	Dry Mill	83 days	Tue 1/03/11	Thu 23/06/11
80	Product Handling & Storage	55 days	Tue 1/03/11	Mon 16/05/11
81	WHIMS Module	150 days	Tue 1/03/11	Mon 26/09/11
82	Ilmenite Plant	152 days	Fri 1/04/11	Mon 31/10/11
83	**Infrastructure - MSP**	**6.82 mo**	**Tue 1/03/11**	**Mon 26/09/11**
84	Earthworks, Drainage, Fencing &	150 days	Tue 1/03/11	Mon 26/09/11
85	**Infrastructure - Mining**	**5.68 mo**	**Fri 1/04/11**	**Thu 22/09/11**
86	Earthworks, Drainage, Fencing &	25 days	Wed 1/06/11	Tue 5/07/11
87	Dredge Starter Pond	40 days	Fri 1/04/11	Thu 26/05/11
88	HV Power Reticulation	40 days	Fri 1/04/11	Thu 26/05/11
89	Buildings	20 days	Fri 1/07/11	Thu 28/07/11
90	Water Supply	50 days	Fri 15/07/11	Thu 22/09/11
91	**Temporary Construction Facilities**	**1.82 mo**	**Tue 2/08/11**	**Mon 26/09/11**
92	Temporary Facilities	40 days	Tue 2/08/11	Mon 26/09/11
93	**Purchase Long Lead Items**	**22.05 mo**	**Tue 1/02/11**	**Mon 10/12/12**
94	**Mining**	**17.14 mo**	**Fri 1/07/11**	**Mon 10/12/12**
95	Dredge	345 days	Tue 16/08/11	Mon 10/12/12
96	Services Barge	215 days	Fri 1/07/11	Thu 26/04/12
97	**Wet Concentrator**	**21.59 mo**	**Tue 1/02/11**	**Mon 26/11/12**
98	Surge Bin Module	345 days	Tue 2/08/11	Mon 26/11/12
99	Spiral Concentrator Module	425 days	Tue 1/02/11	Mon 17/09/12
100	Product Handling	285 days	Tue 3/05/11	Mon 4/06/12
101	**Mineral Separation Plant**	**14.23 mo**	**Wed 1/06/11**	**Fri 10/08/12**
102	Feed Receival	215 days	Thu 1/09/11	Wed 27/06/12
103	Wet Mill	245 days	Tue 2/08/11	Mon 9/07/12
104	Dry Mill	255 days	Wed 1/06/11	Tue 22/05/12
105	Product Handling & Storage	215 days	Thu 1/09/11	Wed 27/06/12
106	WHIMS Module	215 days	Thu 15/09/11	Wed 11/07/12
107	Ilmenite Plant	215 days	Mon 17/10/11	Fri 10/08/12
108	**Construction & commissioning**	**21.36 mo**	**Thu 1/09/11**	**Wed 19/06/13**
109	**Temporary Construction Facilities**	**4.45 mo**	**Thu 1/09/11**	**Mon 16/01/12**
110	Temporary Facilities	98 days	Thu 1/09/11	Mon 16/01/12
111	Temporary Services	20 days	Thu 1/09/11	Wed 28/09/11
112	**Infrastructure - MSP**	**10.77 mo**	**Thu 1/09/11**	**Fri 27/07/12**
113	Earthworks, Drainage, Fencing &	237 days	Thu 1/09/11	Fri 27/07/12
114	Buildings	90 days	Tue 1/11/11	Mon 5/03/12
115	Water Supply	108 days	Tue 13/12/11	Thu 10/05/12
116	**Infrastructure - Mining**	**14.55 mo**	**Thu 1/09/11**	**Wed 21/11/12**
117	Earthworks, Drainage, Fencing &	298 days	Mon 3/10/11	Wed 21/11/12
118	Dredge Starter Pond	150 days	Tue 10/04/12	Mon 5/11/12
119	HV Power Reticulation	114 days	Tue 3/01/12	Fri 8/06/12
120	Communications	155 days	Tue 15/11/11	Mon 18/06/12
121	Road - MSP to Mine	81 days	Thu 1/09/11	Thu 22/12/11
122	Cranage	24 days	Tue 15/05/12	Fri 15/06/12
123	**Wet Concentrator**	**19.09 mo**	**Mon 3/10/11**	**Fri 10/05/13**
124	Surge Bin Module	290 days	Mon 2/04/12	Fri 10/05/13
125	Spiral Concentrator Module	420 days	Mon 3/10/11	Fri 10/05/13
126	Product Handling	20 days	Thu 31/05/12	Wed 27/06/12
127	Wet Concentrator Services	95 days	Tue 15/05/12	Mon 24/09/12
128	**Mineral Separation Plant**	**11.64 mo**	**Wed 1/02/12**	**Wed 23/01/13**

Project: Project execution 10-05-16-AS
Date: Tue 18/05/10

Task | Milestone | Rolled Up Task | Rolled Up Progress | External Tasks | Group By Summary
Progress | Summary | Rolled Up Milestone | Split | Project Summary | Deadline

Page 2

ID	Task Name	Duration	Start	Finish
129	Feed Receival	98 days	Tue 12/06/12	Thu 25/10/12
130	Wet Mill	241 days	Wed 1/02/12	Wed 2/01/13
131	Dry Mill	212 days	Mon 2/04/12	Tue 22/01/13
132	Product Handling & Storage	212 days	Mon 2/04/12	Tue 22/01/13
133	WHIMS Module	98 days	Mon 2/04/12	Wed 15/08/12
134	Ilmenite Plant	212 days	Tue 3/04/12	Wed 23/01/13
135	**Mining**	**11.18 mo**	**Tue 15/05/12**	**Tue 23/04/13**
136	Dredge	168 days	Fri 31/08/12	Tue 23/04/13
137	Services Barge	60 days	Tue 15/05/12	Mon 6/08/12
138	**C1+2 Commissioning**	**5 mo**	**Tue 1/01/13**	**Mon 3/06/13**
139	Mining	83 days	Thu 31/01/13	Mon 27/05/13
140	Wet Concentrator	88 days	Thu 31/01/13	Mon 3/06/13
141	Mineral Separation Plant	89 days	Tue 1/01/13	Fri 3/05/13
142	**C3 Commissioning**	**3.59 mo**	**Fri 1/03/13**	**Wed 19/06/13**
143	Mineral Separation Plant	67 days	Fri 1/03/13	Mon 3/06/13
144	Mining	36 days	Wed 1/05/13	Wed 19/06/13
145	Mine Area	36 days	Wed 1/05/13	Wed 19/06/13
146	Wet Concentrator	36 days	Wed 1/05/13	Wed 19/06/13
147				
148	**Social-Economic**	**20.68 mo**	**Wed 10/03/10**	**Tue 6/12/11**
149	Finalise pre-mining baseline	3 mo	Wed 10/03/10	Wed 9/06/10
150	Compile resettlement Action Plan	3 mo	Thu 10/06/10	Thu 9/09/10
151	Verify social impact & compensation	6 mo	Fri 10/09/10	Mon 14/03/11
152	Complete initial compensation	6 mo	Mon 6/06/11	Tue 6/12/11
153	**Rehabilitation Trials & establishment**	**22 mo**	**Wed 10/03/10**	**Mon 16/01/12**
154	Rehab trials	18 mo	Wed 10/03/10	Wed 14/09/11
155	Establish rehab nursery	6 mo	Tue 15/03/11	Wed 14/09/11
156	Rehab equipment	4 mo	Thu 15/09/11	Mon 16/01/12
157	**Maintenance Systems**	**18 mo**	**Fri 1/07/11**	**Fri 4/01/13**
158	Catalogue Equipment List	6 mo	Fri 1/07/11	Mon 2/01/12
159	Purchase operations spares	12 mo	Tue 3/01/12	Fri 4/01/13
160	PM build ups	6 mo	Thu 5/07/12	Fri 4/01/13
161	**OH&S System development**	**7 mo**	**Mon 2/07/12**	**Thu 31/01/13**
162	Develop OH&S system details	7 mo	Mon 2/07/12	Thu 31/01/13
163	**Recruitment**	**8 mo**	**Mon 1/10/12**	**Mon 3/06/13**
164	Recruit Operations expat employees	4 mo	Mon 1/10/12	Wed 30/01/13
165	Recruit Operations national employees	4 mo	Thu 31/01/13	Mon 3/06/13
166				
167	**First Sales products**	0 days	**Wed 19/06/13**	**Wed 19/06/13**



Project: Project execution 10-05-16-AS Date: Tue 18/05/10	Task		Milestone	◆	Rolled Up Task		Rolled Up Progress		External Tasks		Group By Summary
	Progress		Summary		Rolled Up Milestone ◇		Split		Project Summary		Deadline

Page 3

MDL Mineral Sands Group

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SECTION 14

Management and Personnel

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Copy 16

TABLES

FIGURES

14 MANAGEMENT AND PERSONNEL

14.1 Introduction

The Human Resource Strategy formulated for the GCP draws on the considerable expertise built up over the past five years by MDL in Senegal and directly transferable experience gained during the construction and operation of the Sabodala Gold Project in Senegal. Key elements of the GCO Human Resource Strategy are:

- Industrial relations policy and processes.
- Manning levels and organisation.
- Employee remuneration and conditions.
- Accommodation.
- Human resources systems, including payroll.
- Diversity and cross-cultural policies and processes.
- Performance management and performance appraisal processes.
- Employee training needs assessment, program design and delivery.
- Site and personnel security.

Key factors shaping the Human Resource Strategy are:

- MDL's recent Sabodala experience has been used to inform the organisation, approaches and processes proposed for the GCP.
- The project is located close to small villages such as Diogo and regional towns including Mboro, Tivaouane, and Thiès and the capital city of Dakar.
- GCO commitment to maximising the employment of Senegalese national staff, with preference being given to those who reside locally.
- GCO, from technical and financial necessity, must operate year round on a 24 hour, seven days a week basis and will require shift rosters to be implemented.
- The Senegal Labour Code is applicable.
- Key technical positions will be filled by expatriate staff during the first two to five years of operations with an aim to phase out expatriates in these positions over time.

14.2 Industrial Relations Policy

14.2.1 General

Senegal has well developed and documented labour laws and regulations, which are rigorously enforced by the government labour inspectorate. The French IR laws in Senegal are not based on union monopoly, so a company can employ labour without union delegates but solely with personnel delegates. MDL's Sabodala project operates in this manner.

In the Senegalese system, any company that hires more than 12 employees must elect personnel delegates (not necessarily members of a trade union), who will represent, for three years, all employees by category (general employees, professionals and engineers). Personnel delegates are salaried employees paid by the company and GCO must allot them a quota of hours each month so that they can exercise their mandate.

Having a union delegate is not compulsory, but a trade union can inform management that it has a representative among the company's employees. The union delegate's function is limited by the labour code to prevent the delegate from misusing their mandate inside the company. The trade union has no role to play in the recruitment of the workforce.

14.2.2 Senegal Labour Code

Employment in Senegal is regulated by the government and gazetted by Decree 2006 - 1262 dated 15 Nov 2006. MDL has now operated under the labour code for five years in the country and particularly at Sabodala for three years. The company is fully conversant with the code and the regulatory regime that covers employment in Senegal. Key points of note include:

- The labour code is based on a 40-hour work week with overtime uplift for time worked in excess of the basic number of hours. There is a general overtime limit of 500 hours per year with an additional discretionary allowance of a further 500 hours per year.
- Employment commences with a three- or six-month period of casual status, which is convertible to permanent status after a further three or six month duration. After conversion to permanent status, termination requires a retrenchment payment. Casual employment (day workers) is treated differently and is discussed in Section 14.5.5.
- Annual leave is accrued monthly but cannot be exercised until 23 months of work have elapsed.
- Each administrative region has a government labour inspectorate that oversees the implementation of the law. GCO's initial operations fall within the jurisdiction of the Région de Thiès labour inspectorate.

14.3 Proposed Operational Manning Levels and Organisation

14.3.1 General

The GCO administrative centre will be located near the MSP, approximately 1 km east of Diogo village. Permanent MSP operations, laboratory, administration, support and common services staff will be located in the MSP complex.

The mine and floating concentrator will commence operations 3 km north-west of the MSP and will be continually moving through the orebody, heading generally north. Site clearing, dredge operation, concentrator operation and rehabilitation staff will be located at the mine. A small office for administrative purposes will be located in MDL's existing office in Dakar.

14.3.2 Manning Numbers and Organisational Chart

A summary of labour breakdown by location and day and shift status for permanent company staff is shown in Table 14.1. It is envisaged that at full production the total number of staff employees will be 280 people. The four-panel roster for shift workers will mean that only 25% of the shift workers will be at work at any one time. The complete manning tabulation is included in Appendix 14.1.

Table 14.1 GCO Manpower Requirements

Department	Day Work	Per Shift	Total Manning
Mine	28	13	80
MSP	61	23	153
Administration	42	0	42
Environmental	5	0	5
Total	136	39	280

The GCO staff organisation structure is presented in Figure 14.1.

In addition, a total of 120 contractors and temporary staff will be employed for security, rehabilitation, catering, road maintenance and as drivers. The build-up of these numbers is shown in Appendix 14.1. The overall permanent GCO manning levels allow for an additional 36 people to cover absenteeism, day shift roster coverage, sick and annual leave and training plus an allowance of 16 persons in a designated training pool within the 120 contractors.

Expatriate staff will be utilised for the positions that require a significant history of mineral sands mining or processing experience. It is envisaged that they will be sourced from either Australia or Brazil, which have major operations similar to the GCP. There will be approximately 42 expatriate positions and with some 22 positions filled for a duration of 24 months and subsequently replaced by appropriately skilled senior national staff.

14.3.3 Manning Build-up

Following MDL's practice at Sabodala, future GCO staff will be employed during the construction period as owner's representatives. It is envisaged that some 10 staff rotating on a back-to-back FIFO roster will be required. It is likely that several of the owner's representatives will be required to oversee the completion of detailed design of the project in Australia. Accounting personnel will be located on site as it is intended that the owner's project construction cost control function will be site-based.

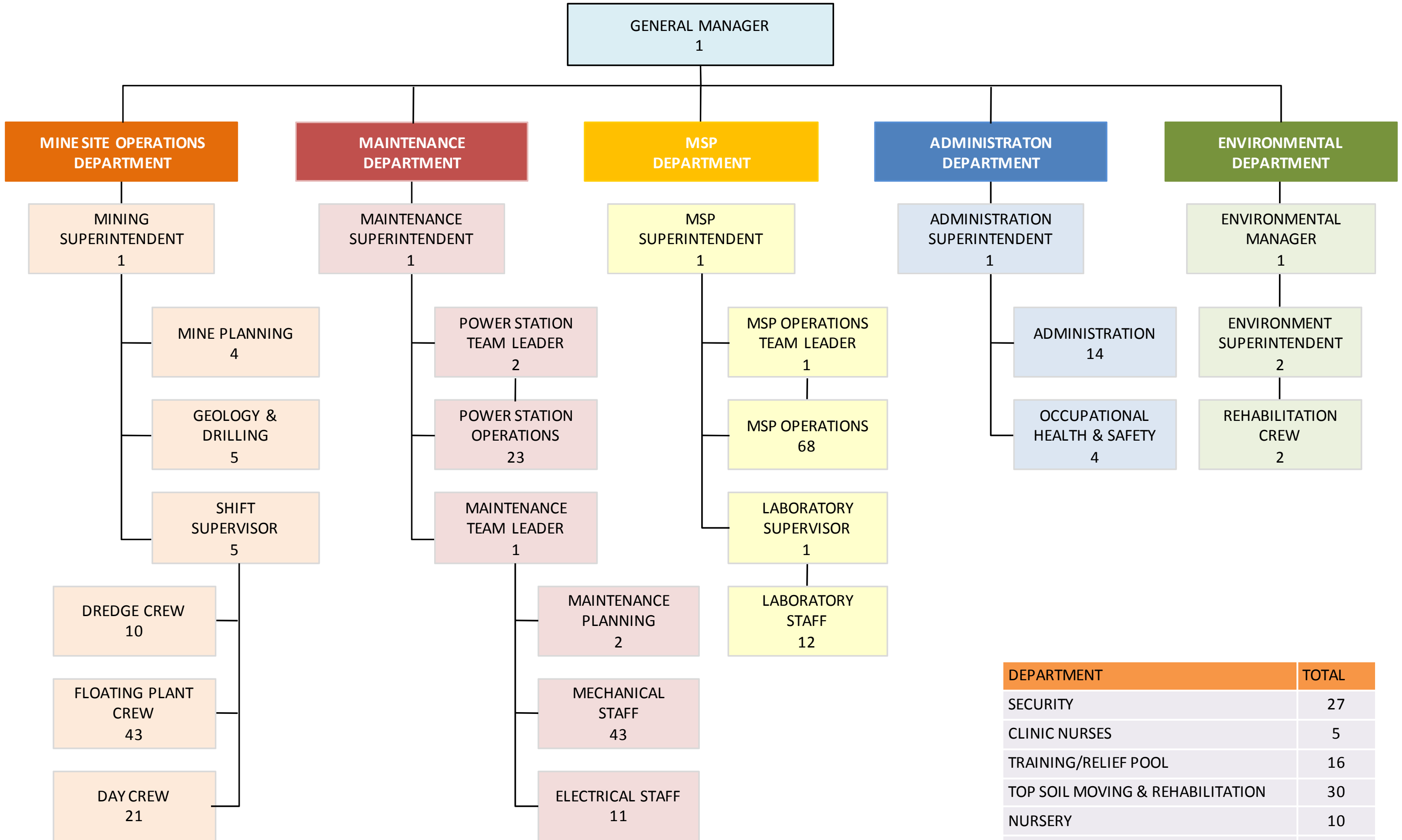
An estimated manning build-up of site personnel for the GCP is shown in Table 14.2

Table 14.2 Project Manning Build-up for Site Personnel

Personnel	**2011**	**2012**	**2013**
Owner's construction team			
Expatriate	10	10	10**
Local	25	25	25**
Subtotal	35	35	35**
Owner's operations team			
Expatriate	na	21*	42
Local	na	na	238
EPCM and subcontractors			
Expatriate	40	40	40**
Local	400	800	200**
Subtotal	440	861	520
Total	475	896	555

** Last quarter 2012 only.*
*** First 2 quarters 2013 only.*

Figure 14.1 Grande Côte Operations Staff Organisation Chart



DEPARTMENT	TOTAL
SECURITY	27
CLINIC NURSES	5
TRAINING/RELIEF POOL	16
TOP SOIL MOVING & REHABILITATION	30
NURSERY	10
RESTAURANT	31
ROAD MAINTENANCE	7
DRIVER	4
TOTAL	130

14.4 Shift Roster Arrangements and Costs

14.4.1 General

GCO will operate 24 hours per day, 365 days per year on a continuous shift operation. Different rosters will operate for mine and plant personnel, day work staff and expatriate staff.

14.4.2 Mine and Plant Shift Rosters

The mine will operate three shifts per day. There will be four panels (crews) working seven days straight followed by two or three days off. Each shift is 8½ hours and the crews rotate between day, afternoon and night shift after each break. The shift roster arrangement is shown in Table 14.3.

The shifts would nominally commence at 0730, 1530 and 2330, finishing at 1600, 2400 and 0800, respectively. This allows for a half-hour mid-shift break and a half-hour overlap for continuity at shift change.

Table 14.3 Shift Roster

	WEEK 1							WEEK 2							WEEK 3							WEEK 4						
Panel	**M**	**T**	**W**	**T**	**F**	**S**	**S**	**M**	**T**	**W**	**T**	**F**	**S**	**S**	**M**	**T**	**W**	**T**	**F**	**S**	**S**	**M**	**T**	**W**	**T**	**F**	**S**	**S**
1	D	D	D	D	D	D	D				A	A	A	A	A	A	A			N	N	N	N	N	N	N		
2	A	A	A			N	N	N	N	N	N	N			D	D	D	D	D	D	D				A	A	A	A
3	N	N	N	N	N			D	D	D	D	D	D	D				A	A	A	A	A	A	A			N	N
4				A	A	A	A	A	A	A			N	N	N	N	N	N	N			D	D	D	D	D	D	D

14.4.3 Day Work Staff Roster

While mining and processing will operate on continuous shifts, other activities will be structured to operate during daylight hours only. To minimise the costs, day shift activities will, where possible, be undertaken Monday to Friday using eight hours as the benchmark shift duration.

In general, office activities, including the laboratory functions, will be day shift only. Other activities will be assessed for suitability for day shift based on safety, cost and logistical criteria. For example, rehabilitation will only be performed during daylight hours. Supporting services such as transport, catering and security will be greatly simplified with the proportion of labour operating on dayshift maximised.

The labour position count on each roster is depicted in Table 14.4.

Table 14.4 Breakdown of Roster Numbers

	Day Shift Position	Rotating Shift Position
Company personnel	136	39
Outsourced personnel	51	16

Day shift working roster includes one panel of staff working five days straight followed by two days off. Each shift is 8½ hours, commencing at 0730 and finishing at 1600. This allows for a half-hour mid-shift break.

14.4.4 Expatriate Staff Roster

Expatriates will be employed on a single status contract “fly in fly out” (FIFO) basis, working an eight week on/four week off roster. Their working day will be 12 hours on either day or night shift.

14.4.5 Construction Labour Rosters

EPCM contractors will comply with GCO’s expatriate employment practice, although a FIFO roster of eight weeks on and two weeks off is to be adopted. This is consistent with international construction practices.

14.4.6 National Manning Categories and Salaries

The typical salary levels for the professional, technical, administrative and operational personnel that will be employed are shown in Table 14.5.

Salaries are based on 40 hour week schedule and have been converted from local currency using an exchange rate of $US1 = 475CFA Frank.

Table 14.5 Manpower Categories and Base Salary

Category	Category Position Descriptions	Typical Annual Gross Salary ($US)
10A	Senior head of department	38,976
9B	Head of department – senior engineer	36,192
P3B	Senior officer/engineer/geologist	27,840
P2B	Senior officer/engineer/geologist	24,221
P1B	Senior officer/engineer/geologist	20,323
AM5	Professional 1	19,404
AM4	Professional 2	18,708
AM3	Professional 3	16,815
AM2	Professional 4	14,644
AM1	Professional 4	12,695
7ème	Professional 5/trade 2	10,686
6ème	Professional 6/trade 3	8,519
5ème	Clerical 3/trade 4	6,682
4ème	Clerical 2/trade 5	5,345
3ème	Clerical 1/field assistant 3	4,343
2ème	Guard/field assistant 4	3,786
1ère	Office/field assistant 5	3,229

14.4.7 Expatriate Salaries

The cost to the company for expatriate employees (based on current costs at Sabodala), averages $US176,200 per year. This assumes predominantly Australian sourced staff. The average cost may be lower if significant numbers are recruited from South Africa or Brazil.

14.5 Recruitment

14.5.1 General

It is envisaged that the recruitment process will commence at the start of construction. Key technical and maintenance staff may be utilised as owner's representatives for the construction duration. Senior operations personnel will be engaged three months prior to commencement of commissioning to familiarise themselves with the plant and to carry out the recruitment and training of national staff prior to start-up.

Nursery and rehabilitation staff will be recruited as early as possible to ensure that plant supplies and rehabilitation procedures are ready well ahead of operations commencement.

A core group of laboratory and geological staff are currently on the GCO payroll and they will be retained and supplemented progressively over the project development period.

14.5.2 Local Recruitment

Local recruitment of unskilled labour from surrounding villages, for both construction and operations positions, will be handled in a manner identical to that established and employed successfully at MDL's Sabodala operations. The recruitment process is as follows:

- The administrative or local authority community leader for the area is the sous-prefect. GCO will consult with him to establish a panel of local residents who are seeking work on the project.
- The sous-prefect in turn, consults with the chiefs of the local villages to arrive at an equitable distribution of available labour.
- GCO will ensure that the geographic spread is manageable and that unreasonable expectations of jobs are not raised.

14.5.3 Non-Local Recruitment

It is anticipated that non-local nationals will be required for many of the semi-skilled and skilled roles. These employees are likely to be based in Dakar and will be recruited by advertising, recruitment specialists and by word of mouth.

14.5.4 Expatriate Recruitment

All senior management level positions will initially be filled by expatriates. Expatriates will be recruited by advertising, recruitment specialists and by word of mouth. A total of 42 expatriates will be required during the initial two years of operation. This number will decrease as nationals are trained to take over these roles.

14.5.5 Recruitment of Day Workers

A labour broker is currently utilised for provision of day labourers at Grande Côte. GCO will establish contracts with at least two labour brokers who will handle the HR and payroll functions for casual labour and some unskilled categories.

14.5.6 Recruitment of Security Personnel

All GCO security personnel will be employed under contract from a Dakar-based company. It will be a requirement (contrary to all other positions) that site guards are not from local villages to ensure impartiality.

14.5.7 Recruitment of Construction Personnel

Construction activities will be managed using an established EPCM contractor. Construction labour will be sourced primarily by the EPCM contractor and all employment will be consistent with GCO's practices and policies.

Maximum use of Senegal-based contractors will be encouraged. However, some trade skills are likely to require expatriates.

Construction day workers will be mandated and hired through the GCO approved labour broker and will follow the hiring practices adopted by GCO. This will ensure that employment uniformity occurs.

GCO will require that EPCM expatriate staff are hired using the GCO employment policy and procedures. This will ensure that visa, travel and local taxation issues are handled consistently with GCO staff. In addition, EPCM staff will be reference checked and will be required to undergo medical checks before being mobilised to Senegal.

14.6 Housing and Accommodation

14.6.1 General

A multi-stage accommodation approach will be adopted for the GCO based on MDL's five years of in-country experience including multiple city based guesthouse operations, site construction and establishment of permanent camps from the recently completed Sabodala project. The strategy for the GCP involves provisions during the following development stages:

- Short term (zero to two years): An expansion of the current exploration camp to meet the housing demand during the construction and commissioning stage.
- Medium term (two to five years): Establishment of multiple guesthouses in the surrounding towns for FIFO expatriate staff during the post-commissioning stage.
- Long term (beyond five years): Planning for a future permanent housing estate at or near one of the nearby towns.

The GCO housing and accommodation strategy is based on the following drivers:

- Minimising capital cost requirements.
- GCP's proximity to large towns with good amenities and services.
- The long project life.

It is envisaged that at least $US5M of capital is being saved by not constructing a permanent camp. This figure is based on actual tendered construction price for the camp from 2007 and is therefore considered to be a conservative saving estimate.

Based on the MDL's in-country experience coupled with 12 months of operating the new Sabodala camp, the per-man-day rates of guesthouse accommodation will be comparable to the cost of operating the permanent camp at Sabodala.

There are three towns within 74 km of the proposed mine site that can be accessed primarily on sealed road. The towns have good housing amenities for guesthouse and hotel operations (see Table 14.6). There are also at least 16 villages within 5 km of the project site.

Table 14.6 Proximity of Project Site to Nearest Towns

Town	Population	Distance from Diogo (km)
Thies	311,324	74
Tivaouane	39,000	43
Mboro	12,289	24

It is intended that accommodation will be provided for all senior management level positions initially to be filled by expatriates. A total of 42 of these roles are in the current manning chart which reduces to 20 on current projections after two years.

14.6.2 Short Term – Construction and Commissioning

The approach to accommodation during the construction and commissioning for the GCO is identical to that successfully adopted for the Sabodala project. The approach is multi-faceted and involves:

- Expatriates travelling to and from Senegal will be accommodated at Dakar guesthouses. While Dakar is clearly not as close to the project site as, say, Thies, guesthouses located in Dakar will allow far easier access to the Dakar airport for both arriving and departing expatriate construction personnel. This is a cost-effective approach and was successfully adopted for the exploration/construction phases of the Sabodala project when personnel movements were high.
- Transfer to and from the guesthouse and the exploration camp will be via a dedicated shuttle bus.
- For personnel requiring onsite accommodation, the current exploration camp, which has a current capacity of 280 people, will be expanded to a capacity of 800 using a mixture of additional 10-man tents and en suite accommodation. Sufficient land exists for this camp expansion.

Expansion of the existing exploration camp is anticipated to be a relatively cheap exercise based on the existing infrastructure in place at the GCP and volume of surplus equipment from the Sabodala construction camp, which will be transferred to GCO. An allowance of US$0.5M has been included in the capital estimate to supplement the existing equipment.

14.6.3 Medium Term - Post Commissioning

The proposed approach to accommodation post commissioning includes:

- Hotel accommodation in Dakar for arriving and departing personnel.
- Transfer from and to Diogo region by dedicated shuttle bus.
- Provision of nine guesthouses for expatriate FIFO staff, providing 60 catered rooms. Guesthouses would be located in Thies, Tivaouane and or Mboro. Appropriate houses currently exist in all three of these locations, plus in the case of Tivaouane and Mboro, entire hotels are potentially available for rent. There is currently no suitable rental accommodation in Diogo and adjacent villages.
- Locally recruited national personnel will be accommodated in their home village or town.
- National personnel, who are recruited and move to the project area, will be expected to find their own accommodation in the nearby villages or towns.

14.6.4 Long Term – Operational

The FIFO approach is not considered the optimal approach based on the anticipated long life of the GCP. A live-in-country approach via a dedicated offsite township is thought to be the best option and is consistent with neighbouring phosphate mining company, Industries Chimiques du Senegal (ICS).

At this point, only preliminary discussions have been held with a suitably experienced developer. These discussions assumed the construction of 30 four-bedroom houses and 20 single-man accommodation units at a location near Mboro or Thiès. Alternatively, land within MDL's mining lease could be used to construct the township and the township could be built within the precincts of one of the surrounding towns to lever off existing local infrastructure.

The cost of in-country accommodation facility is anticipated to be on par with a FIFO approach and has been included in the operating costs.

14.6.5 Provision of Meals and Amenities

For the period of construction, meals will be provided for all residents of the GCO exploration camp with the mid-shift meal being delivered to staff by the establishment of local messes.

Post construction, when the exploration camp is decommissioned, a permanent restaurant/mess room will be provided at the MSP and meals will be catered for both the MSP site and the mine crews. Mine crew meals will be delivered to the mine site crib-room.

14.6.6 Accommodation Costs (Short- and Medium-Term Stages)

The cost structure adopted for guesthouses is based on MDL's Dakar experience, where two guesthouses were in operation for a period of four years as part of Sabodala development. Based on actual Sabodala cost data the cost of providing 16 fully catered rooms varies between US$11,500 and US$13,500 per month depending on occupancy rates (see Table 14.7).

Table 14.7 Guesthouse Accommodation Costs

Description	
Fixed Costs (Overheads)	
Staff salaries	
Rental of (x2) houses	
Maintenance, TV/internet subscription, etc.	
Subtotal	US$8,000/month
Variable Costs	
Water/electricity/gasoil (variable according the period in the year)	
Food (variable according the number of guests)	
Total	US$11,500–13,500/month

Assuming an occupancy rate of 80%, the average monthly costs will be $34 per man-day. This rate is consistent with 2009 all-inclusive man-day rates of US$26 per man day at Sabodala which has significantly higher economies of scale due to the large camp size.

A hotel daily rate of US$90 per night has also been included on the basis of two nights per rostered trip, while bus transfer rates have been included based on indicative pricing from bus operators in Senegal.

14.7 Personnel Transportation

Site transport for personnel will be provided in three general categories:

- Pool vehicles for general traffic around and between the mine, the exploration camp and the MSP.
- A GCO-owned bus fleet will provide transport for GCO personnel from Thiès, Tivaouane and Mboro to suit all shift start and finish times. GCO will be utilising a fleet of the familiar yellow US-sourced ex-school buses. The bus service will be gratis to all employees.
- The EPCM contractors labour will use the GCO-owned bus fleet for transport to the dredge and MSP construction sites from the camp.

For expatriate offshore travel and transfers:

- Offshore travel will be handled through MDL's Mauritian-based travel agency and organised by the employees dependent on the roster cycles. This process is well established and utilised by all expatriates employed at MDL's Sabodala operation.
- Expatriate transport between Dakar airport and the nearby guesthouse will be provided by the existing Dakar based MDL mini-bus. Transfer from the guesthouse to site will be via a third party transport provider operating three to four days per week utilising an air-conditioned shuttle bus.

The same approach will be used for offshore travel and transfers for the EPCM contractor's expatriate labour.

14.8 Human Resource Administration and Payroll

HR administration will be undertaken by staff based at the MSP site. Records will be maintained on a confidential basis. Payroll will be based on attendance records, with pay calculations performed by GCO site staff.

The use of bank accounts is not common in Senegal. Despite this, efforts will be made to encourage staff to obtain bank accounts and utilise electronic banking. National staff may elect to be paid in cash and this will be arranged using a national accounting company delivering the payroll accompanied by security personnel. The payroll system ensures that the appropriate government taxes are deducted and paid to the taxation authorities.

Expatriate personnel will have their payroll records maintained by MDL head office in Melbourne. These staff will be paid electronically and the appropriate local and Australian taxation remitted to the relevant taxation authorities.

14.9 Employee Training and Development

14.9.1 General

Development of the local workforce is a priority for GCO for two main reasons: to have competent and multi-skilled employees in each facet of the process, and to ensure each employee is developed to contribute to the success of the operations.

Training will include health, safety and environment, personal and supervisory development, computer literacy and technical specialities. Prior learning will be recognised and new skills will be gained either through classroom or on-the-job training. Employees will then gain practical experience and will be tested using competency-based tests to ensure the skills acquired can be performed in the workplace.

MDL will also work closely with educational institutions and establish processes to develop students to gain practical experience in various disciplines, while in training at the institution. This will ensure future candidates are available with the necessary mining experience.

Following needs assessments, appropriate training courses and materials will be developed by the training supervisor and the training officers. Expatriates will assist in the training of national staff. The initial focus will be on single skills training will the gradual introduction of multi-skilling across the operation.

14.9.2 Cross-cultural Training Issues

Great care will be taken to ensure that all expatriate staff are conversant with the need to work in a racially and religiously diverse environment. Appropriate screening during the employment process will be followed by briefings on appropriate behaviour will be provided as part of the site induction process.

Expatriates will be encouraged to learn French, although it is recognised that many locals don’t speak French. It is anticipated that most senior nationals will be multilingual. These employees will also be able to act as interpreters.

14.9.3 Site and Personnel Security

14.9.3.1 General

The key security issues for the project are:

- Safety of national and expatriate personnel.
- Protection of company property such as tools, plant and equipment and fuel.
- Restriction of access to industrial sites such as the MSP, camp, expatriate accommodation facilities and the dredging operations.

Dredge pond safety will be given the highest priority together with security of access to the floating plant.

Vehicle access to site will be managed via gatehouses and security guards. There will be additional security during construction and the mine construction area will be fenced temporarily. Security at the port will be managed by the Dakar port authority. Security passes will be issued to all employees and contractors.

14.9.3.2 Safety of National and Expatriate Personnel

Security guards will be provided for local expatriate housing. No additional security as required for the camp, which is already fenced and has a gatehouse and 24-hour guards.

14.9.3.3 Security Personnel

An experienced Dakar-based security company will be engaged to provide site security. It is envisaged that a total of 27 uniformed and armed guards will be required, with the majority of these being on rotating shifts. There will be one guard at each of the MSP guard houses with the rest being deployed at the mine. Frequent staff rotations will be maintained so that familiarity does not develop. The security personnel will report directly to GCO's security leader.

14.9.3.4 Protection of Property and Access Restriction

GCO proposes the following measures to protect company property and restrict access to company infrastructure:

- The MSP will have perimeter fencing (2 m plus barbed wire) and security gatehouses will be manned to ensure that access is restricted to staff and authorised visitors.
- The mine will not be fenced, but will be guarded to limit access to the floating plant. Boundary guards will patrol the dredge pond to ensure the safety of local personnel and animals in the vicinity of operations.

14.9.4 Occupation Health and Safety

GCO will implement a positive policy to drive a culture of safety at its operations in Senegal. GCO is in the process of developing a health and safety management plan according to international standards, and this will be combined into the management operating system, which has already started using a consultant to develop the framework.

The health of each employee will be addressed through pre-employment baseline medicals covering basic health and occupational health, such as hearing, eyesight and lung function testing. Employees will be given basic first aid training.

Health and safety will be the responsibility of each employee and a centralised system will incorporate all policies, procedures, inspections, templates and development modules for each department and will be controlled by the manager.

An ambulance is present at the GCP to assist with necessary medical care.

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SECTION 15
Closure

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CONTENTS

15 CLOSURE

15.1 Introduction

Planning for mine closure is an integral part of the GCP project life cycle. Objectives for the mine closure plan are:

- Progressively restore the landscape to be stable, compatible with surrounding landforms and similar to pre-mining topography, unless otherwise agreed with authorities.
- Progressively re-establish vegetation on dunes that were vegetated pre-mining.
- Dismantle and remove all plant, buildings and infrastructure unless otherwise agreed with authorities.
- Investigate any potential soil contamination and remediate, if necessary.
- Monitor effects of mining on groundwater levels and quality to quantify any adverse effects and provide guidance for remedial activities, if required.
- Minimise the long-term impacts on the livelihoods of the local communities.

15.2 Regulatory Requirements

15.2.1 Environmental Regulations

The Senegal Mining Code is the primary legislation regulating the mining industry in Senegal. The relevant sections of the code that pertain to mine closure are:

- Article 82, which states that the mining title holder is obliged to rehabilitate mines at the expiry of each mining title.
- Article 84, which requires that a mine site rehabilitation fund be established with terms and conditions fixed by decree.

The Mining Code Regulations that pertain to closure are:

- Article 9, which states that information gathered over the course of the mining operations shall be forwarded to the Director of the Department of Mines and Geology.
- Article 115, which requires that registers of information gathered during the operation of the mine shall be forwarded to the Director of the Department of Mines and Geology “at the expiry of the validity of the mining title”. These registers and plans include:
  - An overall plan on a scale of 1:5,000 or a large scale, on which appears all the topographical, geographical and mining information acquired during the undertaking of work.
  - A plan of 1:2,000 or a larger scale of surface and underground works.
  - A register of the progress of works in which all significant information concerning the operation and its results are recorded.

- A workforce control register.
- A register of extraction, storage, sales and shipping of mineral substances.
- A register of the management of explosives and other dangerous products used in the mining operations.

The Mining Convention between MDL and the Government of the Republic of Senegal (GRS) was executed on 9 September 2004. The Mining Convention specifies the rights and obligations of the State and the mining title holder. Commitments and requirements pertaining to closure planning are as follows:

- Article 31.7 states that MDL will comply with Senegalese standards of safety, hygiene and cleanliness and the protection of the environment.
- Article 31.8 states at termination of mining activities, MDL may not transfer its facilities, machines and equipment to third parties before having accorded the State a period of 30 days priority for the acquisition of these goods.
- Article 31.11 states that any decision to open or close exploration or exploitation for mineral substances must be first declared to the Minister for Mines.
- Article 32.6 states that MDL will be required to pay compensation to residents or land-users for losses, privations of use or damages resulting from mining activities.
- Article 32.12 states that infrastructure constructed or installed by MDL Senegal S.A.R.L. and the exploitation company becomes their full legal property. In the event of the expiry of the mining convention, MDL may dispose of the infrastructure at its discretion.
- Article 33.3 states that all holders of mining titles must undertake the reinstatement of sites at the expiry of each mining title except for areas which continue to be covered by a mining exploitation title.
- Article 33.4 states that MDL will establish a trust account to cover the costs of rehabilitation of the mining site.
- Article 33.5 states that MDL Senegal S.A.R.L. and the exploitation company shall as much as possible maintain all infrastructure used. Any deterioration in public infrastructure beyond that of normal use and clearly attributable to MDL Senegal S.A.R.L. or the exploitation company must be repaired.
- Article 33.6 states that MDL Senegal S.A.R.L. or the exploitation company agrees to:
    - Dispose of lands excavated in such a manner as to be able to control, within acceptable limits, landslides and earth movements, the deviation and sedimentation of watercourses, the formation of sites of hazardous water retention and the deterioration of neighbouring soils and vegetation.
    - Shall avoid all discharge of toxic chemical solutions and products and of dangerous substances on to the earth and into the air.
    - Effectively neutralise and control waste products so as to not significantly and unfavourably affect climatic conditions, the soil, vegetation and water resources of the area.

- – Must proceed with the reinstatement of worked sites at the expiry of each title in such a way that the contour of the land blends reasonably with the topography of the location.

An addendum to the Mining Convention (Avenant No 1 a la Convention Minière) between MDL and the GRS was signed on 24 September 2007. This document prescribes that MDL will proceed with rehabilitation after the mobile dune sand is mined and that the land will be returned to the State or the owner. It also raises the possibility of alternative final land use options such as ornamental lakes, fish farm ponds, parks and entertainment areas on the rehabilitated mine path.

A mining permit (*concession minière*) was granted to MDL Senegal S.A.R.L. on 2 November 2007. This document refers to the Mining Convention and the addendum to the Mining Convention as defining the conditions under which mining will be carried out. It provides coordinates defining the limits of the mining permit area, which covers 445.7 km^2. The Mining Permit is valid for 25 years and is renewable.

In February 2008, the Ministry for the Environment, Protection of Nature, Water Retention Basins and Artificial Lakes (Department of the Environment and Classified Establishments) issued the Certificate of Environmental Compliance for the GCP, which applies to the Environmental and Social Impact Assessment (EIES), and its management plan (PGES). This certificate requires implementation of the management plan, including consultation with committees specified for each section of the management plan.

15.2.2 Socio-economic Regulations

The relevant sections in the Senegal Mining Code that pertain to the socio-economic welfare of the Senegalese people are:

- Article 55 ensures that a portion of income (US$150,000) from the mining operation is set aside as a fund for the local communities.
- Article 73 states that holders of mining titles are required to request authorisation from the mining authorities to occupy lands that are necessary for their mining operations, whether such land is located either inside or outside the perimeter of their mining titles.
- Within the perimeter of the mining title, the holders of mining titles can be granted right to occupy lands necessary to their mining activities and related facilities or infrastructures, to fell timber and to use and manage surface waters. Outside the perimeter of the mining title, holders of mining titles are permitted to perform auxiliary activities, including transportation and emergency works.

The Mining Code Application Decree, No. 2004-647 also has sections relevant to the socio-economic welfare of the Senegalese people. These sections are as follows:

- Article 92 states that all mining title holders must duly compensate the appropriate party, such as the land owner or the state, for any loss or damages caused by compulsory acquisition resulting in mining activities being carried out on their land by either the mining company or any contractors working on the mining company's behalf.
- Article 93 states that compensation is required for two types of land:
  - For registered land, agreement is struck between the mining title holder and the land owner.
  - For public land, an agreement is struck between the mining title holder and the local government concerned, or in the absence of such agreement, by a commission comprised of: the prefect of the department concerned, the regional Mines Service, the regional Water Resources and Forestry Service, the Agricultural Service, the regional Land Titles Office, the regional State Lands Department, the Department for the Environment, local government concerned and the mining titleholder.
  - If, for whatever reason, in six months following the date on which the decree or administrative order came into force authorising the occupation of the lands, an agreement has not been reached between the holder of the mining title and holders of the land rights or the rural communities concerned, the beneficiary of the authorisation for occupation shall be authorised by the Minister for Mines to occupy the concerned lands in exchange for the deposit into account of a public accountant of provisional compensation.

The Mining Convention, that was decreed on 4 September 2004, between MDL and GRS also has commitments that are relevant to land occupation and compensation management. The relevant sections are as follows:

- Article 32.3 states that the State guarantees MDL access, occupation and use of all lands, inside and outside the area, necessary for the exploration and mining works on the deposit or deposits which are respectively the object of the mining permit in the context of this agreement and in accordance to the provisions of the Mining Code.
- Article 32.5 states that at the request of MDL, the State will proceed with the relocation of residents whose presence on the land impedes the mining works.
- Article 32.6 states that MDL shall be required to pay an equitable indemnity to the said residents as well as for all the other losses, privations of use or damages that result from its activities.
- Article 32.7 states that in the absence of an amicable settlement, the State agrees to undertake action for public expropriation on behalf of MDL.

15.3 Closure Planning

The closure of the mine will occur in two stages:

1. Ongoing closure.
2. Final closure.

The mine life of GCP is in excess of 10 years and therefore initially a conceptual closure plan (CCP) will be developed. This plan will form the basis for the development of a detailed mine closure plan (DMCP) which will be developed within five years of the planned completion of mining. The CCP will be developed prior to the commencement of construction activities on site.

The preliminary criteria for mine closure will be determined in consultation with stakeholders as part of the CCP. The CCP will take into account the economic, social and environmental factors of the mining operation to ensure that GCO meets its statutory requirements, provides sustainable post-mining land use and ultimately achieves successful relinquishment of security bonds and mining leases.

The CCP will also aim to:

- Identify the resources required for closure.
- Identify the potential issues or risks that may impact upon MDL’s ability to achieve regulatory compliance, or compliance with its social licence to operate.
- Identify the potential risks and opportunities to the ongoing social and economic wellbeing of employees and local communities following mine closure.
- Scope the mine closure activities and likely time frames that are required to achieve final land use objectives.
- Highlight the actions that can be taken during the mine’s operating life that will reduce the ultimate cost of decommissioning and final rehabilitation.
- Ensure that adequate and realistic financial provisions are made for the cost of decommissioning, final rehabilitation and any post-closure monitoring and maintenance that may be required.
- Outline the pathway for establishing with the relevant government agencies and other stakeholders clear and agreed criteria for rehabilitation by which the standard and acceptability of final rehabilitation can be measured and assessed.

In addition to the CCP, GCO will develop and implement a Resettlement Action Plan (RAP) and Social Development Plan (SDP) prior to construction to reduce the significance of potential impacts associated with relocation and mine closure. The key issues that will be considered as part of the development of the RAP and SDP are:

- Continual reviewing of the dredge path to confirm if an area needs to be mined.
- To avoid relocating villagers, replacement of land and assets and undertaking rehabilitation in areas that will potentially be impacted by the future dredge path. It will also be important to keep in mind the possibilities of future project expansion when considering potential relocation or land areas and the positioning of replacement assets.
- Minimising the long-term impact of the GCO on the livelihoods of the local community. Fundamental to livelihood restoration for the GCO will be the feasibility of restoring agricultural productivity on the littoral dune following dredging activities and the strategies and time frame for accomplishing this objective.

- Restoration and/or compensation for loss of local community timber and non-timber forest resources.
- Minimising the potential long-term impacts of changes in groundwater levels on agricultural areas (particularly in the Niayes) or potential changes to groundwater quality.
- Potential health impacts within local communities such as food insecurity and associated nutritional deficiencies arising from loss of access to land and resettlement, increased incidence of sexually transmitted infections (STIs) and other prevalent diseases.
- Potential issues and risks regarding employment such as loss or abandonment of traditional forms of livelihood and a lack of alternative post-mine employment opportunities.
- Potential issues and risks regarding migration such as increased strain on existing social services, social disharmony and conflict between original residents and migrants, less employment opportunities for original residents, gender imbalances, emigration from the mining area post-closure.

Preparation and implementation of a well-resourced RAP and SDP which addresses ongoing closure and final closure issues will be essential in the management and mitigation of potential adverse social impacts.

15.4 Ongoing Closure

The ongoing closure stage occurs as the dredge progresses through the sand dunes, and the landscape is reformed, revegetated and handed back to the landowners.

15.4.1 Rehabilitation Program

The ongoing rehabilitation of the mine site will occur as dredging has been completed in an area. The sand dunes will be reformed using the tailing elevators into landforms that are approximate to the original dune landforms. Revegetation of the reformed landscape will only occur where vegetation existed prior to mining.

The revegetation program will require establishment of a variety of plant species. The plant species may include:

- Rapid growth species to ensure stabilisation of the reformed areas.
- Indigenous vegetation to ensure restoration of pre-mining indigenous and protected vegetation.
- Species of cultural significance.

It is most likely that the revegetation will occur during the wet season and that approximately 14 ha per month will need to be stabilised as part of the ongoing closure requirements. Rehabilitation is expected to take up to 24 months until the new vegetation is established. Trials will be conducted prior to the commencement of mining to confirm the best strategies for dune stabilisation and vegetation.

In addition to rehabilitation of the landforms, the transmissions lines, pipelines and roads will be moved with the dredge path and therefore the location of this infrastructure will also need to be rehabilitated on an ongoing basis. Similar to the dredge path rehabilitation of landforms will be approximate the original landforms and revegetation will occur where required.

Ongoing monitoring of these areas will occur after the rehabilitation has been completed. The ongoing monitoring will include:

- Groundwater monitoring to ensure that the water quality is similar to the pre-mining quality.
- Surveys to asses plant survival rates and replanting of vegetation, where required.
- Assessment of dune stabilisation and where required remedial action will be taken.

15.4.2 Socio-economic Program

The rehabilitation of the dredge path is planned to leave the environment in a state equivalent to that of its original state or better. The rehabilitated dredge path will be given back to the original owners of the land to allow continued use of the land for agriculture or livestock.

Ongoing monitoring of the groundwater will ensure that the groundwater is acceptable for the community when it returns to the rehabilitated site.

Monitoring of the rehabilitated areas will also provide the local community with some potential direct employment associated with the mining activities once the dredge has moved beyond their communities. Once the local agriculture is re-established, then the local community can be re-employed in the local agriculture sector. The local population will also have increased skills that may enable employment in other employment sectors in the community.

EMRC (2009) highlights that there is also the potential for the selection of rehabilitation species that have important food and commercial value (such as cashews) for the local communities. If feasible, plantation of these species is likely to provide some economic benefit to PAPs and may prove to be a suitable alternative livelihood option. There may also be scope for the development of sustainable sources of domestic fuel, in the design of dune rehabilitation and social development programs, to compensate for the loss of dune biomass.

15.5 Final Closure

An outline of the Final Closure Plan is provided below, with the detail to be developed in the DMCP. The final closure stage will occur when the dredging of the mine site has been completed.

15.5.1 Rehabilitation Program

The rehabilitation activities to be undertaken for final closure at GCO include:

- Decommissioning, disassembling and removing the dredge, the mineral processing plant, the power generation plant, fuel storage facility, power lines, pipelines and pumping stations, water bores, workers' accommodation and other facilities, unless agreed otherwise with authorities.
- Rehabilitation of sites previously used for project buildings and infrastructure.
- Rehabilitation of the final dredge pond.
- Final revegetation of the areas disturbed by the mining project.
- Conducting a program of environmental monitoring during the decommissioning phase and for a period of time post-mining as agreed with authorities.

15.5.2 Decommissioning of Infrastructure

All the buildings and infrastructure will be dismantled and removed from the site at the completion of the project. Infrastructure to be removed includes all power transmission lines, fencing and pipelines, unless an alternative use is identified and agreed upon with the authorities.

15.5.3 Rehabilitation of Building and Infrastructure Sites

Inspections of the building and infrastructure sites will be carried out to determine whether any hydrocarbon contamination of the soil has occurred. Remediation of any hydrocarbon-contaminated soil will occur prior to revegetation. The rehabilitation of the landform will be sympathetic to the surrounding landscape. The shaped landforms will approximate the original dune landforms.

The revegetation of the landforms will be undertaken where there was vegetation prior to mining. The vegetation to be replanted will be determined after onsite trials have been completed and the revegetation plan been developed as part of the DMCP.

15.5.4 Rehabilitation of the Final Dredge Site

The dredge will be dismantled and removed from site at the end of mining. The final dredge pond will be filled with sand from the adjacent dunes or left as a lake to create a permanent wetland.

15.5.5 Vegetation Establishment

The landscape will be progressively reformed and revegetated as the dredging progresses. At the mine closure there will be a requirement for the final mining area to be revegetated. The revegetation program will aim to establish vegetation similar to the pre-mining vegetation on the site.

15.5.6 Rehabilitation Monitoring and Maintenance

Ongoing monitoring and maintenance of the closure plan will occur for at least 12 months beyond the cessation of mining.

Routine monitoring of rehabilitation areas and the identification of any requirements for remedial works would include:

- Identification of areas requiring additional remedial planting and other maintenance works to maintain the revegetation process.
- Control of weeds and pests.
- Assessment of the effectiveness of surface water control measures and erosion status reviews.
- Groundwater monitoring.

15.5.7 Socio-economic Program

With the development of the RAP and SDP, GCO will also consider the following additional issues as part of the development of the DMCP:

- Handover to the community of GCO owned or funded educational and medical facilities and programs.
- Ongoing employment opportunities post mine closure. During final closure a number of employment opportunities will remain, although this is likely to be vastly reduced compared to the operational phase. The local workforce will however have significantly improved skills, education and training with which to seek new opportunities.

MDL Mineral Sands Group

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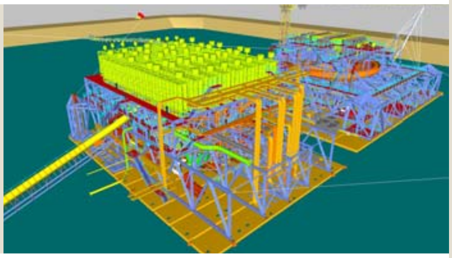

SECTION 16

Capital Cost Estimate

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CONTENTS

TABLES

16 CAPITAL COST ESTIMATE

16.1 Introduction

The capital cost estimate for the DFS is a revised capital cost estimate based on the estimate originally prepared for the Grande Côte Project in August 2006. The revised estimate incorporates most of the previous Grande Côte Zircon Project scope of work as well as additional scope for process upgrades, the ilmenite processing plant and a rail system. The base date of the revalidated estimate is 30 November 2009.

Inputs used to develop the revised capital cost estimate are:

- Applicable installation hours, rates and quantities from the August 2006 Grande Côte Zircon capital cost estimate.
- Scope of work changes (including addition of the ilmenite processing circuit).
- GCO owner’s cost and owner’s scope items.
- Repriced updated mechanical equipment list, based on the August 2006 Grande Côte Zircon capital cost estimate.
- Revised electrical estimate (developed by BEC Engineering, Perth).
- Application of Sabodala Gold Project experience, including rates, installation hours, productivity, contract unit rates, equipment purchase and hire costs, actual supply and installation cost for pre-engineered buildings.
- Ausenco’s recent African experience.
- Rail costs developed by Sandwell Engineering for the ilmenite transport.
- Revised indirect costs.

Ausenco has prepared a basis of estimate document (refer Appendix 13.1) to communicate the approximations, assumptions and interpretations affecting the estimate to avoid misunderstandings, errors and misuse. The basis of estimate includes description of the scope, methodologies, references and defining deliverables used, assumptions and exclusions, and some indication of the level of risk and uncertainty.

The estimate produced for each element covers the:

- Scope of work of the activity.
- Cost, time and resources required for the activity.
- Source of data.
- Assumptions.
- Provisions.
- Exclusions and qualifications.

As the accuracy of the cost estimate is directly related to the accuracy of project definition, it follows that the extent of detail and amount of preparatory engineering work done determines the accuracy of the estimate.

The accuracy of the estimate is also dependent on the precision of the scope definition (items of equipment, quantities of construction materials, motor kilowatts, construction productivity, etc.), and on the reliability of the unit cost rates (cost per tonne, cost per man-hour) used to transform physical quantities into monetary values. This basis of estimate states the basis used for developing these parameters.

The base estimate is shown in Table 16.1.

Table 16.1 Base Capital Cost Estimate

Facility – Area	Earthworks	Civil	Structural	Platework	Mechanical	Piping	Electrical	Instrument	Architectural	Other	EPCM Labour	EPCM Expenditure	Total
	$M	$M	$M	$M	$M	$M	$M	$M	$M	$M	$M	$M	$M
0101 Mining – Dredge	0.03	–	0.22	0.27	19.09	4.56	2.54	–	0.16	–	–	–	26.9
0103 Mining – Services	–	–	-	–	0.05	–	–	–	–	–	–	–	0.0
0104 Mining – Service Barge 0 0	–	–	–	–	0.97	–	–	–	–	–	–	–	1.0
0105 Mining – Earthworks, Drainage, Fencing	9.20	0.78	–	–	–	–	–	–	–	–	–	–	10.0
01 Mining Facility	**9.23**	**0.78**	**0.22**	**0.27**	**20.11**	**4.56**	**2.54**	**–**	**0.16**	**–**	**–**	**–**	**37.9**
0201 Wet Concentrator – Surge Bin Module	–	–	7.62	10.44	7.60	1.37	3.98	–	0.21	–	–	–	31.2
0203 Wet Concentrator – Spiral Concentrator Module	–	–	7.73	7.97	18.58	1.80	–	–	0.19	–	–	–	36.3
0205 Wet Concentrator – Product Handling	–	–	–	–	0.83	1.53	–	–	–	–	–	–	2.4
0206 Wet Concentrator – Services	–	–	1.42	–	7.57	5.63	0.20	–	–	–	–	–	14.8
02 Wet Concentrator Facility	**–**	**–**	**16.77**	**18.40**	**34.58**	**10.33**	**4.18**	**–**	**0.40**	**–**	**–**	**–**	**84.7**
0301 Mineral Separation Plant – Feed Receival	–	–	0.06	0.00	0.01	–	–	–	–	–	–	–	0.1
0302 Mineral Separation Plant – Wet Mill	–	1.24	1.94	0.14	2.50	2.86	1.03	–	0.22	–	–	–	9.9
0303 Mineral Separation Plant – Dry Mill	–	1.63	2.43	0.23	8.35	0.35	1.05	–	0.13	–	–	–	14.2
0304 Mineral Separation Plant – Product Handling	–	0.37	0.33	0.66	0.64	–	–	–	–	–	–	–	2.0
0305 Mineral Separation Plant – Services	–	0.46	0.35	–	0.38	–	–	–	–	–	–	–	1.2
0306 Mineral Separation Plant – WHIMS Plant	–	0.29	0.87	0.78	2.63	0.40	–	–	–	–	–	–	5.0
0307 Mineral Separation Plant – Ilmenite Plant	–	1.94	4.89	0.02	8.87	0.28	1.19	–	0.07	–	–	–	17.3
0308 Mineral Separation Plant – Earthworks, Drainage	4.50	–	–	–	–	–	–	–	–	–	–	–	4.5
03 Mineral Separation Plant Facility	**4.50**	**5.93**	**10.88**	**1.83**	**23.39**	**3.90**	**3.27**	**–**	**0.41**	**–**	**–**	**–**	**54.1**
0401 Infrastructure – Mining – Earthworks, Drainage	1.78	0.21	–	–	–	–	–	–	–	–	–	–	2.0
0405 Infrastructure – Mining – HV Power	–	–	–	–	–	–	6.44	–	–	–	–	–	6.4
04 Infrastructure – Mining Facility	**1.78**	**0.21**	**–**	**–**	**–**	**–**	**6.44**	**–**	**–**	**–**	**–**	**–**	**8.4**
0501 Infrastructure – MSP – Earthworks, Drainage	0.28	–	–	–	–	–	–	–	–	–	–	–	0.3
0502 Infrastructure – MSP – Buildings	–	0.89	–	–	–	–	–	–	4.42	–	–	–	5.3

Facility – Area	Earthworks	Civil	Structural	Platework	Mechanical	Piping	Electrical	Instrument	Architectural	Other	EPCM Labour	EPCM Expenditure	Total
0503 Infrastructure – MSP – Communications	–	–	–	–	–	–	0.07	–	–	–	–	–	0.1
0504 Infrastructure – MSP – Fuel Storage	–	–	–	–	0.04	0.05	–	–	–	–	–	–	0.1
0505 Infrastructure – MSP – Power Station	0.29	–	–	–	45.00	–	–	–	–	–	–	–	45.3
0506 Infrastructure – MSP – Water Supply	–	–	–	–	0.11	–	–	–	–	–	–	–	0.1
05 Infrastructure – MSP Facility	**0.57**	**0.89**	**–**	**–**	**45.15**	**0.05**	**0.07**	**–**	**4.42**	**–**	**–**	**–**	**51.1**
0602 Offsite Infrastructure – Rail & Rolling Stock	–	–	–	–	–	–	–	–	–	18.60	–	–	18.6
06 Offsite Infrastructure Facility	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**18.60**	**–**	**–**	**18.6**
0701 Temporary Construction Facilities – Facilities	–	–	–	–	–	–	–	–	0.24	–	–	–	0.2
0702 Temporary Construction Facilities – Services	–	3.69	–	–	2.05	–	1.78	–	0.16	6.39	–	–	14.1
0703 Temporary Construction Facilities – Camp	–	–	–	–	0.03	–	–	–	–	0.50	–	–	0.5
0704 Temporary Construction Facilities – Cranage	–	0.08	–	–	–	–	–	–	–	3.16	–	–	3.2
0705 Temporary Construction Facilities – Freight	–	–	–	–	–	–	–	–	–	3.38	–	–	3.4
07 Temporary Construction Facilities Facility	**–**	**3.76**	**–**	**–**	**2.08**	**–**	**1.78**	**–**	**0.40**	**13.43**	**–**	**–**	**21.5**
Estimating/Design Allowance	0.55	0.82	2.93	1.98	4.36	2.17	2.11	–	0.43	1.41	–	–	16.8
0801 Indirects – EPCM	–	–	–	–	–	–	–	–	–	–	35.84	5.87	41.7
0802 Indirects – Commissioning	–	–	–	–	–	–	–	–	–	0.35	1.91	–	2.3
0806 Indirects – Project Fee	–	–	–	–	–	–	–	–	–	–	–	8.16	8.2
08 Indirects Facility	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**0.35**	**37.75**	**14.03**	**52.1**
0901 Owner's Costs – Owner's Costs	–	–	–	–	–	–	–	–	–	29.49	–	–	29.5
0902 Owner's Costs – Mobile Equipment	–	–	–	–	–	–	–	–	–	6.51	–	–	6.5
0903 Owner's Costs – Capital Spares	–	–	–	–	–	–	–	–	–	10.00	–	–	10.0
0904 Owner's Costs – First Fills	–	–	–	–	–	–	–	–	–	1.00	–	–	1.0
0905 Owner's Costs – Owner's Contingency	–	–	–	–	–	–	–	–	–	13.80	–	–	13.8
09 Owner's Costs Facility	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**60.80**	**–**	**–**	**60.8**
Total	**16.6**	**12.4**	**30.8**	**22.5**	**129.7**	**21.0**	**20.4**	**–**	**6.2**	**94.6**	**37.8**	**14.0**	**406.0**

16.2 Scope of the Estimate

16.2.1 Initial Scope

The estimate includes EPCM services, equipment and materials supply, construction, installation, pre-commissioning and commissioning of the facilities. The scope of the estimate includes the scope covered in the August 2006 Grande Côte Zircon Project capital cost estimate plus additional scope changes and additional owner costs.

The August 2006 Grande Côte Zircon Project capital cost estimate covered the following scope of work for the EPCM contract, which included the complete design, engineering, procurement, construction and management and pre-commissioning activities for:

- One cutter-suction dredge.
- A floating wet concentrator plant (WCP) consisting of one single-circuit, including a screening system, surge bin, wet gravity concentrator and a wet high-intensity magnetic separation (WHIMS) circuit along with concentrate stockpile and tailings stacking systems.
- A mineral separation plant (MSP) to produce three marketable zircon products as well as rutile, leucoxene and a large volume of ilmenite.
- Site infrastructure, including power, water, roads, product load-out, administration and maintenance facilities.

The mine is designed to process nominally 7,000 tph of sand containing nominally 1.8% to 2.0% HM. Mining Operations and the MSP are to be constructed on separate sites near the village of Diogo.

The site for commencement of mining operations (such as dredging and floating wet concentrator) is owned by MDL and located adjacent to the starting point of the mining path. The topography is best described as rolling sand dunes with minimal vegetation present.

The dredge includes:

- A single dredge with a cutter-suction arrangement and with a nominal capacity of 7,000 tph and capable of a peak of 8,750 tph.
- Winches for dredge manoeuvring.
- A dredge control room and MCC panels.
- High-voltage (HV) power supply from the dredge pond bank via floating lines.
- Floating pipeline supply to the wet concentrator.

The mine site wet concentrator plant (WCP) includes:

- One surge bin module to accommodate a surge capacity of a minimum 12 minutes, with twin trommel screens to remove trash and oversize.

- A tower crane mounted on the surge bin module for use during construction and ongoing maintenance.
- A gravity concentrator floating plant consisting of wet spirals and capable of processing 7,000 tph of sand at an average feed grade of nominally 1.8% to 2.0% HM.
- A float line for carriage of products ashore and HV power supply from the shore to the floating plant and dredge.
- Plant control room and MCC panels.
- Fire fighting system.

The mineral separation plant (MSP) includes:

- A WHIMS circuit plant capable of processing a maximum of 160 tph of heavy mineral concentrate from the WCP.
- Concentrate stacking facilities.
- Concentrate receival, product storage and product load-out systems.
- A wet gravity concentrator mill (wet mill) capable of processing a nominal 28 tph of non-magnetic concentrate from the WCP.
- A dry mill capable of processing a nominal 18 tph of concentrates from the wet mill
- Plant control room and MCC panels.
- Process water circuit.
- Fire fighting system.

The infrastructure requirements include:

- Power services by site-based dual-fuel (HFO/natural gas) generators with supply to:
  - Mine site transformers for dredge and wet concentrator supply.
  - MSP transformers.
  - Site services, including administration, maintenance, stores and product load-out facilities.
  - The Ausenco bare cost estimate has an allowance for an HFO fuel option. The DFS includes an allowance for a dual fuel power station at a $3.0M premium.
- Water supply, including potable water for camp and site requirements and bore water for mine site and MSP requirements.
- Buildings and fit out for administration, laboratory, maintenance, stores, site security, first aid and ablutions.
- Temporary construction camp upgrade.
- Product storage and load-out.
- Site road works.

- Area access road works.
- Site communications.
- Fuel supply and storage.
- Mobile equipment.

16.2.2 Scope Changes

The following are the scope changes to the August 2006 estimate scope.

16.2.2.1 Dredge System

- No change.

16.2.2.2 Mine Site and Wet Concentrator Plant (WCP)

WHIMS Module

- Removed from mine site and relocated to MSP.

Surge Bin Module

- Reorientated relationship with respect to spiral module.
- Reorientated tower crane to suit new arrangement.
- Additional support steel for 1,150 mm diameter main feed line.
- Relocation of equipment on pontoon deck to allow efficient rougher spiral feed. This includes relocation of forward port winch and sheave to opposite corner.
- Review of control room location due to exposure to newly positioned winch sheave.
- Relocation of service barge docking position to spiral concentrator.
- Revised A-frame pinned module attachment arrangements.

Spiral Concentrator Module

- Change primary spiral type from HC1 to HC1RS for rougher, middling scavenger and cleaner spirals stages.
- Additional HG10 spirals banks added to recleaner and finisher spiral stages to treat additional intermediate products from revised primary spirals.
- Additional tails dewatering stage incorporating twin pumps and cyclone clusters and new pump feed hoppers.
- Fitting additional main feed line through the plant as a function of reorientation of modules. Includes relocation of feed bridge from surge bin module and additional support steelwork for feed line.
- Resultant additional pontoon volume to cater for increased mass for revised scopes above.

- Resultant additional structural steel and pontoon stiffening to support additional masses above.
- Additional truss steelwork to accommodate additional pontoon volume.
- Relocation of services bridge to spiral concentrator from WHIMS module.

Tails Stacker Module

- Revised from two separate stackers to one single stacker with twin discharge pipes (due to reorientation of modules).
- Resultant additional pontoon volume to cater for increased mass for revised scopes above.

16.2.2.3 Mineral Separation Plant (MSP)

MSP Wet Mill

- Removal of feed system with direct linkage to WHIMS plant.
- Revised equipment list to suit higher heavy mineral (HM) recovery associated with newer spirals.
- Addition of a tails scavenger circuit.

MSP Dry Mill

- No change in flow chart.

Concentrate Handling

- Change from shore stacking of magnetic and non-magnetic products and subsequent trucking to the MSP to the overland pumping of the total HMC stream.
- Associated infrastructure for overland pumping such as power supply, overland piping, etc.
- Stockpiling/stacking capacity and MSP.

Wet High-Intensity Magnetic Separation (WHIMS) Module

- Relocation from being a floating module to being land based at the MSP site.
- Feed system changes from continuous slurry feed on the floating module to stockpile, bin and feeder and conveyor, etc. at MSP.

Ilmenite Dry Mill

- Complete ilmenite dry mill added to the project scope.

Rail and Associated Infrastructure

- Construction of truck haul road and purchase of rolling stock added to project scope.

Infrastructure

- Allowance for a dual fuel (HFO/natural gas) power station added to scope.
- A higher power output from the power station is required for the revised scope. Additional power is required for concentrate pumping and tails returns, increased capacity deep water borefield, lateral containment borefield and ilmenite plant.
- Increased capacity deep water borefield, lateral containment borefield.

Capital Spares

After discussion with Ausenco and a number of client site visits the capital spares allowance has been increased significantly.

General arrangement drawings are shown in Appendix 16.1. The facilities are listed in the project work breakdown structure shown in Appendix 13.1.

16.2.3 Design Complete by Discipline

Table 16.2 lists the design completion estimates for the various disciplines and takes into consideration the additional design work required as a result of the scope changes.

Table 16.2 Design Completion Estimates

Discipline	% Complete
Process	60
Earthworks	65
Civil and Structural	60
Mechanical and Platework	60
Piping	45
Electrical/Instrumentation	40

16.2.3.1 Procurement Status

Table 16.3 summarises the procurement status. A total of 11 of the 125 equipment packages have been awarded amounting to $7.22M. No contract packages have been awarded at this time.

Table 16.3 Procurement Status

Items	Value
1. Major equipment packages awarded: 006 Dredge pump 045 Surge bin (tower) crane 052 Camp sewage treatment plant 053 Fire water pumps 064 MSP, camp and fire water tanks 066 Dredge cutter gearbox 086 IT38G integrated tool carrier 0303 HTR refurbishment 0305 ESPs (second-hand) 1507 Second-hand dredge 0514 Modular 2 bedroom accommodation units	The total value is $7.22M
2. Forecast expenditure for balance of the equipment packages:	Forecast expenditure of $60.4M
Contract Packages Awarded:	Nil

16.3 Build-Up of Estimate

16.3.1 Accuracy of the Estimate

The estimate prepared for the Grande Côte Project is an update to the capital cost estimate prepared in August 2006, with additional scope and owner's costs added. The previously tendered equipment prices were revalidated by successful previous bidders and Sabodala Project experience was used for subcontract and material rates.

The level of accuracy of this estimate is assessed to be within ±15%. The status of engineering work completed to achieve this level of accuracy is shown in Table 16.4.

Table 16.4 Status of Engineering Work

Discipline	Deliverable/Document	Required/ Not Required	Level of Detail	Status
Process Engineering	Process description	Required	Basic engineered	Complete
	Design criteria	Required	Basic engineered	Complete
	Process area(s) flow diagrams	Required	Basic engineered	Complete
	Process and Instrument Drawings (P&IDs)	Refer Section 6.0	Incl. instruments and valves	Incomplete as per SOW
	Bench scale tests	Required	Suit plant optimisation and accommodate ore variability	Complete by GCO
	Laboratory pilot plant tests	If required by process	Suit plant optimisation and accommodate ore variability	Complete by GCO
	Demonstration plant tests	If required by process/GCO	Suit plant optimisation and accommodate ore variability	Complete by GCO
	Mass and heat balance	Required	Basic engineered	Complete
	Water balance	Required	Basic engineered	Process complete, site wide by to be completed by GCO hydrologist
	Operating cost estimate (including administration and camp)	Required	Basic engineered	By GCO
	Control philosophy	Required	Basic engineered	Complete within limits of P&IDs
	Tailings production plan	Required	Basic engineered	Complete
	Battery limits matrix	Required	Basic engineered	Complete
Mechanical Engineering	Design criteria	Required	Basic engineered	Complete
	Equipment list	Required	Four line format	Complete
	General arrangement drawings	Required	Basic engineered	Complete
	Specifications and data sheets for mechanical equipment	Required	Basic engineered	Complete
	Budget quotes for a minimum of 80% of total mechanical equipment cost	Required	Enquiry to ≥2 vendors	97% complete
	Mechanical installation cost estimate	Required	Enquiry to ≥2 contractors	Incomplete

Discipline	Deliverable/Document	Required/ Not Required	Level of Detail	Status
	First fill consumables list	Required	Basic engineered	Incomplete
	Spares list	Required	Basic engineered	PC allowance from GCO
Piping Engineering **Factored Estimate**	Specifications	Required	Basic engineered	
	Design criteria	Required	–	
	Off-plot piping layouts and material take-off	Required	Basic engineered	
	Off-plot pipe, valves and fittings purchase cost	Required	Enquiry to ≥ 2 vendors	
	Off-plot pipe, valves and fittings installation cost	Required	By factor	
	On-plot piping purchase and installation cost	Required	By factor	
	On-plot piping layouts and isometric sketches, including quantities	Not Required	–	
Piping Engineering **Estimate by MTO**	Specifications	Required	Basic engineered	Complete
	Design criteria	Required	Basic engineered	Complete
	Piping layouts and material take-off	Required	Basic engineered	Complete
	Pipe, valves and fittings purchase cost	Required	Enquiry to ≥2 vendors	Valve pricing revalidated Est. factors used for pipe and fittings
	Pipe, valves and fittings installation cost	Required	Enquiry to ≥2 contractors	Incomplete
	Piping layouts and isometrics for MTO purposes	Required	Basic engineered	75% complete
Civil Engineering	Design criteria	Required	Basic engineered	Not complete
	Geotechnical and hydrogeological study	Required	Test pits required	Geotech low level complete Hydro – largely complete
	Site plot plan and topographical map	Required	Basic engineered	Low level complete
	Site drainage and sewer systems layout	Required	Basic engineered	Allowance made
	Building dimensions and type of construction	Required	Basic engineered	Complete
	Bulk earthworks quantity calculation	Required	Basic engineered	Complete
	Bulk earthworks cost and schedule of rates	Required	Enquiry to ≥2 contractors	Incomplete

Discipline	Deliverable/Document	Required/ Not Required	Level of Detail	Status
	Concrete design and calculations	Required	Basic engineered	Complete
	Concrete MTO	Required	Basic engineered	Complete
	Concrete cost and schedule of rates	Required	Enquiry to ≥2 contractors	Incomplete
Structural Engineering	Design criteria	Required	Basic engineered	Complete
	Structural steel design and calculations	Required	Basic engineered	Complete
	Structural steel MTO	Required	Basic engineered	Complete
	Structural steel fabrication cost and schedule of rates	Required	Enquiry to ≥2 contractors	Incomplete
	Structural steel erection cost and schedule of rates	Required	Enquiry to ≥2 contractors	Complete
	Platework design and calculations	Required	Basic engineered	Complete
	Platework MTO	Required	Basic engineered	Complete
	Platework supply and erect schedule of rates	Required	Enquiry to ≥ 2 contractors	Supply complete Erection incomplete
Electrical Engineering	Design criteria	Required	Basic engineered	Complete
	HV power distribution design	Required	Basic engineered	Complete
	MV power distribution design	Required	Basic engineered	Complete
	LV power distribution design	Required	Basic engineered	Complete
	Single line drawings	Required	HV, MV and examples of LV	Complete
	Detailed drawings	Required	Example electrical terminations	Complete
	Major electrical equipment supply costs	Required	Enquiry to ≥2 vendors	Complete
	Electrical installation rates	Required	Enquiry to ≥2 contractors	Complete
	Electrical equipment list and estimate	Required	Final study level	Complete
Instrument Engineering	Design criteria	Required	Basic engineered	Complete
	Process control determination (PLC, DCS)	Required	Basic engineered	Complete
	Process control system quotation	Required	Enquiry to ≥2 vendors	Complete
	Major instrument/sampler supply cost	Required	Enquiry to ≥2 vendors	Complete
	Instrument installation rates	Required	Enquiry to ≥2 contractors	BEC data base used
	Instrument list and estimate	Required	Final study level	Complete

Discipline	Deliverable/Document	Required/ Not Required	Level of Detail	Status
	Detailed drawings	Required	Example instrument terminations	Instrument layouts produced
Project Scope and General Requirements	Location of plant site	Required	Final	Complete
	Define scope of work c/w battery limits	Required	Final	Complete
	Define study scope of services	Required	Final	Complete
	Basis of estimate document	Required	Final	Complete
	Capital cost estimate methodology	Required	Final	Complete
	Work breakdown structure	Required	Basic engineered	Complete
	Approved contractor list	Required	Final study level	Incomplete
	Approved vendor list	Required	Final study level	97% complete
	Location specific unit cost criteria for bulk materials	Required	Enquiry to ≥2 contractors	Incomplete
	Location specific craft labour rates	Required	Enquiry to ≥2 contractors	Incomplete
	Location specific craft labour productivity factors	Required	GCO/Ausenco previous data	Complete
	Location specific taxes, tariffs and duty type costs	Required	By enquiry	Incomplete
	Location specific freight costs	Required	Enquiry to ≥2 contractors	Incomplete
	Temporary site facilities and services	Required	Enquiry to ≥2 contractors	Incomplete
	Construction mobile equipment plan	Required	Basic engineered	Incomplete
	Project EPCM estimate for project scope of services	Required	Final study level	Complete
	Project EPC Schedule	Required	Final study level	Complete
	Project procurement plan	Required	Final study level	Complete
	Project logistics plan	Required	Final study level	Incomplete
	Environmental/Socio-Economical Impact Study – if in scope	Required	Final study level	Completed by others
	Owner’s costs – if in scope	Required	Final study level	Complete
Estimating	Compiled and formatted estimate	Required	Final study level	Complete
	Collated and referenced support file structure (audit trail)	Required	Final study level	Complete
	Mechanical installation cost estimate	Required	Enquiry to ≥2 vendors	Incomplete
	Pipe, valves and fittings	Required	Enquiry to ≥2	Incomplete

Discipline	Deliverable/Document	Required/ Not Required	Level of Detail	Status
	installation cost (if required)		contractors	
	Bulk earthworks cost and schedule of rates	Required	Enquiry to ≥2 contractors	Incomplete
	Structural steel fabrication cost and schedule of rates	Required	Enquiry to ≥2 contractors	Incomplete
	Structural steel erection cost and schedule of rates	Required	Enquiry to ≥2 contractors	Incomplete
	Platework supply and erect schedule of rates	Required	Enquiry to ≥2 contractors	Supply complete Erection incomplete
Drafting	Process area(s) flow diagrams	Required	Basic engineered	Complete
	Process and instrument drawings (P&IDs)	Refer Section 6.0	Instruments and valves shown	Completed to Drawing 1520 stage only on GCO request
	General arrangement drawings to suit civil structural MTO	Required	Scope and detail drawings	Incomplete
	Site plot plan and topographical map	Required	Scope drawings	Incomplete
	Site drainage and sewer systems layout	Required	Scope drawings	Incomplete
	Building dimensions and type of construction	Required	Scope and material drawings	Complete
	Off-plot piping layouts	Required	Scope and detail drawings	80% Complete
	Piping layouts and isometrics for MTO purposes	Required	Basic engineered	80% complete
	Electrical single line drawings	Required	HV, MV and examples of LV	Complete
	Electrical detail drawings	Required	Example electrical terminations	Electrical layouts produced
	Instrument detail drawings	Required	Example instrument terminations	Preliminary Instrument layouts produced

16.3.2 Reference Documents

The capital estimate follows industry guidelines in its structure. The reference documents are shown in Table 16.5.

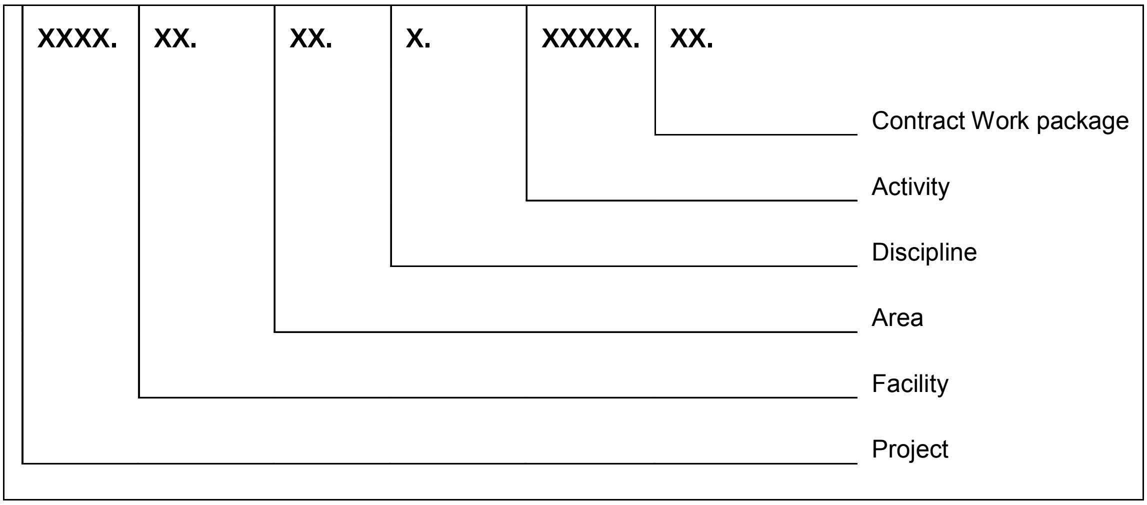
Table 16.5 Reference Documents for Estimate

Doc. No.	Document Description	Rev.	Status
1938-SCH-001	Master project schedule	A	Preliminary
1938-F-001 to 014	Process flow diagrams and mass balance	A	Complete
1520-P-001 to 027; 031 to 062	Instrumented flow sheets (P&IDs)	A	70% complete
1938-DC-001	Process design criteria	A	Complete
Various documents	Material selection and specifications	A	Complete
1520-LE- 001 1938-LM-001	Electrical and mechanical equipment lists	A	Electrical – not updated to reflect current scope Mechanical – complete
Various drawings	General arrangement drawings	A	Complete
Various documents	Earthworks design drawings and calculations	A	Preliminary
Various documents	Concrete design drawings and calculations (for major structures)	A	60% designed & 40% preliminary calculations
Various documents	Structural steel design drawings and calculations (for major structures)	A	60% designed & 40% preliminary calculations
1938-G-001, 002, 003, 005, 008 and 011	Site general arrangement drawings	A	Complete
Various documents	Site survey report/topography (prepared and supplied to Ausenco by GCO)	A	Preliminary
Various documents	Soil Study Reports (prepared and supplied to Ausenco by GCO)	A	Preliminary
1938-E-031 to 034	Electrical single line diagrams	A	Complete
	Electrical equipment layout	A	Nil
Various documents	Engineering material take-offs	A	Substantially complete
Various documents	Temporary facilities requirements	A	Assumed
AMC to advise	Air and water pollution regulation for the geographical area of the plant and for the type of plant	A	Preliminary
Various documents	Actual labour rates for the geographical area of the plant and labour availability in the geographical region	A	Calculated
1938-RPT-0006	Estimate of services (engineering, procurement, construction and commissioning) required for the project	A	Detailed
1938-RPT-0006	All other indirect costs as stated in the estimate summaries	A	Estimated

16.3.3 Work Breakdown Structure (WBS)

The WBS for the estimate of the direct cost is as shown in Table 16.6. The estimate is organised in accordance with the Facility, Area and Discipline designators, which is further detailed in the WBS.

Table 16.6 Work Breakdown Structure



16.3.4 Capital Cost Assumptions

The following assumptions were made for the capital cost estimate:

- Airfares for the engineer's personnel at business class level.
- Semi-skilled and unskilled labour will be available locally.
- Local labour work hours and roster is 60 hours per week.
- Engineer's expatriate construction management personnel are assumed to be Australian nationals.
- Engineer's expatriate work roster is eight weeks on and two weeks off. Travel time (nominally two days each way) is included in the eight-week working period. Travel time payment is for eight hours per day while travelling. While on site, every second Sunday is a rest day and is not charged. Work hours are nominally 11 hour days.
- Construction accommodation will be of a suitable standard.
- All items fit within the freight envelope sizing of 20 m long x 6 m wide x 4.5 m high above trailer tray.
- The delivery of all break bulk items (out of gauge) is possible through the Port of Dakar at no additional cost to in-gauge items.
- All equipment and materials that have already been purchased for the project have been suitably stored, are in good condition and no maintenance or refurbishment is required.

- The power station installation will be complete and ready to provide power for the engineer's C1 commissioning stage work.
- The estimate allowance for the second-hand work barge has been provided by GCO.

The following items are included in the contractors' rates:

- Concrete batch plant.
- Mobile plant hire.
- Polypipe welding machine – ex Sabodala.
- 35 t all-terrain crane (self-perform model).
- Spare parts for mobile fleet (self-perform model).
- 25 t Franna crane.
- Mobile concrete batch truck (new).
- 10 t BHB crane.
- 16G grader (self-perform model).
- CAT730 articulated truck (self-perform model).
- CAT563 sheep's foot roller (self-perform model).
- CAT563 smooth roller (self-perform model).
- CAT416D backhoe (self-perform model).
- CAT330 excavator (self-perform model).
- Trailer 50 t (self-perform model).
- Water truck (self-perform model).
- Service truck (self-perform model).

GCO supplied cost estimates for owner's supplied items as follows:

- All required permits and approvals.
- Site security services.
- Construction accommodation, meals and accommodation services.
- Supply, installation and support of the satellite communications system, including all hardware, software, operating costs and access to communications network for the entire engineer's team and all site contractors.
- All fuel for construction.
- Contractor's all-risk (CAR) insurance and marine transit insurance for all freighted items. Insurance requirements, including any allowance for deductibles have not been assessed and this assessment is required prior to project execution.
- All repair and replacement services and spare parts for all construction mobile plant and equipment.

- Potable water for construction accommodation and for site construction activities.
- Power for construction and commissioning.
- Engineer's site vehicles for construction.
- An allowance of US$10M for spares, which includes initial spares, commissioning spares and insurance spares.
- Managing and performing commissioning beyond the engineer's C2 stage commissioning.
- A sum of $5.6M for a dedicated truck haul road from the MSP to the local roads.
- A sum of $17M for rail haulage of bulk ilmenite, including rolling stock, new track at the port, port facilities and upgrades to the existing ICS rail loading facilities.

GCO supplied items (that is, at no additional capital cost) as follows:

- Supply of an IT38G (integrated tool carrier) – ex Sabodala.
- Supply of an ambulance – ex Sabodala.
- Supply of a 75 KVA generator – ex Sabodala.

16.3.5 Battery Limits for Engineer's Works

The battery limits for the scope of the work on the process plant performed by Ausenco are shown in Table 16.7.

Table 16.7 Battery Limits for the Engineer's Work – Ausenco

Parameter	Battery Limit	
Mineral	**In**	**Out**
	• Dredge cutter openings	• Surge bin overflow chute • Trommel oversize chute • Tails dewatering cyclone O/F pipe • Tails stacker nozzle outlet • MSP rejects return pipe outlet • Ilmenite load-out bin discharge • Rutile container loading system discharge • Leucoxene container loading system discharge • Zircon container loading system discharge

Parameter	Battery Limit	
	In	Out
Process water and other waters	• Outlet flange on surface level pipe off the deep bore field pumps (10 off) • Outlet flange on surface level pipe off the lateral bore field pumps (52 off) • Outlet flange on surface level pipe off the MSP bore pump • Inlet for dredge screen water pump intake screen • Inlet for dredge pond process water pumps No. 1 and 2 • Inlet for surge bin high-pressure water pump • Inlet for surge secondary agitation water pump	• Dredge services water screen overflow • WCP cooling water discharge • Dredge services cyclone overflow • Mine water return discharge
Sewage	Discharge flange at the sewage treatment plants – for connecting to sewage collection trucks (by others).	
Communications	Provisions have been made in the estimate for IT and telephone communications. PABX and phone handsets have been included in the MSP office fit-outs. It is assumed that the PABX will be linked the GCO's existing VSAT system.	
Electrical Power	Connecting to the outgoing terminals of the 11 kV switchboard at the GCO-supplied power station.	

16.3.6 Units of Measure

Metric units are used throughout the estimate.

16.3.7 Estimating and Design Allowances

Each element of the estimate has been developed initially at bare cost only. An estimating and design allowance has then been allocated to each element of the direct and indirect costs to reflect the level of definition relating to that element.

The purpose of the estimating and design allowance is to cater for items such as the accuracy of:

- Quantity take-offs based on the level of engineering and design undertaken at feasibility study level.
- Materials and labour rates used in the estimate preparation.
- Productivity expectations.
- Equipment budget pricing used in the estimate preparation.
- Bulk materials budget pricing used in the estimate preparation.

Estimate allowances have been provided for provisional cost (PC) sum items (e.g. power station, rail). The owner's cost and indirect costs have not had an estimating and design allowances applied separately as these allowances were already included in the costs.

The following Table 16.8 lists the estimating and design allowances applied to the estimate at a discipline level. Further refinement of the estimating and design allowances has been made at a line item level to result in a weighted average accuracy provision of 4.0% across the estimate.

Table 16.8 Estimating and Design Allowances

Discipline	Discipline Name	Estimating and Design Allowance %
B	Earthworks	6.0
C	Civil	9.5
S	Structural	9.5
F	Platework	9.5
M	Mechanical	5.0
P	Piping	11.5
I	Instrumentation	11.5
A	Architectural	9.5
E	Electrical	11.5
V	Other	5.0
X	EPCM expenses	0
Z	EPCM labour	0

16.3.8 Definition of Costs

The direct costs are those costs that pertain to the permanent equipment, materials and labour associated with the physical construction of the process facility, infrastructure, utilities and buildings. The contractor's indirect costs are either included explicitly or are in the rates.

The indirect costs include all costs associated with implementation of the plant and incurred by the owner, engineer or consultants in the design, procurement, construction, and commissioning of the project.

16.3.9 Market Availability

The pricing and delivery information for revalidated equipment, material and services was provided by suppliers based on the market conditions and expectations applicable at the time of developing the estimate.

The market conditions are susceptible to the impact of demand and availability at the time of purchase and could result in variations in the supply conditions. The estimate and schedule were based on information provided by suppliers and assumes there are no problems associated with the supply and availability of equipment and services during the execution phase.

16.3.10 Labour Rates

The craft base wages are based on current gang rates applying to other project estimates within the region. To facilitate the allocation of costs to contract packages gang rates are inclusive for the following:

- Base labour rate, overtime premiums, payroll burdens and benefits.
- Daily start-up and pack-up time.
- Transportation within the site.
- Transportation to and from project site.
- Small tools and consumables.
- Safety clothing and safety supplies.
- Construction equipment – except major lifting equipment.
- Cranage to 35 t.
- Contractor's profit.
- Site facility running costs.
- Site management, administration and supervision.

The labour rates used in the estimate are shown in Table 16.9.

Table 16.9 Labour Rates Used in the Estimate

Discipline	Rate ($US/hr)
Earthworks (B)	$28.77
Civil (C)	$28.77
Structural (S)	$28.77
Platework (F)	$28.77
Mechanical (M)	$28.77
Piping (P)	$28.77
Architectural (A)	$28.77
Electrical and Instrumentation (E)	$37.45

16.3.10.1 Unit Man-hours

Installation times are based on typical Australian man-hours and adjusted for productivity, based on information obtained from site, an assessment of contractors' labour productivity and comparison to actual productivity seen at MDL's Sabodala project and other projects in the region. The productivity factors are shown in Table 16.10.

Table 16.10 Productivity Factors

Activity	Productivity Factor
Earthworks	9.0
Civil	9.0
Structural	3.5
Platework	3.5
Mechanical	3.5
Piping	3.5
Architectural	3.5
Electrical	3.5
Other	1.0

16.3.11 Construction Equipment

Construction equipment will be purchased by GCO for the project to reduce costs associated with extended equipment hire periods. Costs for small items of mobile plant and equipment such as welding machines, compressors and general yard cranes have been allowed for.

Maintenance, fuel and spare parts for all mobile plant and equipment will be provided by GCO and these costs are included in the EPC costs. Subcontractors' plant and equipment will be maintained by the subcontractor. Heavy lift cranage for the wet plant construction will be hired from Europe or Senegal (if available at the time).

16.3.12 Preliminaries

Contained in the estimate for each site works contract are costs for non-recurring preliminaries. These include:

- Mobilisation and demobilisation.
- Insurances.
- Bank guarantees.
- Establishment and disestablishment of site facilities.

The amounts allowed for non-recurring preliminaries in each site works discipline have been calculated based on a percentage of either the total direct labour costs or of total subcontract value of the works. The percentages used have been based on historical data from similar contracts.

Recurring preliminaries are generally included in the labour rates. Recurring preliminaries for civil works are included in the unit rates. Bulk earthworks recurring preliminaries are allowed for as a line item and are based on an 11.5 month contract duration.

16.3.13 Freight Cost and Duties

Freight costs and duties are not included in the equipment and material purchase prices.

16.3.13.1 Equipment Supply

Equipment supply has been requested on a free carrier (FCA) suppliers works basis. Freight costs from FCA suppliers works to the project site at Diogo have been estimated based on pricing provided by Antrak in Perth (suppliers works to Dakar) and SDV in Senegal (under hook Dakar port to Diogo).

The total estimate for the freighting of the equipment packages is shown in the freight backup information in Appendix 13.1.

16.3.13.2 Steel Supply

Antrak has provided a quotation for the steel supply (pontoons, dredge hull, structural trusses, break bulk, etc.) freight component based on sea freight to Dakar and road freight from Port of Dakar to site. This estimate was provided on the basis that all items fit within a freight envelope sizing of 20 m long x 6 m wide x 4.5 m high trailer tray.

There are some items that do not meet the freight envelope criteria, but the same rate has been applied to these items. The estimate has been developed on the basis that delivery of break bulk items (out of gauge) would be possible through the Port of Dakar. There is no allowance in the estimate for additional costs associated with movement or handling of this freight, should this not be possible.

Bulk freight components will require a thorough logistics review to ensure passage through Dakar is viable from a size perspective. Details of the freight estimate are shown in the freight backup information in Appendix 13.1.

16.3.13.3 Airfreight

A provision of $500,000 has been allowed for airfreight at the owner's request.

16.3.14 Duties

A 2.5% duty is payable on ex-works value of all goods entering Senegal. An allowance for this cost has been included.

16.3.15 Escalation

Where unit rates from the Sabodala Project have been used in the estimate, they have been increased by 15% to allow for escalation. This is based on the labour index increasing by 25% over the period, but bulk commodity prices staying flat.

Where unit rates from the Grande Côte Zircon Project August 2006 estimate have been used in the estimate, they have been increased by 25% to allow for escalation. This is consistent with the average for equipment price increase from the tender price validation carried out.

A provision for escalation beyond the estimate base date (30 November 2009) has not been included in the estimate.

16.4 Engineering Work Packages

16.4.1 Bulk Earthworks

The capital estimate allows for bulk earthworks design and construction for the minerals separation plants, infrastructure areas and construction requirements. The scope of bulk earthworks includes all labour, materials and equipment required for the bulk excavation, bulk filling, backfilling, surface drainage and benching. Detailed earthworks such as excavations for footings, slab or bunds are included in the civil works package.

The bulk earthworks quantities have been measured using drawings sketches and preliminary contour information. Road allowances are based on preliminary cross section sketch 1520-K-022 Revision A and assumes a flat landscape. Road lengths have been measured from the plan. No allowances have been made for bulking. No allowances have been made for excavation of rock.

Bulk earthworks rates from BCM, the earthworks contractor for the Sabodala Project have been escalated and used in the estimate. Where the contractors' schedules of rates did not align with the scope of work, the Grande Côte Zircon Project August 2006 estimate rates were escalated and used (refer Section 16.3.15). These rates are termed "subcontract rates" and include installation costs. For the purposes of manning, scheduling, progress measurement and construction accommodation planning, the associated installation hours have been noted in the estimate.

For the power station earthworks, the estimate and scope of work includes an allowance for provision of a cleared area of 200 m x 250 m with a 200 mm thick wear course layer placed and compacted. Limited geotechnical site investigation has been carried out but will be completed prior to construction.

It is intended to let a design and construct (turnkey) contract to a specialised power station provider and that this supplier will provide the engineering design required for any earthworks for the power station.

16.4.2 Civil Works

The capital estimate allows for civil works design, supply and construction for the minerals separation plant, infrastructure and temporary construction areas. The scope of civil works includes all labour, materials and equipment required for the set-out, detailed excavation, formwork, reinforcement, and concrete supply, pouring, stripping and finishing of concrete works.

Sheet piling has been included in the estimate as shoring for a 100 m long retaining wall at the south edge of the construction pond. The shoring is required to provide close access to the edge of the pond for cranage so that heavy lifts can be achieved at the shortest reasonable lift radii.

The surge bin tower crane will be temporarily installed at the southern end of the construction pond during erection of the floating plant. The estimate allows for piles to be installed as part of the temporary concrete base for the tower crane. Later in the construction phase this tower crane will be permanently installed on the surge bin module.

The civil works quantities have been prepared by the appropriate discipline engineers based on design drawings, sketches and engineering calculations. It has been assumed that general site geotechnical conditions are suitable based on site inspection and on the limited soil testing undertaken to date (refer Section 5).

All quantities nominated are measured quantities derived from the design documents and CAD models. No allowance has been applied for over-excavation, unsuitable material or over-supply of concrete (including sand and aggregate). Pile quantities from the August 2006 estimate have been used.

Concrete rates used in the estimate are based on rates from current projects in the region from Ausenco's database, including Sabodala and have been checked against historical data. For non-concrete items, the August 2006 estimate rates were escalated and used (refer Section 16.3.15). Installation hours have been entered into the estimate for both ex-works and subcontract items. In the case of the ex-works items, these installation hours have been multiplied by the productivity factor and the labour rate to provide an installation cost for each line of civil works.

The hours for the subcontract pricing are for the purpose of calculating total site manning hours only. The installation hours for subcontract civil works have no effect on the pricing. The hours are based on Ausenco's standard civil works construction hours.

16.4.3 Structural Steel

The estimate allows for structural steel supply, preparation of shop drawings, fabrication and installation for all support structures and platforms (including gridmesh, handrails, stairways and ladders) required as part of the mining, wet concentrator and mineral separation plant areas.

The structural steel quantities have been prepared by the appropriate discipline engineers, using drawings, sketches and engineering calculations.

Structural steel supply and fabrication rates have been obtained from Taggart China via the Ausenco Beijing office. The rates are inclusive of additional quality management and supervision.

Installation hours are based on Ausenco's standard structural steel installation hours. These installation hours have been multiplied by the productivity factor and the labour rate to provide an installation cost for each line of structural works.

The freight for structural steel is divided into break bulk (out of gauge) and containerised (in-gauge). The freight for break bulk component of all structural steel has been quoted by Antrak. This component forms the majority of the structural steel freight cost in the estimate.

The balance of the freight cost, which is for containerised structural steel, has been factored based on either unit weight or as a percentage of the total ex-works cost. These factors are based on historical data.

16.4.4 Plate Work

The estimate allows for plate work design, fabrication and installation for the mining, wet concentrator, mineral separation plant and Infrastructure facilities.

The plate work quantities have been prepared by the appropriate discipline engineers, using drawings, sketches and engineering calculations.

Supply rates have been revalidated for pontoon and surge bin platework. The rate used in the estimate is the Shanghai Cosco Kawasaki (SCK) China rate, which is the lowest of the three revalidated rates. The rates are inclusive of significant additional Ausenco quality management and supervision. SCK premises and capabilities have been inspected and found to be acceptable.

Installation hours are based on Ausenco's standard platework installation hours. These installation hours have been multiplied by the productivity factor and the labour rate to provide an installation cost for each line of platework.

The freight for platework is divided into break bulk (out of gauge) and containerised (in-gauge). The freight for break bulk component of all platework has been quoted by Antrak. This component forms the majority of the platework freight cost in the estimate.

The balance of the freight cost, which is for containerised platework, has been factored based on either unit weight or as a percentage of the total ex-works cost. These factors are based on historical data.

16.4.5 Mechanical

The estimate allows for mechanical design, supply and installation for the wet concentrator, mineral separation plant, infrastructure and temporary construction facilities.

The mechanical equipment list Revision D has been used as the basis for the mechanical estimate. A copy of the equipment list is contained in Appendix 13.1.

The project was formally tendered to the marketplace in 2006–07. Separate pricing was obtained for:

- The purchase of vendor data to allow engineering design to be undertaken immediately.
- Equipment pricing for the actual purchase of the equipment at a future date. The vendor data was purchased and the equipment pricing information was held on file. Long lead time items and certain immediate equipment needs were purchased outright.

For the purposes of this estimate, the successful vendor data suppliers from 2006–07 have revalidated their equipment pricing, some offering six months validity as requested, others as little as 30 days (refer to the revalidation summary shown as mechanical estimate backup information in Appendix 13.1).

Pricing for the additional equipment required for changes of scope that is similar to existing equipment has been factored and based on the revalidated prices.

Installation hours are based on the Grande Côte Zircon Project August 2006 estimate mechanical installation hours. These installation hours have been multiplied by productivity factors based on the Sabodala Project experience.

Equipment supply has been requested on a FCA suppliers works basis. Freight costs from FCA suppliers' works to the Project Site at Diogo have been estimated based on pricing provided by Antrak in Perth (suppliers works to Dakar) and SDV in Senegal (under hook Dakar Port to Diogo). This estimate is based on preliminary weights and measures.

16.4.6 Piping

The estimate allows for pipe work supply and installation for the wet concentrator, mineral separation plant and infrastructure facilities. The piping quantities have been prepared by the appropriate discipline engineers using drawings, sketches and engineering calculations. Where available, carbon steel and HDPE pipe and fitting pricing from the Sabodala Project purchase orders have been applied. The balance of the piping materials has been priced as described below.

Freight for piping has been allowed for as 12.9% of the material supply cost. This factor is based on historical data.

16.4.6.1 In-plant HDPE

Material prices for in-plant HDPE pipe are based on US$2.46 per kg. This price was obtained from a current Indonesian vendor quote. Fittings are based on recent catalogue pricing from an Australian vendor.

A per metre rate for each size of pipe was built up using an allowance for equal tee sections, elbows, flanges and backing rings per 12 m length of pipe. Five per cent of the material cost was allowed for bolts and other fittings and a 10% allowance for wastage was then applied to acquire a final total supply cost.

Installation hours were calculated based on industry standard hours for site handling, fitting installation and testing. These hours were then multiplied by the labour rate, productivity factor and quantity to provide a total installation cost. The hours allowed are for 100% site installation with no off-site spooling.

16.4.6.2 Field Piping

Material prices for field HDPE pipe are based on US$2.46 per kg. This price was obtained from a current Indonesian vendor quote. Fittings are based on recent catalogue pricing from an Australian vendor.

A per metre rate for each size of pipe was built up using an allowance of one weld per 11.8 m. Flanges, backing rings and other fitting have been allowed for as per the materials take-off (MTO) and have been shown as separate line items for each pipe run.

Installation hours were calculated based on industry standard hours for site handling, fitting installation, pipe joining and testing. These hours were then multiplied by the labour rate, productivity factor and quantity to provide a total installation cost.

16.4.6.3 In-plant Carbon Steel and Rubber Lined Piping

Material prices for in-plant carbon steel and rubber lined pipe are based on Australian vendor catalogue pricing and an Australian based rubber lining quote.

A per metre rate for each size of pipe was built up using an allowance for equal tee sections, elbows and flanges per 12 m length of pipe. Five per cent of the material cost was allowed for bolts and other fittings and 10% of the pipe supply cost was allowed for wastage, to acquire a final total supply cost.

Installation hours were calculated based on industry standard hours for site handling, fitting installation and testing. These hours were then multiplied by the labour rate, productivity factor and quantity to provide a total installation cost. Hours allowed are for 66% shop fabrication (pipe spooling) and 34% site installation.

16.4.6.4 Valves

Budget vendor pricing for the valves MTO has been applied to the estimate as a lump sum.

16.4.7 Electrical and Instrumentation

The capital estimate allows for supply and installation of electrical and instrumentation items for the wet concentrator, mineral separation plant, infrastructure and temporary construction facilities. Major electrical equipment includes switch room, motor control centres (MCC), distribution boards, variable speed drives as shown on the single line diagrams. The instrumentation and control system includes a fully programmed programmable logic controller (PLC) system, one supervisory control and data acquisition (SCADA) terminal, instruments as detailed on the process and instrument drawings (P&IDs), MCC interface and instrument marshalling boxes.

The electrical works quantities have been prepared using the mechanical equipment list Revision C in conjunction with preliminary drawings, sketches and typical instrument lists. The expanded electrical works estimate is contained in electrical and instrumentation estimate backup information in Appendix 13.1.

Pricing was via formal tender to the marketplace in 2006 and 2007. Separate pricing was obtained for:

- The purchase of vendor data to allow engineering design to be undertaken immediately.
- Equipment pricing for the actual purchase of the equipment at a future date. The vendor data was purchased and the equipment pricing information was held on file.

For the purposes of this estimate, the successful vendor data suppliers from 2006 and 2007 have revalidated their equipment pricing, some offering six months validity as requested, others 30 days. The revalidation summary is shown in mechanical estimate backup information in Appendix 13.1.

Prices for the additional equipment due to scope change, that are similar to existing equipment, have been factored based on the revalidated prices. Pricing for cable, cable connectors and other miscellaneous components are based on updated unit rates.

Installation hours are based on the Grande Côte Zircon Project August 2006 estimate electrical and instrument (E&I) installation hours. These installation hours have been multiplied by productivity factors based on Sabodala Project experience.

Equipment Supply has been requested on a FCA suppliers works basis. Freight costs from FCA suppliers works to the project site at Diogo have been estimated based on pricing provided by Antrak in Perth (suppliers works to Dakar) and SDV in Senegal (under hook Dakar port to Diogo).

This estimate is based on preliminary weights and measures. Antrak also provided an estimate for the freight of all other miscellaneous bulk electrical equipment that will cover four 40 ft open-top containers and six 20 ft general purpose containers from Australia. For the total freight estimate of the E&I packages, refer to freight backup information in Appendix 13.1.

16.4.8 Architectural

The capital estimate allows for architectural supply and installation for the mining, wet concentrator, mineral separation plant and infrastructure areas. The estimate includes the following buildings:

- Dredge control room.
- Dredge switch room.
- Surge bin control room.
- Surge bin amenities building.
- Surge bin workshop (20 ft container).
- Wet concentrator switch room.
- Wet mill control room.
- Wet mill switch room.
- Dry mill control room.
- Dry mill switch room.
- MSP maintenance office.
- MSP laboratory.
- MSP admin buildings (including gatehouses, first aid, weighbridge, lunch room and ablutions).
- MSP store building.
- MSP workshop.

Generally these are the same quantities as the Grande Côte Zircon August 2006 estimate, with the only change being that the store building has been increased in size based on Sabodala experience.

Quantities for the fit-out of the administration, first aid, gatehouse, laboratory, maintenance office, weighbridge, workshop and store buildings has been allowed for as per the quantities in the Grande Côte Zircon August 2006 estimate.

Generally, the Grande Côte Zircon August 2006 estimate architectural rates were used. No escalation has been applied to these rates, as the experience at Sabodala was that local-style construction would be appropriate for this type of building and the unescalated rates are sufficient.

The supply costs for the MSP workshop and MSP store buildings have been taken from the purchase orders for the supply of the Sabodala Project buildings. Allowances have been made for store building racking and lighting in these buildings.

Laboratory equipment pricing has been updated with revalidated pricing.

Generally, freight for architectural has been allowed for as 12.9% of the material supply cost. Where the percentage approach was not considered to be appropriate, suitable volumetric or tonnage freight rates have been applied. Freight for building fit-out items has been allowed for as a lump sum equivalent to six 40 ft containers from Australia. Two 40 ft containers have been allowed for freight of the laboratory equipment from Australia.

16.4.9 Power Station

The bare and total base case cost estimate by Wartsila for supply of a dual-fuel (HFO/natural gas) power station is $45M. The quote from Wartsila is shown in Appendix 9.2. Further details on the power station are in Section 9.

16.4.10 Road and Rail Transport

A 25 km long dedicated haul road will be constructed from the MSP to the rail load-out. The cost of the road, including mass earthworks, is estimated at $6.5M including indirects. Rolling stock owned by the GCP will transport bulk ilmenite from ICS to the Port of Dakar. The cost of rolling stock, new track at the port, port facilities and upgrades to the existing ICS rail loading facilities has been provided by Sandwell and is estimated at $13.0M including indirects. Further details on the road and rail facilities are contained in Section 9.

16.4.11 EPC Items Supplied by the Owner

For the EPC component of the GCP, GCO plans to direct purchase a number of items rather than hire the equipment to reduce extended hire periods and costs during construction. Rates and costs for the items of plant and equipment have been developed using current market information and estimates.

Some items of specific mobile plant and equipment, which are owned by MDL, may also be transferred from the Sabodala operation in Senegal to the GCP. These items are considered free issue to the GCP. The EPC items supplied by the owner include:

- Gensets and pumps.
- Purchase of scaffold.
- Purchase of large mobile plant and equipment other than heavy-lift cranage. Some of this equipment will be second-hand, such as dozers.
- Spreading equipment and rehabilitation machinery.
- Supply of temporary site utilities (potable water, electricity and waste disposal).
- Allowance for replacement of tools and consumables purchased for the Grande Côte Zircon Project and used on the Sabodala Project.
- First fills.
- Spare parts (operation, insurance and commissioning).
- Spare parts for plant and equipment.

- Consumables for maintenance team.
- Maintenance tools for plant and equipment.
- Maintenance of all access roads and bridges.
- Earthworks machinery maintenance.
- Mobile plant, genset and vehicle maintenance.
- LV maintenance costs.
- Maintenance salaries.

A more detailed listing of the EPC items supplied by GCO is shown in Appendix 13.1.

16.4.12 Equipment Costs

The equipment costs total $12.1M, and are shown in Table 16.11.

Table 16.11 Equipment Costs

Item	Cost $M	Basis of Estimate
Renault prime movers and trailer	0.11	Estimate based on units available in Senegal from dealers today
Scaffold	0.34	Lump sum allowance based on actual costs at Sabodala
Concrete batch plant – cost in subcontract rates	0.00	Not applicable
160 t Liebherr crane – hook only	0.08	Quote from Liebherr
IT38G (integrated tool carrier) – ex Sabodala	0.00	Assume moved at no cost
Reinforcing bending machines	0.01	Transport allowance only – units from Sabodala
Clearing dozers	2.08	Caterpillar
Mobile plant hire	0.00	Included in gang rates
Mobile plant, vehicle and genset maintenance	3.00	Lump sum allowance based on actual costs at Sabodala
Polypipe welding machine – ex Sabodala	0.00	Included with bar bending allowance above.
Consumables	0.23	Lump sum allowance based on actual costs at Sabodala
Bus	0.15	Lump sum allowance based on actual costs at Sabodala
Bobcat with plain bucket (new)	0.09	2006 cost estimate plus 25%
Bobcat all fittings & trailer	0.04	2006 cost estimate plus 25%
35 ton all terrain crane (self-perform model)	0.00	Included in gang rate.
Container forklift 25 t – ex Sabodala	0.00	Not returning to Grande Côte, hence allowance for V900 Cat below.
Ambulance – ex Sabodala	0.00	This is onsite at Grande Côte already
75 KVA generator – ex Sabodala	0.00	This is onsite at Grande Côte already

Item	Cost $M	Basis of Estimate
Wear consumables PC	0.03	2006 cost estimate plus 25%
Spare parts for mobile fleet (self-perform model)	0.00	Included in unit rates.
Crane truck	0.12	Lump sum allowance based on actual cost of similar unit at Sabodala
Telehandler 1	0.05	Lump sum allowance based on actual cost of similar unit at Sabodala
25 tonne Franna crane	0.00	Included in gang rate
Fire truck	0.04	Lump sum allowance based on actual cost of similar unit at Sabodala
Boom lift 45 ft min	0.28	2006 cost estimate plus 25%
Scissor lift	0.07	Lump sum allowance based on actual cost of similar unit at Sabodala
Dredge anchors CAT LGP D8Ns, including modified blade	2.45	Lump sum allowance based on costs available online plus freight allowance
Hydraulic nut tensioner (new)	0.03	Lump sum allowance based on actual cost of similar unit at Sabodala
Laser alignment tool (new)	0.02	Lump sum allowance based on actual cost of similar unit at Sabodala
Mobile concrete batch truck (new)	0.20	Lump sum allowance based on actual cost of similar unit at Sabodala
10 t BHB crane	0.00	Included in gang rate
85 t Grove all terrain crane	0.35	Lump sum allowance based on actual cost of similar unit at Sabodala
V900 Cat container handler	0.15	Lump sum allowance based on actual cost of similar unit at Sabodala
Seed Spreading Equip/Rehab Machinery (new)	0.20	Lump sum allowance
16G grader (self-perform model)	0.17	Included in unit rates
CAT730 Articulated Truck (self-perform model)	0.19	Included in unit rates
CAT 980 Loader	0.20	Lump sum allowance based on costs available online plus freight allowance
CAT 563 sheep's foot roller (self-perform model)	0.00	Included in unit rates
CAT 563 smooth roller (self-perform model)	0.00	Included in unit rates
CAT 416D backhoe (self-perform model)	0.00	Included in unit rates
CAT 330 excavator (self-perform model)	0.12	Included in unit rates
Trailer 50 t (self-perform model)	0.00	Included in unit rates
Water truck (self-perform model)	0.17	Included in unit rates
Service truck (self-perform model)	0.17	Included in unit rates
CAT 980 loader	1.00	Lump sum allowance based on costs available online plus freight allowance
Total	12.11	

16.4.13 Spare Parts

There is a provisional cost (PC) of $10M for all spare parts based on an estimating rule of thumb that spares should cost 10% to 12% of installed vendor equipment cost. This allowance is closer to 14%, reflecting the large items in the dredge that are not vendor supplied. Spares will be bought within this lump sum based on full criticality analysis and vendor recommendations. The aforementioned approach was successfully adopted at Sabodala by MDL.

16.4.14 First Fills

There is a PC of $1M for all first fills. This consists of 1M litres of heavy fuel oil at $650,000, $250,000 for oils and $100,000 for gasoil (diesel fuel).

16.5 Indirect Costs

16.5.1 Engineering, Procurement, Home Office Service and Construction Management

This includes the cost of services, which includes basic engineering, detail engineering, procurement, home office services and construction management. The details are shown in Table 16.12.

Table 16.12 Indirect Costs

Activity	Indirect Costs Included
Engineering	Includes the drawings and documents for the complete engineering package necessary to construct the intended facilities. In addition to drawings, the work includes preparation of construction and equipment specifications, bills of materials and data sheets, technical bid evaluations, Vendor drawing review and checking, and field Vendor drawing review and checking, and field inspections and coordination.
Procurement	Includes both local and foreign purchasing. Procurement encompasses request for quotations, commercial evaluations and recommendations, terms and conditions negotiation, purchase order placement and maintenance, logistics and traffic, expediting, local inspection and foreign source inspection. Vendor representation on site. Subcontracts for installation and other services.
Home office services	Includes specialist personnel necessary to support the engineering and construction plans. These services involve project management, cost control, scheduling, engineering, estimating, procurement, project accounting, construction administration, industrial relations, personnel, administration, quality, OH&S.
Construction management	The cost of services, which includes site procurement, construction management, pre-commissioning, commissioning and start-up services of the project. Labour hours and costs are developed from an organisation chart indicating required site staff position and rates extended by the duration contemplated for each position. This estimate also includes the required field expenses for construction management personnel, including travel and relocation expenses to the site.

16.5.2 EPCM Expenses and Fee

The engineering, procurement, construction and management (EPCM) fee is 3% of direct costs under management by the EPCM contractor and has been included in the estimate.

Expenses have been forecast using historical data from relevant projects and include the following typical categories:

- Office recovery is A$6.50 per man-hour.
- Domestic airfares.
- Domestic accommodation.
- General travelling expenses.
- International airfares.
- Owner's office in Ausenco home offices.
- Communications.
- Couriers.
- Consultants.
- In-transit accommodation and taxi fares.
- Insurances.
- Handling fee of 8% on consultants' invoices and office expenses.

16.5.3 Temporary Construction Facilities

All office supplies, courier, postage, first aid and safety supplies are included as indirect costs. Temporary construction buildings and running costs are included in direct costs.

The costs of setting up a site construction operation complete with furnishings, office equipment, including facsimile, computer copier, CAD station are included in direct costs.

16.5.4 Temporary Site Utilities

Temporary site utilities and supply are required and these include:

- Potable water supply.
- Power supply.
- Communications.
- Waste management and disposal of effluent from the site.
- Fuel.

16.5.5 Pre-Commissioning and Commissioning

Engineering supervision and field engineering manpower have been included in the EPCM estimate. Operating staff and labour are part of the MDL's operations team, and included in the operating costs. No allowance has been made for the provision of labour outside the owner's operations team for any plant modifications required by the owner during commissioning.

Table 16.13 Durations for Each Phase of Commissioning

Table 16.13 shows the durations for each phase of commissioning:

Phase	Support/Checking
C0 – Pre-commissioning	2 weeks
C1 – Dry commissioning	8 weeks
C2 – Wet commissioning	7 weeks

Due to the staged commissioning of the separable areas, commissioning occurs across a total of four months, with each area completed in approximately eight weeks.

Contractor support after the handover (C3 and C4 ore and performance commissioning phases) would be supplied by the owner's operating staff and labour.

16.5.6 Third Party Services

The capital estimate includes allowances for the following third party services:

- Naval architects.
- Dredge design review, fabrication and site assembly.
- Dredge cutter gearbox inspection and meshing testing.
- Dredge switch room air-conditioning design.
- Finite element analysis check of surge bin trommel design.
- Process consultants.
- Internal design review consultants.
- Geotechnical consultants.
- Structural steelwork fabrication inspection.
- Platework fabrication inspection.
- Major equipment – vendor site commissioning representatives.
- Site surveying for foundations, footings, buildings, mechanical support structures and all equipment.
- High-voltage and harmonics design and installation audits.
- Testing and inspection of concrete, structural steel and welding.
- QA/QC of concrete, structural steel, welding and HDPE liner installation.

- Shop inspection, testing.
- Expediting.
- Recruitment.
- Taxation.
- Legal services.
- Transport and logistics study.

16.5.7 Owner's Costs

The owner's costs include GCO's representatives during construction, accommodation, transport, communications, studies and other miscellaneous GCO costs associated with local and statutory considerations. The following items are included in owner's costs:

- Owner's representatives salaries.
- Construction accommodation, including buildings, catering, maintenance and repairs, power, services, food, water and sewage.
- Bus transfers (airport to site).
- Bus services for site.
- V-Sat service for internet and phone.
- Owner's freight and flights.
- Cars.
- Radios.
- Site medical station.
- Emergency response team equipment.
- Freight for equipment being transferred from Sabodala to Grande Côte Project.
- Freight for construction accommodation.
- Studies, permitting and mitigation.
- Hydrological modelling and testing.
- Metallurgical test work costs.
- Permits and approvals.
- Land compensation.
- Contractor all-risk (CAR) insurance.
- Marine transit insurance.
- Recruitment costs for operations people.
- Due diligence costs.
- Legal costs associated with financing.
- Banker's fees.

- Financing costs.
- Social post-funding work.
- Costs associated with the acquisition of lands.
- Provision of site security services for the project construction period and beyond.
- Owner's contingency.

Details of costs are provided below.

16.5.8 Owner's Representative's Salaries

The owner's representative's salaries are estimated at $3.0M.

16.5.9 Construction Accommodation and Catering

An estimate of $11.60M has been allowed for construction accommodation infrastructure. The costs of the construction accommodation have been provided for in owner's costs based on 400 persons for year one and 800 persons for year two. This includes all costs associated with the operation of the construction accommodation such as power, freight, food, village staff and repairs and maintenance using appropriate and current market rates.

The accommodation requirements in respect of overall schedule, ramp up and peak load have not been assessed at this time. This will be completed prior to project execution.

16.5.10 Transport, Communications, Fuel and Freight

Allowances for transport, communications, fuel and freight total $3.40M and are detailed in Table 16.14.

Table 16.14 Transport, Communications, Fuel and Freight

Item	Cost $M	Basis of Estimate
Bus transfer service (airport to site)	0.4	
Consumables	0.7	70% of Sabodala actual
Contractors and consulting	0.4	Sabodala for two years
Freight	0.8	Sabodala actual $1M for two years, Diogo freight rate is 30% of that applicable to Sabodala so is conservative
Communications	0.4	V-Sat service for internet and phone, based on quotation for additional bandwidth to that existing using existing hardware
On-site bus service	0.2	
Vehicle fuel	0.5	Sabodala actual for two years
Total	3.4	

16.5.11 Studies

Additional studies are estimated to cost $0.20M and are detailed in Table 16.15.

Table 16.15 Studies

Item	Cost $M	Basis of Estimate
Hydrological modelling revisions	0.10	Lump sum allowance
Metallurgical testwork	0.10	Lump sum allowance
Total	0.20	

16.5.12 Miscellaneous

Miscellaneous estimated owner's costs total $5.70M and are detailed in Table 16.16.

Table 16.16 Miscellaneous Costs

Item	Cost $M	Basis of Estimate
Permits and approvals	0.10	In place already
Land compensation	0.10	Lump sum allowance
Social post-funding work	0.42	Lump sum from Earth Systems in Volume 2
Construction insurance	0.50	Estimate based on Sabodala actuals during construction ($0.25M/year)
IT hardware and software	0.25	Lump sum allowance based on actuals for five years of guesthouse operation in Dakar by MDL.
Guesthouse operations in Dakar	0.25	Lump sum allowance based on actuals for five years of guesthouse operation in Dakar by MDL.
Recruitment costs	0.50	Lump sum allowance, which is five times the cost for Sabodala
Due diligence costs	0.50	Lump sum allowance based on Sabodala
Radios	0.04	Estimate
Cars	0.75	Quotation
Site medical station	0.08	Estimate
Site surveyor	0.26	Lump sum allowance based on actual costs for Sabodala
Legal costs associated with financing	0.75	Lump sum allowance based on actual costs for Sabodala
Bankers fee	1.00	Lump sum allowance based on actual costs for Sabodala
Emergency response team equipment	0.2	Estimate
Total	5.70	

The estimating and design allowance relating to owner's cost items is covered by the owner's contingency. The total owner's cost is $23.90M or 6% of the total estimated capital cost. This is summarised in Table 16.17.

Table 16.17 Owner's Costs

Item	Cost $M
Owner's Representative's Salaries	3.00
Site Accommodation	15.00
Studies	0.20
Miscellaneous	5.70
Total	23.90

A detailed listing of the owner's costs is shown in Appendix 13.1.

16.5.13 Contingency

A contingency allowance of $13.80M has been included by GCO in the capital estimate. This contingency is based on a risk assessment (see Section 21).

16.6 Exclusions

The following items are excluded from the capital cost estimate:

- Costs associated with the development of the Grande Côte Project Definitive Feasibility Study (DFS) as this is included in corporate costs.
- Costs incurred and any expenditure on the Grande Côte Zircon Project to date as this is included in corporate costs.
- Costs incurred in the development of the Grande Côte Zircon Project ilmenite estimate as this is included in corporate costs.
- Communications infrastructure outside the boundary of the mineral separation plant.
- Resettlement and relocation costs.
- Containers for concentrate.
- Demurrage for capital freight.
- Any additional costs associated with addressing access restrictions at the Port of Dakar and through the Dakar metropolitan area for break bulk cargo.
- Working capital, which is included in the financial model (Section 19).
- Refurbishment or maintenance for equipment and materials that have already been purchased and are in storage.
- Withholding taxes and other similar Senegalese taxes.
- Corporate costs.
- Costs associated with changes to the site works mobilisation commencement date of 1 October 2010.
- Costs associated with changes to the engineering commencement date of 1 April 2010.

- Community relations and services.
- Future scope changes (post 1 November 2009).
- Special incentives (schedule, safety or others).
- Third party consultants other than those listed.
- All owner-payable taxes.
- Sustaining or deferred capital costs, which are included in the financial model (Section 19).

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SECTION 17

Operating Cost Estimate

Copy 16

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CONTENTS

TABLES

FIGURES

17 OPERATING COST ESTIMATE

17.1 Introduction

A production and operating cost model has been prepared by GCO for the mining, wet concentrator, mineral separation processing operations, transportation and the supporting services required for the operations at Grande Côte.

The costs have been used to calculate unit operating costs and the total annual costs for the project life. They have also been included as inputs into the financial evaluation (see Section 19).

17.2 Accuracy of Estimate

While the accuracy of the individual cost items varies, the overall accuracy of the operating cost estimates is ±15%.

17.3 Exchange Rates

The exchange rates used for conversion of costs are:

- 1 A$ equals 0.90 US$.
- 1 Euro equals 1.50 US$.
- 1 CFA equals 0.0022 US$.

17.4 Base Date and Escalation

The operating cost estimates are correct at April 2010. No escalation has been applied to the costs beyond this base date.

17.5 Contingency

No allowance for contingency has been included in the operating cost estimates.

17.6 Operating Cost Breakdown Structure

The operating cost breakdown structure is provided in Table 17.1 and summarised in Figure 17.1 and Figure 17.2.

Table 17.1 Operating Cost Structure

Code	Description	Rate	Units	Source Data
10000	**Power and Fuel**			
10010	Power generation	0.131	US cents/kWh	Owner's Estimate based on Sabodala Actual and BEC 2010.
10020	Drying fuel and mobile equipment – gasoil	838.00	$US/t	Shell, 2010
11000	**Employee Costs**			
11010	GCO staff	7.1M	US$ pa	Government labour rates, Owners estimate, May 2010
11020	Contract labour	0.7M	US$ pa	Government labour rates, Owners estimate, May 2010
12000	**Maintenance**			
12010	Dredge and wet plant	0.135	$US/t mined	TZMI benchmark data, April 2010
12020	MSP (non-magnetics)	3.00	$US/t throughput	TZMI benchmark data, April 2010
12030	Ilmenite (magnetics)	2.41	$US/t throughput	TZMI benchmark data, April 2010
12040	Borefield	0.30M	$US pa	Owner's estimate, May 2010
12050	HMC pumping system	0.95M	$US pa	Owner's estimate, May 2010
12060	Mobile fleet and cars	2.8M	$US pa	Owner's estimate, May 2010
13000	**Transportation/Shipping**			
13010	Containers to Dakar (Zr Ru Lx)	52.46	$US/t (Zr Ru Lx)	Damco quotation, Sept 2009
13020	Trucking bulk freight to railhead	3.4	$US/t ilmenite	Gamma Logistics, Dec 2009
13030	Rail bulk freight to Dakar (ilmenite)	13.38	$US/t ilmenite	Transrail/Sandwell, April 2010
13040	Bulk load facility costs (ilmenite)	5.40	$US/t ilmenite	Port Authority Dakar/Grimaldi, Dakar, April 2010
13050	Port charges bulk load costs (ilmenite)	2.70	$US/t total	Owner's estimate, May 2010
13060	Warehouse general freight (road and air)	0.77M	US$ pa	Owner's estimate based on Sabodala. , May 2010
14000	**Other**			
14010	Site catering (restaurant)	1.2M	$US pa	Owner's estimate, April 2010
14020	Expat accommodation and messing	0.35M	$US pa	Owner's estimate, April 2010
14030	Bus service (site and expat transfer)	0.64M	$US pa	Owner's estimate, April 2010
14041	Social – resettlement, comp. and livelihood restoration	0.39M	$US pa	Earth Systems land impact baseline assessment, May 2010
14042	Social – social management and monitoring	0.41M	$US pa	Earth Systems Land impact baseline assessment, May 2010
14043	Social – administration	0.33M	$US pa	Earth Systems land impact baseline assessment, May 2010
14050	Environment – rehabilitation works	0.9M	$US pa	Owner's estimate, April 2010
14060	Site admin expenses – misc	0.68M	$US pa	Owner's estimate, April 2010
14070	Insurance – political risk (% of debt)	0.7%	$US pa	Strathearn quote, April 2010
14080	Insurances – other	2.0M	$US pa	Strathearn quote, April 2010

Figure 17.1 GCP Operating Cost Breakdown – 2015 Production, Proportion (%)

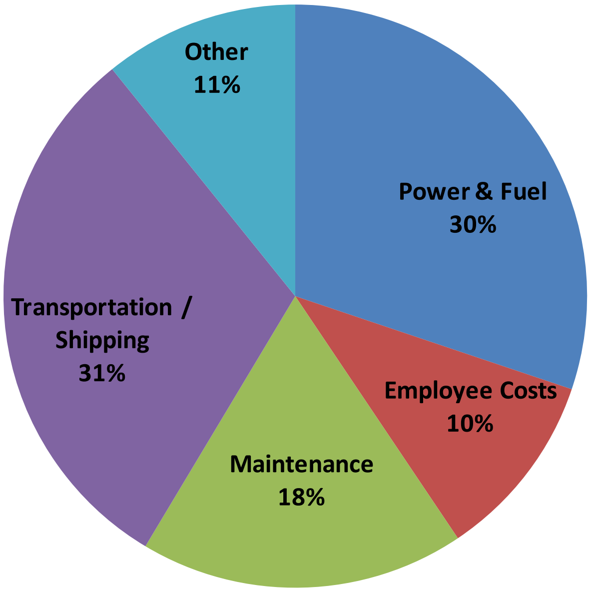
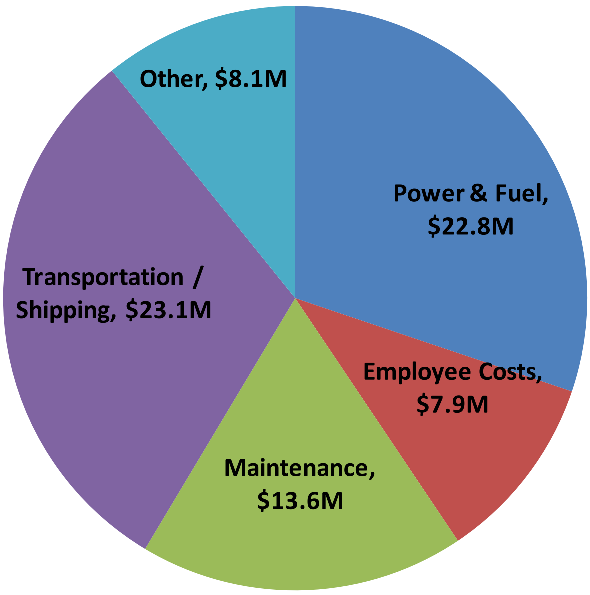


Figure 17.2 GCP Operating Cost Breakdown – 2015 Production, Annual Cost ($US pa)



Transportation and shipping are the largest proportion of expenses (31%, $23.1M), with power and fuel (30%) and maintenance (18%) the next largest components. The labour component is 10%.

17.7 Operating Cost Model Assumptions

Costs provided in this analysis are extracted from 2015, as representative of annual costs. The operating costs are also reported in the financial modelling section

(Section 19). The costs were based on production inputs discussed in Sections 4 and 6 and the cost inputs from sources as detailed in Table 17.1.

The assumptions in the operating cost model are:

- Ramp-up of production over six months in 2013 to name-plate capacity.
- 30% of magnetic ore processed and remainder stockpiled in the first year of full production in 2014.
- Production rate is maintained for the remainder of the 14-year production schedule.

17.8 Power and Fuel

The annual cost estimate for power is based on electrical equipment loading and maximum demand assessment provided by BEC Engineering (BEC, 2010). The unit cost for the power generation is based on the Wartsila gas and HFO dual-fuel option.

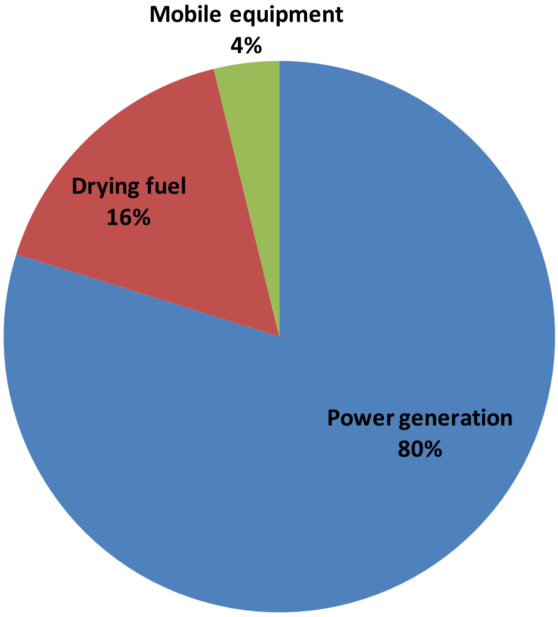
The unit rate cost estimate for the power station was based on the Sabodala power station fuel consumption rate, downtime and performance. The 2009 actual (as at January 2010) fuel consumption rate (oil and heavy fuel oil (HFO)), from the Wartsila power station at Sabodala was use to calculate the consumption (per kWh) in conjunction with first principles sourced Wartsila maintenance costs in order that a total c/kWh cost could be derived. Additionally this data was compared to total actual costs from Sabodala (which includes labour and overheads) with the Grande Côte fuel cost included as a real comparative measure to the accuracy of power costs.

The inputs for the fuel cost estimation are based on the Senegal Government fuel pricing schedule (SGO, 2010). There are two fuel type inputs used for the estimation of cost due to varying grades required for different uses. The fuels used for which pricings are provided are; HFO180 for power generation, gasoil for drying and mobile equipment. The prices for the HFO180 and gasoil are US$0.63 and US$0.84 per litre respectively delivered to Diogo as of April 2010.

The fuel cost rate used in the calculation of the power cost (US$0.131/kWh) is based on the published fuel pricing schedule (April 2010). The power cost estimated from first principles above does not include operating labour; these are treated separately in the labour section below (17.9).

A breakdown of the energy costs (power and fuel, Figure 17.3) indicates the majority of the costs are power generation related costs (80%).

Figure 17.3 GCP Energy Operating Cost Breakdown (Power and Fuel) – 2015 Production, Proportion (%)



A further breakdown of the power costs (Figure 17.4 and Figure 17.5) indicates the majority of costs (72%, $13.0M pa) are expensed in the dredge and wet plant. MSP wet plant (8%) and HMC pumping (7%) are the next main contributors.

Figure 17.4 GCP Power Operating Cost Breakdown – 2015 Production, Proportion

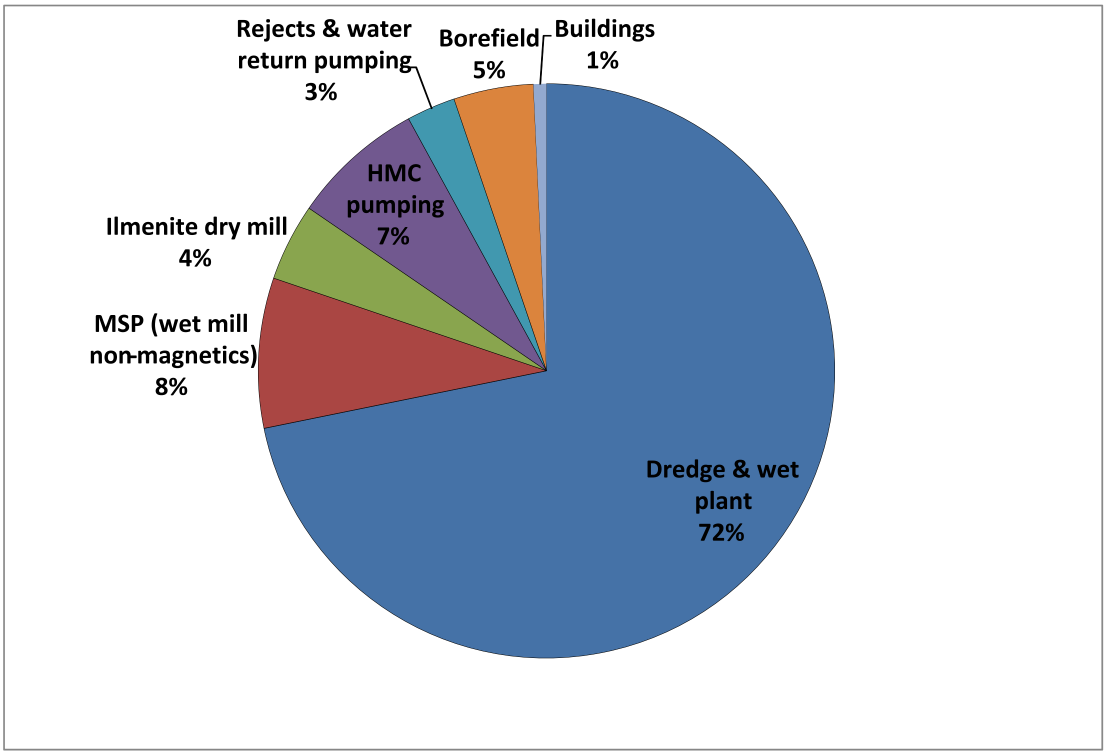
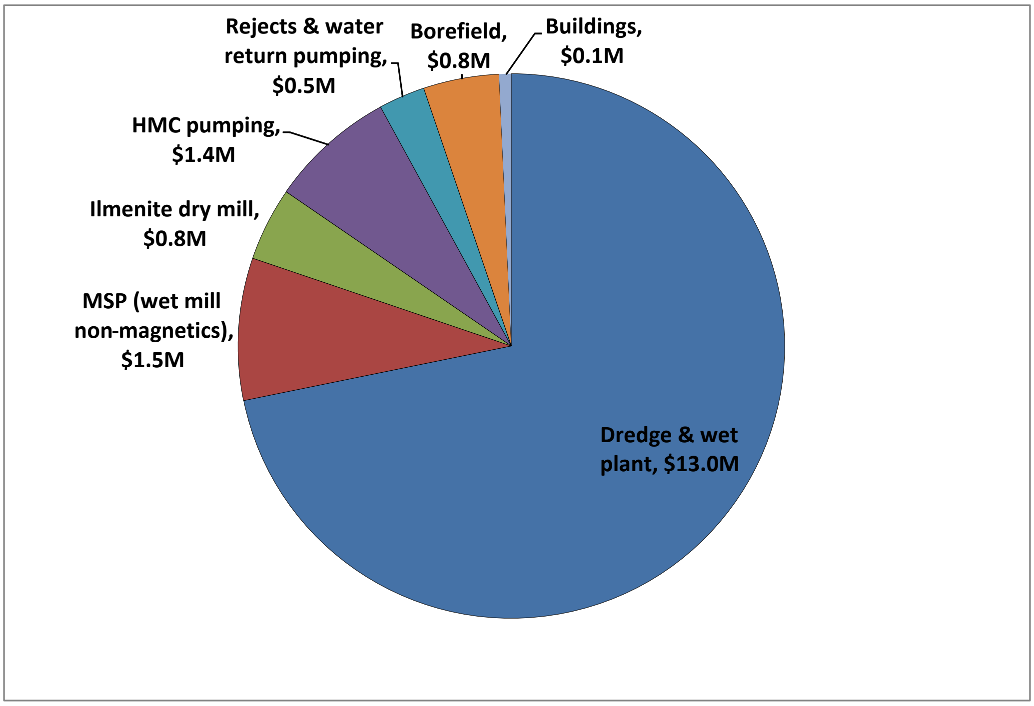


Figure 17.5 GCP Power Operating Cost Breakdown – 2015 Production, Annual Cost ($US pa)



The principal cost inputs and assumptions used in the power calculation are included in Table 17.2.

Table 17.2 Principal Components Used in the Calculation of Power Unit Rate

Input	Unit	Amount	Source
Oil usage	L/kWh	0.0014	Sabodala actual, CY2009
HFO usage	L/kWh	0.2196	Sabodala actual, CY2009
HFO price	$US/L	0.63	Senegal benchmark price, 20/2/2010
Gasoil price	$US/L	0.84	Senegal benchmark price, 20/2/2010
Annual power	MW pa	141,000	BEC, 2010
Maintenance	$US pa	$1.4M	Wartsila

The assumptions are based on a full year of operating experience at Sabodala (CY2009).

17.9 Labour

Manning levels include all management, operational maintenance and support personnel and are detailed in Section 14.

Expatriate salaries are based on the current operation at Sabodala. The national labour rates are as regulated by the government and gazetted by Decree 2006-1262 dated 15 November 2006. The annual salary bands for the national personnel used are shown in Table 17.3 below.

Table 17.3 National Personnel Salary Ranges for Categories

	Category Position Descriptions	Typical Annual Gross Salary Range ($US)
	Senior head of department	38,976
	Head of department – senior engineer	36,192
	Senior officer/engineer/geologist 1B – 3B	20,323 – 27,840
	Professional 4 – 1	12,695 – 19,404
	Professional 5&6/trade 2&3	8,519 – 10,686
	Clerical 2&3/trade 4&5	5,345 – 6,682
	Field assistants 3	3,229 – 4,343

Labour rates include all on-costs such as government taxes, superannuation, etc. Salary rates are 2010 real basis. A breakdown of labour costs (Figure 17.6 and Figure 17.7) for the GCP in 2015 operation indicates the majority of the costs are associated with the MSP (50%, $4.0M pa). The mine site (25%) and administration (15%) are the other main components.

Figure 17.6 GCP Labour Operating Cost Breakdown – 2015 Production, Proportion (%)

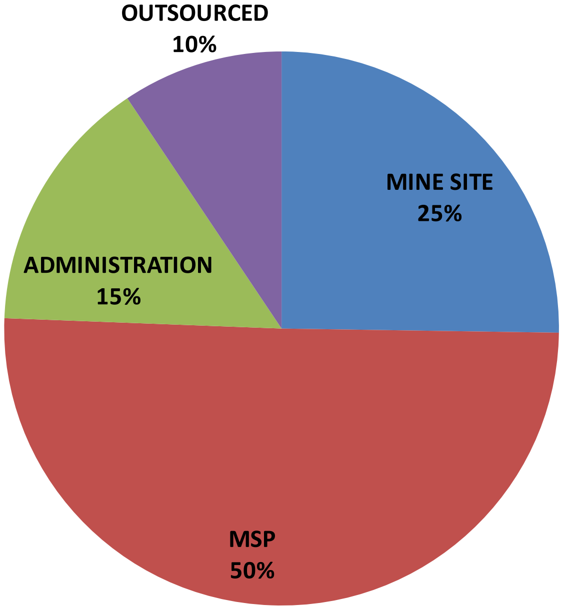
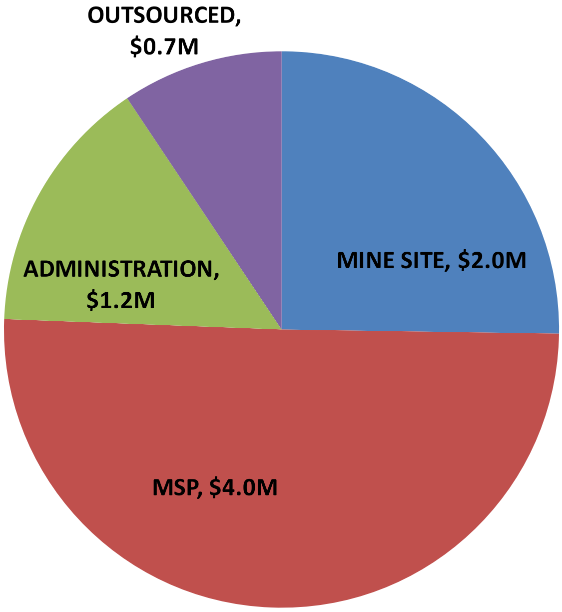


Figure 17.7 GCP Labour Operating Cost Breakdown – 2015 Production, Annual Cost ($US pa)



17.10 Maintenance

Total maintenance costs are built up in two components. The labour costs are based on the manning levels from the organisational structure in Section 14 and included in the labour section of the financial model. The maintenance cost of each major area of plant is on a unit rate basis for the dredge and wet plant, MSP and the ilmenite plant. Annual costs are included for the borefield and HMC pumping system.

The annual cost estimate for maintenance is US$13.6M pa (excluding maintenance labour cost). The costs are primarily for the dredge and wet plant (US$7.0M pa), mobile fleet and cars (US$2.8M pa) and the ilmenite plant (US$1.7M pa).

The basis for the dredge and wet plant, MSP and ilmenite plant maintenance costs are TZMI benchmark data (TZMI, 2010).

The basis for the annual cost of the borefield is an owner's estimate (Appendix 17.1) based on five replacement containment bores, one replacement deep aquifer bore and other miscellaneous pumping equipment per annum at US$0.3M pa.

The basis for the HMC pumping system is also an owner's estimate predicated on sixteen operating pumps with three replacement pumps per annum and associated costs totaling $950,000 pa.

The mobile fleet and cars annual cost of US$2.8M is based on an owner's first principles estimate (Appendix 17.1), broken down into the following areas:

- Drill Rig (US$0.45M pa).
- Anchor Dozers (US$0.29M pa).
- Clearing Dozers (US$0.61M pa).
- Articulated Trucks (US$0.05M pa).
- Cat 980 Loaders (US$0.69M pa).
- Cat 16G Grader (US$0.05M pa).
- Cat 330 Excavator (US$0.06M pa).
- Cars (US$0.32M pa).
- Cranes (US$0.14M pa).

A breakdown of maintenance costs (Figure 17.8 and Figure 17.9) for the GCP in 2015 operation indicates the majority of the costs are associated with the dredge and wet plant (52%, $7.0M pa). The mobile fleet and cars (21%) and ilmenite plant (12%) are the other main components.

Figure 17.8 GCP Maintenance Operating Cost Breakdown – 2015 Production, Proportion (%)

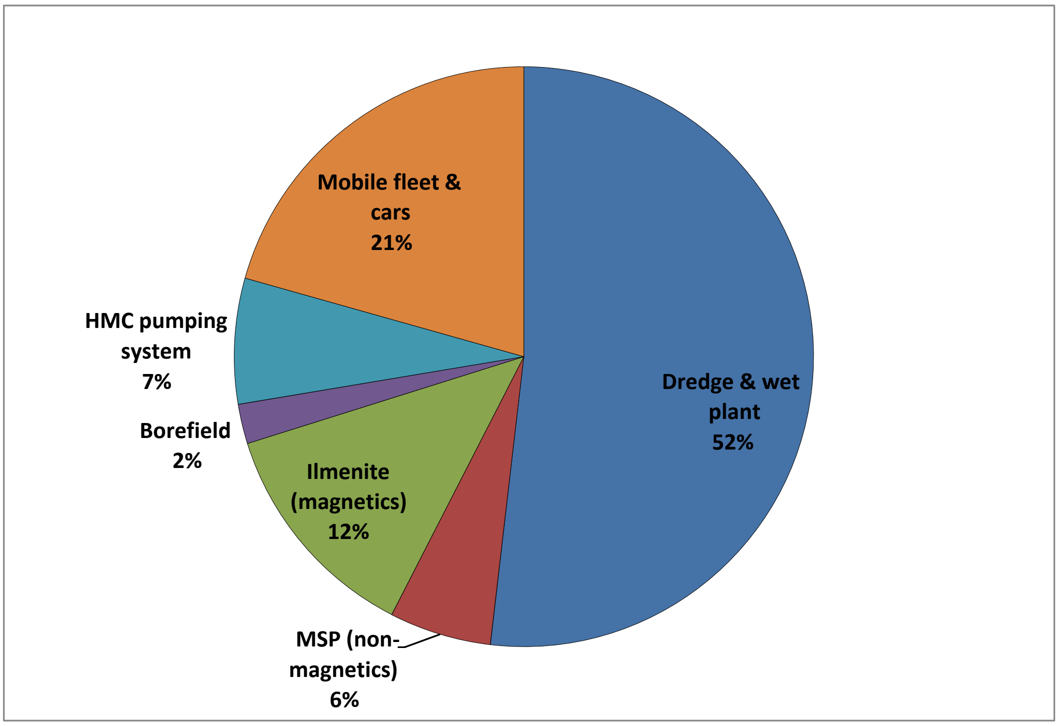
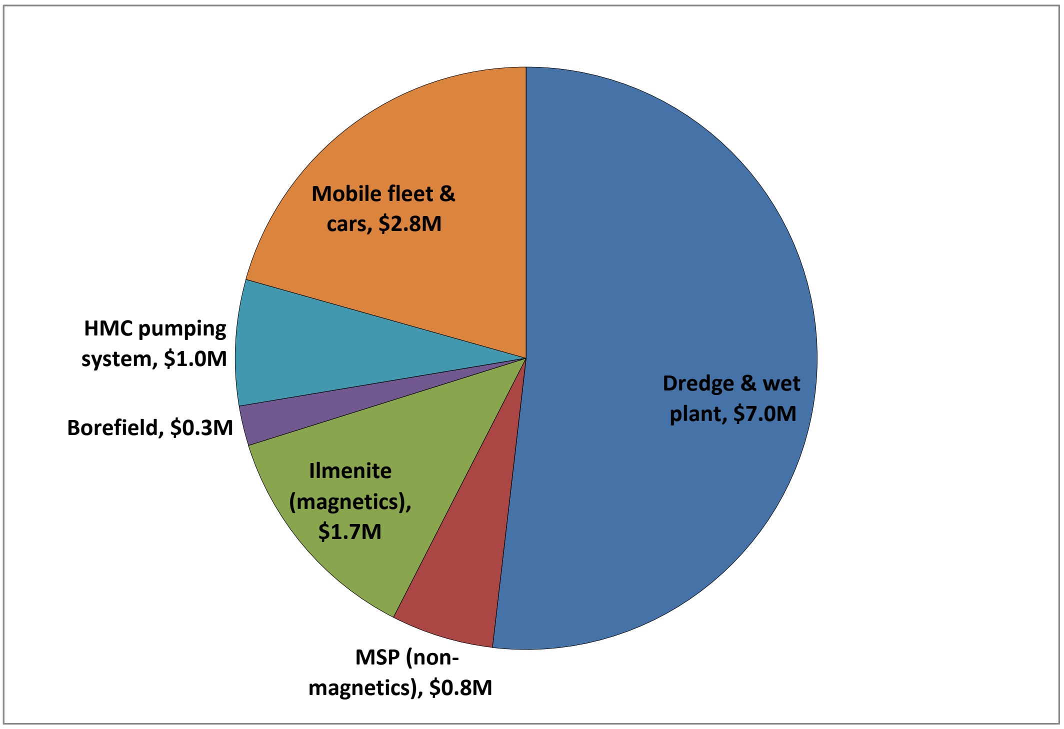


Figure 17.9 GCP Maintenance Operating Cost Breakdown – 2015 Production, Annual Cost ($US pa)



17.11 Transportation/Shipping

The annual cost estimate for transportation of containers to Dakar, storage and export formalities for zircon, rutile and leucoxene is approximately US$5.6M pa. Bulk transportation of ilmenite includes US$2.2M pa road transport to the railhead and US$8.8M pa for rail transport to Dakar from year three onwards.

A separate cost has been included for insurance during freight (see Cost Code 14080 Table 17.1 and Section 17.12.6).

Shipping costs are not included as the majority of sales will be made on a free on board (FOB) basis.

The unit cost estimate for transporting containers to Dakar of US$52.46/t of zircon, rutile and leucoxene is calculated based on quotation from DAMCO (2009).

The unit cost estimate of US$3.40/t of ilmenite for transporting bulk freight from site to the Mboro railhead by truck is based an offer from Gamma Logistics (2010).

The unit cost estimate of US$13.38/t of ilmenite for transporting bulk freight from Mboro to Dakar by rail is based on a Transrail offer (2010) which includes supply and operation of locomotives.

The bulk load and facility costs comprising vessel charges and Port charges of US$5.80/t ilmenite are based on Port Authority Dakar (2006) and Grimaldi Dakar (2010). Major assumptions include 15 vessels pa at 40,000 t ilmenite/vessel. Demurrage is included in the estimate, based on US$20,000/day costs.

The basis for the estimate for the load-out facility at the Port of US$2.70/t ilmenite assumes a rental charge from ICS based on 660,000 tpa load-out. Power, maintenance and labour costs have been estimated from first principles.

Costs US$0.77M pa associated with container freight, site freight, air freight and warehouse general costs are an owner's estimate based on MDL Sabodala actual costs (Appendix 17.1).

A breakdown of transport and shipping costs (Figure 17.10 and Figure 17.11) for the GCP in 2015 operation indicates the majority of the costs are associated with bulk freight transport of ilmenite (38%, $8.7M pa). Transporting containers of Zr, Ru and Lx (24%) and bulk load facilities at port (16%) are the other main components.

Figure 17.10 GCP Transport and Shipping Operating Cost Breakdown – 2015 Production, Proportion (%)

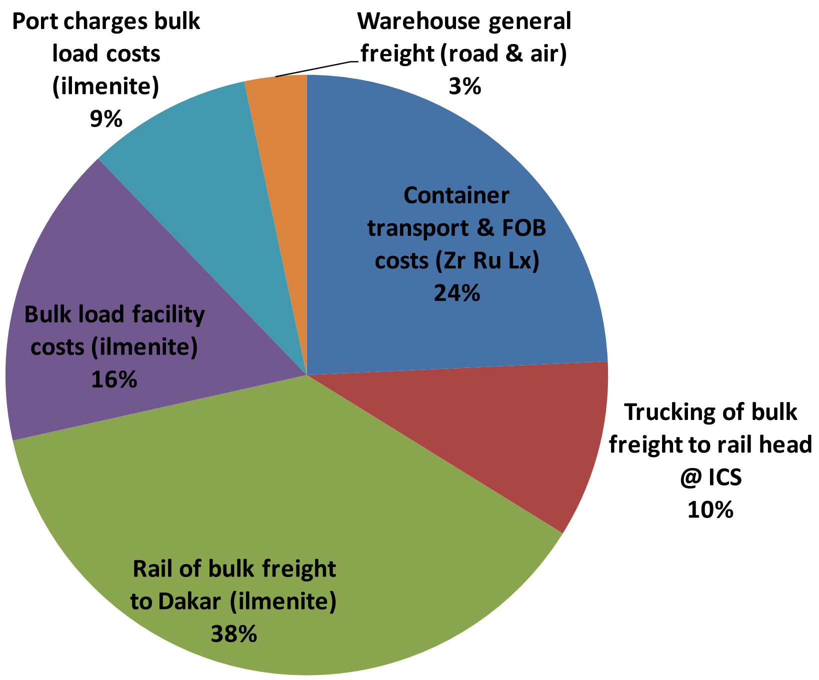
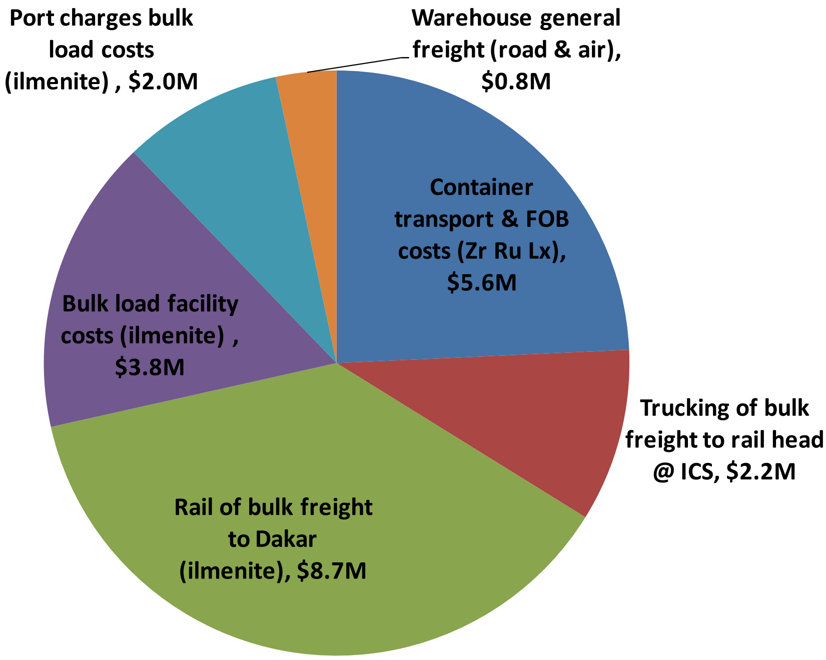


Figure 17.11 GCP Transport and Shipping Operating Cost Breakdown – 2015 Production, Annual Cost ($US pa)



17.12 Other Operating Costs

The annual cost estimate for other items is approximately US$8.1M pa. These include:

- Site catering.
- Expatriate accommodation and messing.
- Bus service (site and expat transfer).
- Environment rehabilitation works.
- Miscellaneous site administration expenses.
- Social programs.
- Insurances.

Detail of the development of these costs is provided in the following sections and Appendix 17.1.

17.12.1 Site Catering

A first principles estimate for operational messing of US$1.2M pa has been generated by MDL which includes staffing requirements, food requirements and miscellaneous costs (utilities).

17.12.2 Expatriate Accommodation and Messing

Annual accommodation and messing costs for expatriate personnel has been estimated from first principles, based on MDL Dakar experience. The total estimated cost is US$0.35M pa. The cost is based on senior management level positions initially to be filled by 42 expatriates.

Exploration camp costs are included in the capital expenditure estimate as an owner's cost. This facility will be decommissioned at the end of the construction period.

17.12.3 Bus Service (Site and Expat Transfer)

A first principles estimate has been generated for the bus service of US$0.64M pa.

17.12.4 Environment Rehabilitation Works

Rehabilitation costs of US$0.90M pa are based on a first principles estimate assuming US$5,000/ha.

Site administration costs of US$0.68M pa are based on a first principles estimate generated by MDL.

17.12.5 Social Programs

The social program operating cost estimate is summarised in Table 17.4. The costs are sourced from the Earth Systems land impact assessment document (see Volume 2 Appendix 2.6).

Table 17.4 GCP Social Program Operating Cost Summary

Component	Costs (USD)										
	Operating Costs (Years 1 to 10)										
	1	2	3	4	5	6	7	8	9	10	Operating (Total)
Resettlement, Compensation and Livelihood Restoration											
Diogo hamlets	23,248	23,248	23,248	23,248	23,248	23,248	23,248	23,248	23,248	23,248	232,481
Foth hamlets	72,761	72,761	72,761	72,761	72,761	72,761	72,761	72,761	72,761	72,761	727,615
Diourmel hamlets	57,770	57,770	57,770	57,770	57,770	57,770	57,770	57,770	57,770	57,770	577,704
Thiakmat hamlets	49,607	49,607	49,607	49,607	49,607	49,607	49,607	49,607	49,607	49,607	496,068
Other land/assets in the GCPDA	68,099	68,099	68,099	68,099	68,099	68,099	68,099	68,099	68,099	68,099	680,987
Revegetation Areas	119,737	119,737	119,737	119,737	119,737	119,737	119,737	119,737	119,737	119,737	1,197,365
Sub-total	***391,222***	***391,222***	***391,222***	***391,222***	***391,222***	***391,222***	***391,222***	***391,222***	***391,222***	***391,222***	***3,912,220***
Social Management and Monitoring											
Stakeholder Liaison	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	300,000
Government Liaison											
Contractors/ Consultants	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	1,000,000
Management of Community Projects	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	500,000
Funding of Community Projects	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	2,000,000
Socio-economic monitoring	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	250,000
Sub-total	***405,000***	***405,000***	***405,000***	***405,000***	***405,000***	***405,000***	***405,000***	***405,000***	***405,000***	***405,000***	***4,050,000***
Administration of the Community Relations Departments											
Office Admin	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	200,000
Personnel	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	1,500,000
Training - Workforce Induction	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	500,000
Training - CR Personnel	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	250,000
Training - Community Education	45,000	45,000	45,000	45,000	45,000	45,000	45,000	45,000	45,000	45,000	450,000
Vehicle (3)	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	200,000
Computer (6) / Printer (2) / Fax/Copier (1)	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	20,000
Reporting	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	50,000
Auditing	-	30,000	-	30,000	-	30,000	-	30,000	-	30,000	150,000
Sub-total	***317,000***	***347,000***	***317,000***	***347,000***	***317,000***	***347,000***	***317,000***	***347,000***	***317,000***	***347,000***	***3,320,000***
Total	***1,113,222***	***1,143,222***	***1,113,222***	***1,143,222***	***1,113,222***	***1,143,222***	***1,113,222***	***1,143,222***	***1,113,222***	***1,143,222***	***11,282,220***

The three principal areas are:

- Resettlement, compensation and livelihood restoration (US$0.39 pa).
- Social management and monitoring (US$0.41M pa).
- Administration of the Community Relations Department (US$0.33M pa).

Post-funding social management activities are included in the capital account.

17.12.6 Insurances

Political risk insurance of 0.7% of debt financing is based on a quote from Strathearn (2010). Other annual insurance premiums quoted by Strathearn total US$2.0M (Appendix 17.1), covering the following areas:

- Combined MD/MB/BI.
- Third party liability.
- Mobile plant.
- Marine cargo.
- Motor vehicles.

17.13 Operating Cost Summary

The operating cost summary, based on the above inputs is detailed in Table 17.5 with the total costs for ramp up years and the first two full years of production.

Table 17.5 Operating Cost Summary

Y/End 30 June (US$M)	Rate	Unit	2013	2014	2015	2016
Throughput		'000t		41,084	52,122	54,575
Power & Fuel						
Power generation	0.13	cents / kWh	$0.1	$14.3	$18.2	$18.6
Drying fuel - gasoil	838.00	$US / t	$0.0	$2.7	$3.7	$3.6
Mobile equipment/ vehicles - gasoil	838.00	$US / t	$0.4	$0.9	$0.9	$0.9
	Subtotal	$USM	$0.5	$17.9	$22.8	$23.1
Employee Costs						
GCO staff			$4.0	$10.4	$7.1	$7.1
Contract labour			$0.0	$0.7	$0.7	$0.7
	Subtotal	$USM	$4.0	$11.2	$7.9	$7.9
Maintenance						
Dredge & Wet Plant	0.14	$US / t mined	$0.0	$5.5	$7.0	$7.4
MSP (non magnetics)	3.00	$US / t throughput	$0.0	$0.6	$0.8	$0.7
Ilmenite (magnetics)	2.41	$US / t throughput	$0.0	$1.2	$1.7	$1.7
Borefield	0.30	$USM / annum	$0.0	$0.3	$0.3	$0.3
HMC pumping system	0.95	$USM / annum	$0.0	$1.0	$1.0	$1.0
Mobile Fleet & Cars	2.80	$USM / annum	$0.0	$2.8	$2.8	$2.8
	Subtotal	$USM	$0.0	$11.4	$13.6	$13.8
Transportation / Shipping						
Container transport & FOB costs (Zr Ru Lx)	52.46	$US / t (Zr Ru Lx)	$0.0	$4.1	$5.6	$5.4
Trucking of bulk freight to rail head @ ICS	3.40	$US / t ilmenite	$0.0	$1.6	$2.2	$2.1
Rail of bulk freight to Dakar (ilmenite)	13.38	$US / t ilmenite	$0.0	$6.3	$8.7	$8.4
Bulk load facility costs (ilmenite)	5.80	$US / t ilmenite	$0.0	$2.7	$3.8	$3.6
Port charges bulk load costs (ilmenite)	2.70	$US / t ilmenite	$0.0	$1.5	$2.0	$2.0
Warehouse general freight (road & air)	0.77	$USM / annum	$0.0	$0.8	$0.8	$0.8
	Subtotal	$USM	$0.0	$17.0	$23.1	$22.4
Other						
Site catering (restaurant)	1.20	$USM / annum	$0.3	$1.2	$1.2	$1.2
Expat Accomodation and messing	0.35	$USM / annum	$0.2	$0.4	$0.4	$0.4
Bus service (site & expat transfer)	0.64	$USM / annum	$0.3	$0.6	$0.6	$0.6
Social - Resettlement, Comp. & Livelihood Restoration	0.39	$USM / annum	$0.0	$0.4	$0.4	$0.4
Social - Social Management and Monitoring	0.41	$USM / annum	$0.0	$0.4	$0.4	$0.4
Social - Administration	0.33	$USM / annum	$0.0	$0.3	$0.3	$0.3
Environment- Rehabilitation works	0.90	$USM / annum	$0.0	$0.9	$0.9	$0.9
Site admin expenses - misc	0.68	$USM / annum	$0.2	$0.7	$0.7	$0.7
Insurance -Political risk (% of debt)	0.07	$USM / annum	$0.0	$1.1	$1.3	$1.1
Insurances -other	2.00	$USM / annum	$2.0	$2.0	$2.0	$2.0
	Subtotal	$USM	$3.0	$8.0	$8.2	$8.0
	Total	$USM	$7.4	$65.4	$75.4	$75.2

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SECTION 18

Closure Cost Estimate

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CONTENTS

18 CLOSURE COST ESTIMATE

18.1 Introduction

Planning for mine closure is an integral part of the GCP project life cycle and has been considered in the development of the capital and operating costs. The closure of the mine will occur in two stages:

- Ongoing closure.
- Final closure.

Details of these closure plans are in Section 15 and are briefly summarised below.

18.2 Ongoing Closure Costs

The ongoing closure stage occurs as the dredge progresses through the sand dunes, and the landscape is re-formed, revegetated and handed back to the landowners. Ongoing closure costs include the following activities:

- Re-forming of the sand dunes using the tailing elevator.
- Removal of the transmissions lines, pipelines and roads and rehabilitation of the disturbed land as the dredge path advances and these facilities are no longer required.
- Where vegetation existed prior to mining, revegetation of the re-formed landscape.
- Ongoing monitoring of rehabilitation areas after the rehabilitation has been completed.

Costs for these activities are included in the operating costs and are detailed below:

- Re-forming the sand dunes is included in the mining operating costs as detailed in Section 17.
- Removal of transmission lines and other services is included in operating costs as detailed in Section17.
- A total annual allowance of $1.5M has been included for ongoing rehabilitation. This is based on an average rehabilitation requirement of 300 ha pa at an average cost of $5,000/ha. This cost has been developed based on actual in-country costs incurred by Senegal government forestry department of US$1,600/ha all-inclusive cost for rehabilitating identical dunes to those in the mining lease with considerable margin/allowance.
- Ongoing monitoring costs are included in the rehabilitation costs.

18.3 Final Closure Costs

The final closure costs include the following activities:

- Decommissioning of all infrastructure including plant, storage and dispatch facilities.
- Rehabilitation and revegetation of building and infrastructure sites.
- Rehabilitation and revegetation of the final dredge site.
- Rehabilitation monitoring and maintenance.
- A socio-economic program to minimise the economic impact of the mine closure on the local communities.

While the DFS has considered a mining and process period of 14 years, the resource at Grande Côte is not exhausted at the end of this period. It is reasonably likely that a sizeable proportion of the remaining resource would be converted to reserve and would be mined after the initial 14 years of production. Consequently, final closure and final closure costs are likely to be incurred well beyond the period considered in the financial model, and have therefore not been included.

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SECTION 19

Financial Modelling

Copy 16

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TABLES

FIGURES

19 FINANCIAL MODELLING

19.1 Introduction

This section provides an overview of the GCP economics, including a financial evaluation and sensitivity analysis. The period to 2027 has been considered for the financial modeling and analysis and a breakdown of the capital, operating and closure costs are detailed in Sections 16, 17 and 18, respectively.

19.2 Financial Evaluation Assumptions and Inputs

19.2.1 Metal Price Forecasts

The GCP generates revenue from the sale of the following products:

- Sulphate Ilmenite (56% TiO_2).
- Chloride Ilmenite (58% TiO_2).
- Premium Zircon.
- Intermediate Zircon.
- Standard Zircon.
- Secondary Zircon.
- Rutile.
- Leucoxene.

The product specifications and price forecast for the various products are discussed in Section 2. For all products TZMI price analysis and forecasts to 2027 have been used. Annual revenue forecasts are detailed in Section 19.3.1.

19.2.2 Base Date and Escalation

All capital dollars are US real dollar amounts as at 30 November 2009. Operating costs are current at April 2010. Escalation has not been applied.

19.2.3 Project Financing

Financing options have not been assessed in this economic evaluation. A debt-to-equity ratio of 50/50 is used for the financial evaluation based on instruction from MDL.

19.2.4 Production Schedule

The first year of production is 2013 based on the project development schedule detailed in Section 13. The production ramp-up is consistent with that specified in Section 6, on mineral processing. It assumes 50% capacity production in the first year of operation in 2015, followed by full capacity in subsequent years.

Grades, recoveries and recovered mineral are consistent with those in the production model developed from the mine and processing plans. The average HMC feed processing rates at full production capacity is approximately:

- 240,000 tpa through the wet mill.
- 105,000 tpa through the dry mill.
- 680,000 tpa through the ilmenite dry plant.

19.2.5 Operating Costs

Total operating costs are US$1024.6M to 2027. The total unit operating cost averages US$1.36/t of ore mined and includes provision for the following items:

- Fuel products have been specified as gasoil for drying and mobile equipment at US$838/t.
- A unit cost for power generation of 0.131 cents/kWh, which includes all fuel, lubricants and maintenance associated with power generation.
- Manning costs average US$7.8M pa. These costs are supplemented by a restaurant, catering and busing provision of US$1.2M pa.
- Maintenance costs include:
  - Dredge and wet plant at US$0.135/t of ore mined.
  - MSP at US$3.00/t of non-magnetics processed.
  - Ilmenite plant at US$2.41/t of ilmenite processed.
  - The borefield and pumping station operation at US$0.3M pa and US$0.95M pa respectively.
  - Mobile fleet and cars of US$2.8M pa.
- A resettlement, compensation and livelihood provision of US$0.39M pa has been included and an annual rehabilitation cost of US$0.9M commencing in 2014. Post-funding social management activities are included in the capital estimate.
- Other site costs include:
  - Expatriate accommodation and messing of US$0.35M pa.
  - A bus transfer service US$0.64M pa.
  - Miscellaneous site expenses of US$0.68M pa.
  - Insurances expenses have been estimated at US$2.0M pa.

All operating costs have been provided by GCO. Corporate costs and operating contingency are not included. The accuracy of the operating costs is ±15%.

19.2.6 Capital Costs

The total GCP capital cost is US$406M and this is spread over three years, from 2011 to 2013. This cost includes an owner's cost contingency estimate of US$13.8M. A separate estimating design allowance has also been included and totals US$16.68M. The derivation of these capital costs are detailed in Section 16. The accuracy of capital costs is estimated by Ausenco at ±15%.

In addition, there is an owner's allowance for working capital of US$53.6M over 2013 to 2015. Sustaining capital has been estimated at US$1.5M in 2015 and US$4.9M pa, subsequently.

19.2.7 Port and Freight

Transportation and shipping costs estimated in the cost model include:

- Container transport and FOB costs of US$52.46/t of zircon, rutile and leucoxene.
- Trucking to the railhead at ICS of US$3.40/t of ilmenite.
- Rail provision to the Port of Dakar at US$13.38/t of ilmenite.
- Bulk load facility costs US$5.80/t of ilmenite.
- Port charges and warehousing of US$2.70/t of ilmenite.
- Warehouse and general road and air freight of US$$0.77M pa.

Demurrage of US$20,000 pa is included in the overall cost of bulk freight costs for ilmenite.

19.2.8 Royalties and Taxes

The royalty and taxation arrangements for the GCP are detailed in Section 20. In summary, the GCP is exempt from Senegalese Government taxes for a period of 15 years from the start of operation, with provision also made for exemptions during investment and development.

Specific articles that relate to project cash flows and expenditures are detailed in Table 20.1. In summary:

- The holder of the mining exploitation permit or mining concession, in addition to enterprises working on its behalf, benefits from an exemption from all excise and import duties.
- Over a period of 15 years calculated from the date of issue of the Mining Concession, not counting the two-year investment period, and subject to the provisions of Article 26 of this Convention, the holder of the Mining Concession shall benefit from a total taxation exemption.
- The holder of the mining concession benefits over a period of 15 years from an exemption from company tax, calculated from the date of issue of the Mining Concession.

- The exploitation company shall agree to contribute to the social development of local communities in the Grande Côte region, which are located in areas surrounding the exploitation site. Thus, it shall agree to invest an amount of $US 150,000 per year for this purpose.
- The exploitation company shall contribute, on the basis of a protocol to be concluded with the Ministry for Mines, to the basic and further training of Senegalese officers responsible for the management and promotion of the mining sector and logistical support to the technical services of the Ministry for Mines; to this end, the exploitation company shall agree to allocate the sum of $US 50,000 pa for each year of production.
- MDL shall accept that the mining royalty to be paid pursuant to Article 57 of the Mining Code be 5% of the pithead value. An additional 2% will also be set aside to support the new town development project.

A provision for social training and development is included in the cost model in accordance with these requirements, including social management and monitoring estimated at US$0.41M pa and administration of US$0.33M pa. The royalty and taxation requirements have been included in the capital and operating cost estimates developed in the DFS, see Sections 16 and 17.

19.3 Financial Analysis

19.3.1 Gross Revenue

The GCP is forecast to generate total gross revenue of US$2,687M over the first 14 years of operation.

The total amount of saleable product to 2027 is 9,693,900 tonnes consisting annually of approximately:

- 85,000 t of zircon (premium, intermediate, standard, secondary).
- 6,000 t of rutile.
- 11,000 t of leucoxene.
- 575,000 t of TiO_2 sulphate and chloride ilmenite.

Total revenue is split between these different products, with zircon sales contributing to 56.9% of total gross revenue, ilmenite 37.0%, leucoxene 3.5% and rutile 2.5%. Revenue is shown in Table 19.1.

19.3.2 Operating and Capital Costs

Total capital costs are US$459.6M excluding sustaining capital and are spread over years 2011 to 2015. Total operating costs are US$1024.6M to 2027. Operating and capital costs are shown in Table 19.2.

Table 19.1 GCP Production and Revenue

Y/End 30 June	Input	Units	2009	2010	Total/Av	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Year						(2)	(1)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Resource																						
Ore Mined		'000t			748,104	0	0	0	41,084	52,122	54,575	54,575	54,575	54,575	54,575	54,575	54,575	54,575	54,575	54,575	54,575	54,575
Grades																						
Heavy Mineral (HM)		% in ore			1.8%	0.0%	0.0%	0.0%	1.8%	2.0%	1.8%	1.8%	1.8%	1.8%	1.8%	1.9%	1.7%	1.8%	1.7%	1.9%	1.6%	1.5%
Zircon		% in HM			10.7%	0.0%	0.0%	10.7%	10.7%	10.7%	10.7%	10.7%	10.7%	10.7%	10.7%	10.7%	10.7%	10.7%	10.7%	10.7%	10.7%	10.7%
Rutile		% in HM			2.5%	0.0%	0.0%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
Leucoxene		% in HM			3.2%	0.0%	0.0%	3.2%	3.2%	3.2%	3.2%	3.2%	3.2%	3.2%	3.2%	3.2%	3.2%	3.2%	3.2%	3.2%	3.2%	3.2%
Ilmenite		% in HM			74.5%	0.0%	0.0%	74.5%	74.5%	74.5%	74.5%	74.5%	74.5%	74.5%	74.5%	74.5%	74.5%	74.5%	74.5%	74.5%	74.5%	74.5%
Overall Recovery																						
Zircon		%			81.3%	0.0%	0.0%	0.0%	81.3%	81.3%	81.3%	81.3%	81.3%	81.3%	81.3%	81.3%	81.3%	81.3%	81.3%	81.3%	81.3%	81.3%
Rutile		%			24.9%	0.0%	0.0%	0.0%	24.9%	24.9%	24.9%	24.9%	24.9%	24.9%	24.9%	24.9%	24.9%	24.9%	24.9%	24.9%	24.9%	24.9%
Leucoxene		%			30.9%	0.0%	0.0%	0.0%	30.9%	30.9%	30.9%	30.9%	30.9%	30.9%	30.9%	30.9%	30.9%	30.9%	30.9%	30.9%	30.9%	30.9%
Ilmenite		%			84.1%	0.0%	0.0%	0.0%	84.1%	84.1%	84.1%	84.1%	84.1%	84.1%	84.1%	84.1%	84.1%	84.1%	84.1%	84.1%	84.1%	84.1%
Saleable Product																						
Premium, Intermediate, Standard Zircon		'000t			1,127.0	0.0	0.0	0.0	64.1	87.9	85.1	84.2	83.8	81.9	81.4	85.6	79.6	83.8	77.7	88.4	75.4	68.0
Secondary Zircon		'000t			28.6	0.0	0.0	0.0	1.6	2.2	2.2	2.1	2.1	2.1	2.1	2.2	2.0	2.1	2.0	2.2	1.9	1.7
Zircon total		'000t			**1,155.6**	**0.0**	**0.0**	**0.0**	**65.7**	**90.2**	**87.3**	**86.4**	**85.9**	**84.0**	**83.5**	**87.8**	**81.6**	**85.9**	**79.7**	**90.6**	**77.3**	**69.7**
Rutile		'000t			81.9	0.0	0.0	0.0	4.7	6.4	6.2	6.1	6.1	5.9	5.9	6.2	5.8	6.1	5.6	6.4	5.5	4.9
Leucoxene		'000t			131.5	0.0	0.0	0.0	7.5	10.3	9.9	9.8	9.8	9.6	9.5	10.0	9.3	9.8	9.1	10.3	8.8	7.9
Subtotal		'000t			1,369.0	0.0	0.0	0.0	77.9	106.8	103.4	102.3	101.7	99.5	98.9	104.0	96.7	101.7	94.4	107.4	91.6	82.6
Ilmenite		'000t			8,324.9	0.0	0.0	0.0	473.5	649.6	628.9	622.1	618.7	605.0	601.6	632.3	587.9	618.7	574.2	652.8	557.1	502.5
Total Saleable Product		'000t			**9,693.9**	**0.0**	**0.0**	**0.0**	**551.3**	**756.4**	**732.3**	**724.4**	**720.4**	**704.5**	**700.5**	**736.3**	**684.6**	**720.4**	**668.7**	**760.2**	**648.8**	**585.1**
Prices																						
Premium, Intermediate, Standard Zircon		$US/t			1,323.67	0.00	0.00	1,130.00	1,225.00	1,300.00	1,350.00	1,350.00	1,350.00	1,350.00	1,350.00	1,350.00	1,350.00	1,350.00	1,350.00	1,350.00	1,350.00	1,350.00
Secondary Zircon		$US/t			661.83	0.00	0.00	565.00	612.50	650.00	675.00	675.00	675.00	675.00	675.00	675.00	675.00	675.00	675.00	675.00	675.00	675.00
Rutile		$US/t			830.67	0.00	0.00	805.00	815.00	820.00	835.00	835.00	835.00	835.00	835.00	835.00	835.00	835.00	835.00	835.00	835.00	835.00
Leucoxene		$US/t			730.67	0.00	0.00	705.00	715.00	720.00	735.00	735.00	735.00	735.00	735.00	735.00	735.00	735.00	735.00	735.00	735.00	735.00
Ilmenite		$US/t			118.33	0.00	0.00	105.00	110.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00
Revenue																						
Premium, Intermediate, Standard Zircon		US$M			1,509.1	0.0	0.0	0.0	78.5	114.3	114.9	113.7	113.1	110.6	109.9	115.6	107.4	113.1	104.9	119.3	101.8	91.8
Secondary Zircon		US$M			19.1	0.0	0.0	0.0	1.0	1.5	1.5	1.4	1.4	1.4	1.4	1.5	1.4	1.4	1.3	1.5	1.3	1.2
Zircon total		US$M			**1,528.2**	**0.0**	**0.0**	**0.0**	**79.5**	**115.8**	**116.4**	**115.1**	**114.5**	**112.0**	**111.3**	**117.0**	**108.8**	**114.5**	**106.3**	**120.8**	**103.1**	**93.0**
Rutile		US$M			68.2	0.0	0.0	0.0	3.8	5.2	5.2	5.1	5.1	5.0	4.9	5.2	4.8	5.1	4.7	5.4	4.6	4.1
Leucoxene		US$M			96.3	0.0	0.0	0.0	5.3	7.4	7.3	7.2	7.2	7.0	7.0	7.3	6.8	7.2	6.7	7.6	6.5	5.8
Subtotal		US$M			1,692.7	0.0	0.0	0.0	88.7	128.4	128.9	127.5	126.8	124.0	123.3	129.6	120.5	126.8	117.7	133.8	114.2	103.0
Ilmenite		US$M			994.3	0.0	0.0	0.0	52.1	78.0	75.5	74.7	74.2	72.6	72.2	75.9	70.5	74.2	68.9	78.3	66.9	60.3
Total Revenue		US$M			**2,687.0**	**0.0**	**0.0**	**0.0**	**140.7**	**206.4**	**204.3**	**202.1**	**201.0**	**196.6**	**195.5**	**205.4**	**191.0**	**201.0**	**186.6**	**212.1**	**181.0**	**163.2**

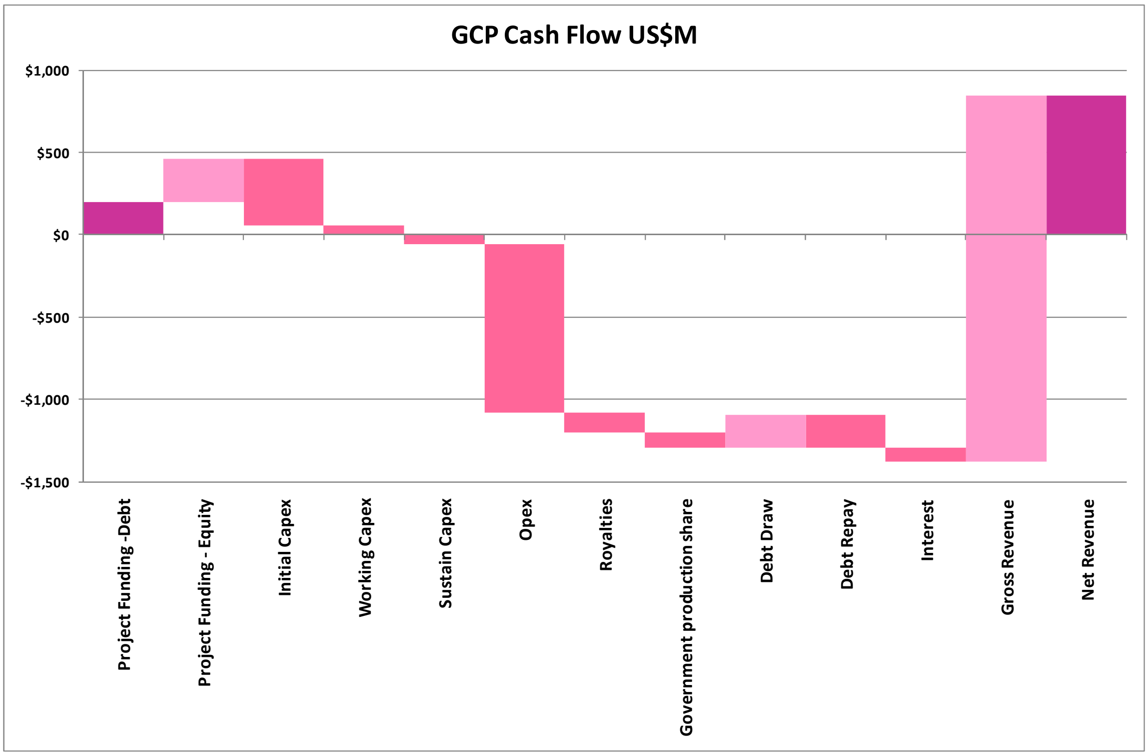
Table 19.2 GCP Cash Flows

Y/End 30 June	Input	Units	Total	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Year				(2)	(1)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Resource																				
Ore Mined		'000t		0	0	0	41,084	52,122	54,575	54,575	54,575	54,575	54,575	54,575	54,575	54,575	54,575	54,575	54,575	54,575
Saleable Product																				
Premium, Intermediate, Standard Zircon		'000t	1,127.0	0.0	0.0	0.0	64.1	87.9	85.1	84.2	83.8	81.9	81.4	85.6	79.6	83.8	77.7	88.4	75.4	68.0
Secondary Zircon		'000t	28.6	0.0	0.0	0.0	1.6	2.2	2.2	2.1	2.1	2.1	2.1	2.2	2.0	2.1	2.0	2.2	1.9	1.7
Zircon total		'000t	**1,155.6**	**0.0**	**0.0**	**0.0**	**65.7**	**90.2**	**87.3**	**86.4**	**85.9**	**84.0**	**83.5**	**87.8**	**81.6**	**85.9**	**79.7**	**90.6**	**77.3**	**69.7**
Rutile		'000t	81.9	0.0	0.0	0.0	4.7	6.4	6.2	6.1	6.1	5.9	5.9	6.2	5.8	6.1	5.6	6.4	5.5	4.9
Leucoxene		'000t	131.5	0.0	0.0	0.0	7.5	10.3	9.9	9.8	9.8	9.6	9.5	10.0	9.3	9.8	9.1	10.3	8.8	7.9
Subtotal		'000t	1,369.0	0.0	0.0	0.0	77.9	106.8	103.4	102.3	101.7	99.5	98.9	104.0	96.7	101.7	94.4	107.4	91.6	82.6
Ilmenite		'000t	8,324.9	0.0	0.0	0.0	473.5	649.6	628.9	622.1	618.7	605.0	601.6	632.3	587.9	618.7	574.2	652.8	557.1	502.5
Total Saleable Product		'000t	**9,693.9**	**0.0**	**0.0**	**0.0**	**551.3**	**756.4**	**732.3**	**724.4**	**720.4**	**704.5**	**700.5**	**736.3**	**684.6**	**720.4**	**668.7**	**760.2**	**648.8**	**585.1**
Prices																				
Premium, Intermediate, Standard Zircon		$US/t	1,323.67	0.00	0.00	1,130.00	1,225.00	1,300.00	1,350.00	1,350.00	1,350.00	1,350.00	1,350.00	1,350.00	1,350.00	1,350.00	1,350.00	1,350.00	1,350.00	1,350.00
Secondary Zircon		$US/t	661.83	0.00	0.00	565.00	612.50	650.00	675.00	675.00	675.00	675.00	675.00	675.00	675.00	675.00	675.00	675.00	675.00	675.00
Rutile		$US/t	830.67	0.00	0.00	805.00	815.00	820.00	835.00	835.00	835.00	835.00	835.00	835.00	835.00	835.00	835.00	835.00	835.00	835.00
Leucoxene		$US/t	730.67	0.00	0.00	705.00	715.00	720.00	735.00	735.00	735.00	735.00	735.00	735.00	735.00	735.00	735.00	735.00	735.00	735.00
Ilmenite		$US/t	118.33	0.00	0.00	105.00	110.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00
Revenue																				
Premium, Intermediate, Standard Zircon		US$M	1,509.1	0.0	0.0	0.0	78.5	114.3	114.9	113.7	113.1	110.6	109.9	115.6	107.4	113.1	104.9	119.3	101.8	91.8
Secondary Zircon		US$M	19.1	0.0	0.0	0.0	1.0	1.5	1.5	1.4	1.4	1.4	1.4	1.5	1.4	1.4	1.3	1.5	1.3	1.2
Zircon total		US$M	**1,528.2**	**0.0**	**0.0**	**0.0**	**79.5**	**115.8**	**116.4**	**115.1**	**114.5**	**112.0**	**111.3**	**117.0**	**108.8**	**114.5**	**106.3**	**120.8**	**103.1**	**93.0**
Rutile		US$M	68.2	0.0	0.0	0.0	3.8	5.2	5.2	5.1	5.1	5.0	4.9	5.2	4.8	5.1	4.7	5.4	4.6	4.1
Leucoxene		US$M	96.3	0.0	0.0	0.0	5.3	7.4	7.3	7.2	7.2	7.0	7.0	7.3	6.8	7.2	6.7	7.6	6.5	5.8
Subtotal		US$M	1,692.7	0.0	0.0	0.0	88.7	128.4	128.9	127.5	126.8	124.0	123.3	129.6	120.5	126.8	117.7	133.8	114.2	103.0
Ilmenite		US$M	994.3	0.0	0.0	0.0	52.1	78.0	75.5	74.7	74.2	72.6	72.2	75.9	70.5	74.2	68.9	78.3	66.9	60.3
Total Revenue		US$M	**2,687.0**	**0.0**	**0.0**	**0.0**	**140.7**	**206.4**	**204.3**	**202.1**	**201.0**	**196.6**	**195.5**	**205.4**	**191.0**	**201.0**	**186.6**	**212.1**	**181.0**	**163.2**
Costs																				
Unit Operating Cost		US$/t	1.36	0.00	0.00	0.00	1.59	1.45	1.38	1.37	1.36	1.35	1.34	1.37	1.32	1.35	1.31	1.38	1.29	1.24
Operating Expenses		US$M	(1,024.7)	0.0	0.0	(7.4)	(65.4)	(75.4)	(75.2)	(74.7)	(74.4)	(73.6)	(73.2)	(74.7)	(72.3)	(73.7)	(71.3)	(75.3)	(70.4)	(67.7)
Capital Expenses		US$M	(406.0)	(24.2)	(164.7)	(217.1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Working Capital		US$M	(53.6)	0.0	0.0	(4.8)	(35.6)	(13.3)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sustaining Capital		US$M	(60.3)	0.0	0.0	0.0	0.0	(1.5)	(4.9)	(4.9)	(4.9)	(4.9)	(4.9)	(4.9)	(4.9)	(4.9)	(4.9)	(4.9)	(4.9)	(4.9)
Royalties		US$M	(120.9)	0.0	0.0	0.0	(6.3)	(9.3)	(9.2)	(9.1)	(9.0)	(8.8)	(8.8)	(9.2)	(8.6)	(9.0)	(8.4)	(9.5)	(8.1)	(7.3)
Government production share		US$M	(90.6)	0.0	0.0	0.0	(2.6)	(7.3)	(7.1)	(7.0)	(7.1)	(6.8)	(6.9)	(7.8)	(6.7)	(7.6)	(6.4)	(8.3)	(5.5)	(3.5)
Interest		US$M	(84.4)	0.0	0.0	(6.2)	(13.4)	(13.6)	(12.0)	(10.4)	(8.8)	(7.2)	(5.6)	(4.0)	(2.4)	(0.8)	0.0	0.0	0.0	0.0
Tax		US$M	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Debt Drawdowns		US$M	200.0	0.0	0.0	155.0	45.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Debt repayments		US$M	(200.0)	0.0	0.0	0.0	(20.0)	(20.0)	(20.0)	(20.0)	(20.0)	(20.0)	(20.0)	(20.0)	(20.0)	(20.0)	0.0	0.0	0.0	0.0
Annual Net Cash Flow		US$M	**846.4**	**(24.2)**	**(164.7)**	**(80.5)**	**42.3**	**66.0**	**76.0**	**76.0**	**76.8**	**75.2**	**76.1**	**84.8**	**76.1**	**85.0**	**95.6**	**114.1**	**92.0**	**79.8**
Cummulative Net Cash Flow		US$M		**(24.2)**	**(188.9)**	**(269.4)**	**(227.1)**	**(161.1)**	**(85.1)**	**(9.1)**	**67.7**	**142.9**	**219.0**	**303.8**	**380.0**	**464.9**	**560.5**	**674.6**	**766.6**	**846.4**
IRR				**21%**																

19.3.3 Cash Flow

The GCP has a net cash flow equal to US$846.6M from commissioning to 2027 (see Figure 19.1 and Table 19.2).

Figure 19.1 GCP Overall Cash Flow (US$M)



The net annual cash flow is positive in 2014, at US$42.3M, subsequently averaging US$79.7M pa as shown in Figure 19.2 and 19.3.

Figure 19.2 GCP Net Annual Cash Flow

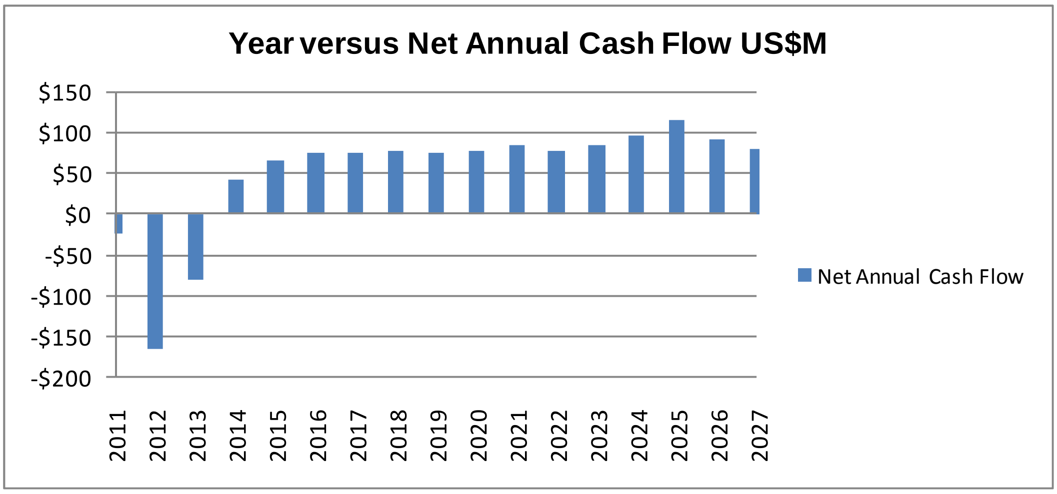


Figure 19.3 GCP Overall Cash Flow (US$M)

19.3.4 Net Present Value (NPV)

The net present value of the project to 2027 is US$208.3M.

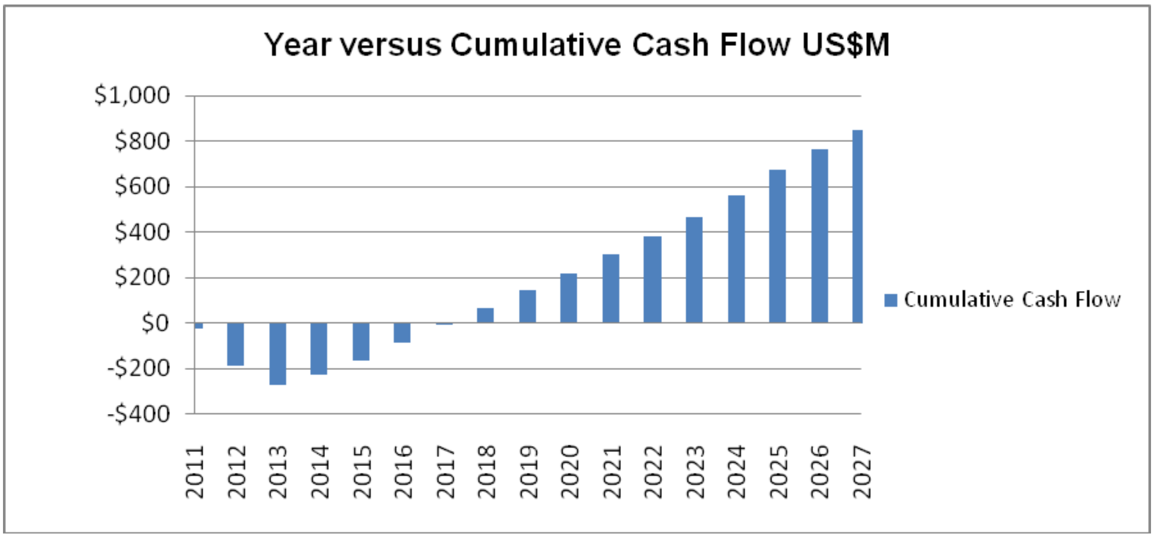
19.3.5 Internal Rate of Return (IRR)

The internal rate of return of the project to 2027, assuming 50% debt and 50% equity is 21% (Table 19.2).

19.3.6 Payback

The GCP experiences undiscounted, cumulative positive payback in 2018, shown in Figure 19.4, with cumulative revenue of US$67.8M in that year (Table 19.2).

Figure 19.4 GCP Cumulative Cash Flow



19.4 Sensitivity Analysis

Single-point deterministic sensitivity analysis was conducted whereby a parameter was varied in isolation to all other parameters and the economic performance of the project determined. The parameters that have been selected for single-point sensitivity analysis represent those which could be considered to have a material impact on the project value, either in isolation or combined with other factors. In some cases, such as heavy mineral grade, commodity price, operating and capital costs, the multiple entries were varied as a single entity. The overall results are shown in Table 19.3.

Table 19.3 Overall Single Point Sensitivity Analysis Results

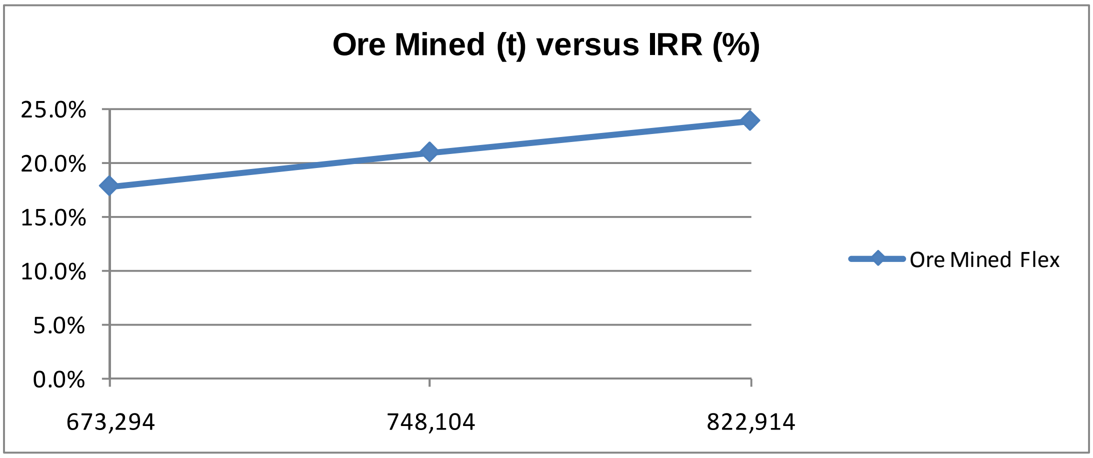
Sensitivity	IRR @ 90%	IRR @ 100%	IRR @ 110%	IRR Change +/-10%
Ore Mined (Tonnes)	673,294	748,104	822,914	149,621
IRR %	18%	21%	24%	6%
Net Revenue US$M	684.5	846.4	1,008.4	323.8
Payback Year	2018	2018	2017	-1
HM Grades (%HM Grade)	1.6%	1.8%	2.0%	0.4%
IRR %	17%	21%	24%	7%
Net Revenue US$M	658.3	846.4	1,034.6	376.3
Payback Year	2018	2018	2017	-1
Recovery (Saleable Product '000t)	8,724.5	9,693.9	10,663.3	1,938.8
IRR %	17%	21%	24%	7%
Net Revenue US$M	658.3	846.4	1,034.6	376.3
Payback Year	2018	2018	2017	-1
Commodity Prices (Revenue US$M)	2,418.3	2,687.0	2,955.7	537.4
IRR %	16%	21%	26%	10%
Net Revenue US$M	589.8	846.4	1,103.0	513.2
Payback Year	2019	2018	2017	-2
Operating Expenses (Total Opex US$M)	922.2	1,024.7	1,127.2	204.9
IRR %	23%	21%	19%	-4%
Net Revenue US$M	948.9	846.4	744.0	(204.9)
Payback Year	2017	2018	2018	1
Capital Expenses (Project Capital US$M)	365.4	406.0	446.6	81.2
IRR %	24%	21%	18%	-6%
Net Revenue US$M	887.0	846.4	805.8	(81.2)
Payback Year	2017	2018	2018	1
Working/Sustaining Capital (Total W & S Capex US$M)	102.5	113.9	125.3	22.8
IRR %	21%	21%	21%	-1%
Net Revenue US$M	857.8	846.4	835.0	(22.8)
Payback Year	2018	2018	2018	0
All Capital (Total Capital US$M)	467.9	519.9	571.9	104.0
IRR %	24%	21%	18%	-6%
Net Revenue US$M	898.4	846.4	794.4	(104.0)
Payback Year	2017	2018	2018	1

19.4.1 Production Rate

Production rate sensitivity has been evaluated for a range of ±10%. The results indicate a range in IRR from 18% to 24% increasing with ore mined as shown in Figure 19.5.

With a 10% increase in production, the net revenue increases to US$1008.5M (Table 19.3) despite the corresponding increase in operating costs. Positive cumulative payback shifts to 2017.

Figure 19.5 Change in IRR with Increasing Production



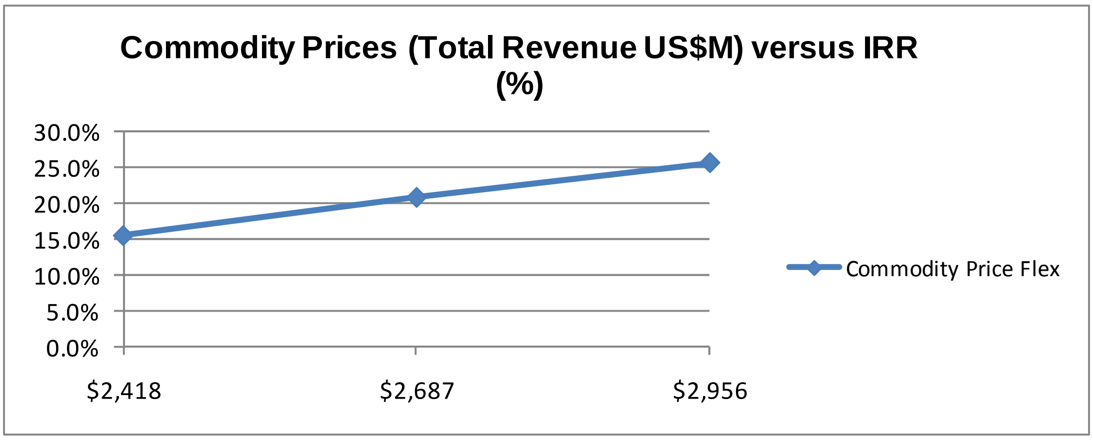
19.4.2 Commodity Prices

Commodity price sensitivity has been evaluated for a range of ±10%. The results indicate an IRR range from 16% to 26%, as shown in Figure 19.6.

The maximum net revenue given a 10% overall increase in commodity prices is US$1,103.2M (Table 19.3).

Positive cumulative payback is delayed in the event of a 10% decrease in commodity prices to 2019 and net revenue is reduced to US$590.1M.

Figure 19.6 Change in IRR with Increasing Commodity Prices



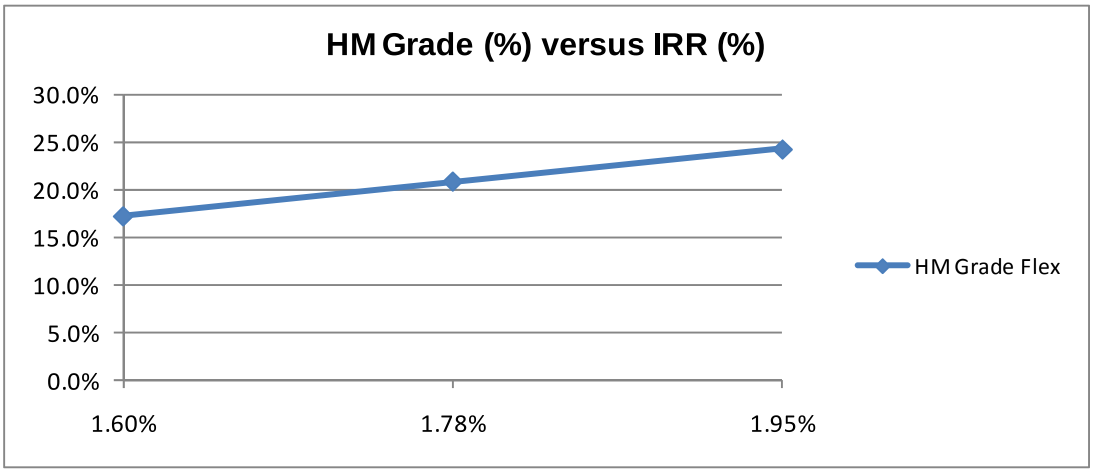
19.4.3 Heavy Mineral Grade

Heavy mineral grade sensitivity has been evaluated for a range of ±10%. The results indicate a decreasing IRR with increasing heavy mineral grade and a range of 17% to 24% as shown in Figure 19.7.

A 10% increase in heavy mineral grade increases the net revenue of the GCP to US$1,034.7M and positive cumulative payback is 2017 (Table 19.3).

Alternatively, a 10% decrease in heavy mineral grade decreases the net revenue to US$658.4M and positive cumulative payback is 2018.

Figure 19.7 Change in IRR with Increasing Heavy Mineral Grade



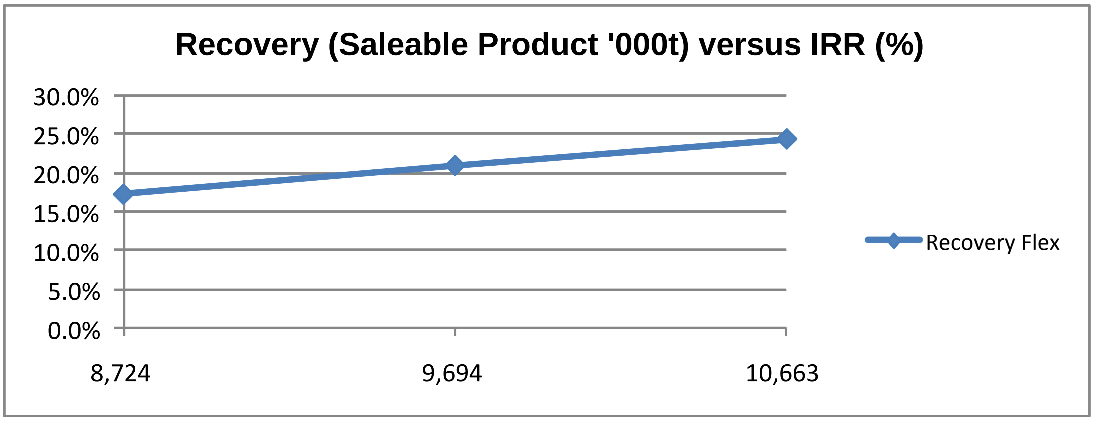
19.4.4 Heavy Mineral Recovery

Heavy mineral recovery sensitivity has been evaluated for a range of ±10%. The results indicate a decreasing IRR with increasing heavy mineral recovery and a range of 17% to 24% as shown in Figure 19.8.

A 10% increase in heavy mineral recovery increases the net revenue of the GCP to US$1,034.7M and positive cumulative payback is 2017 (Table 19.3).

Alternatively, a 10% decrease in heavy mineral recovery decreases the net revenue to US$658.4M and positive cumulative payback is 2018.

Figure 19.8 Change in IRR with Increasing Heavy Mineral Recovery



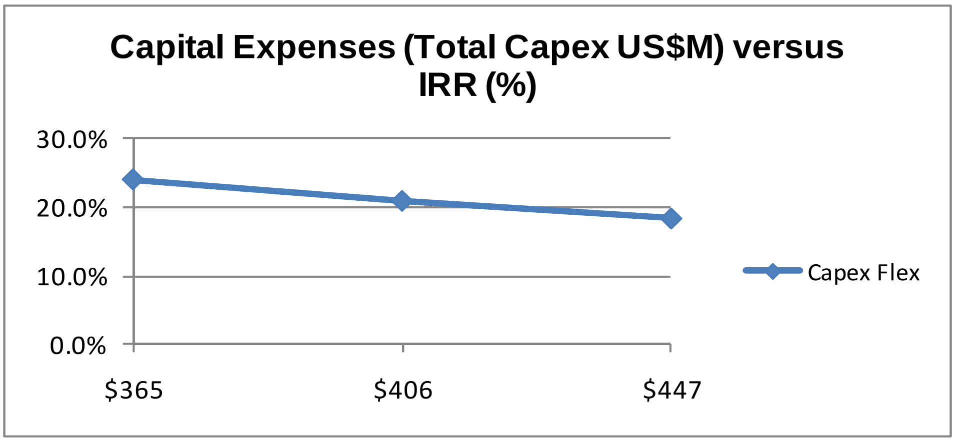
19.4.5 Capital Costs

Capital expenditure sensitivity has been evaluated for a range of ±10%. The results indicate a decreasing IRR with increasing capital expenditure and a range of 24% to 18% as shown in Figure 19.9.

A 10% increase in capital expenditure reduces the net revenue of the GCP to US$806.0M and positive cumulative payback is 2018 (Table 19.3).

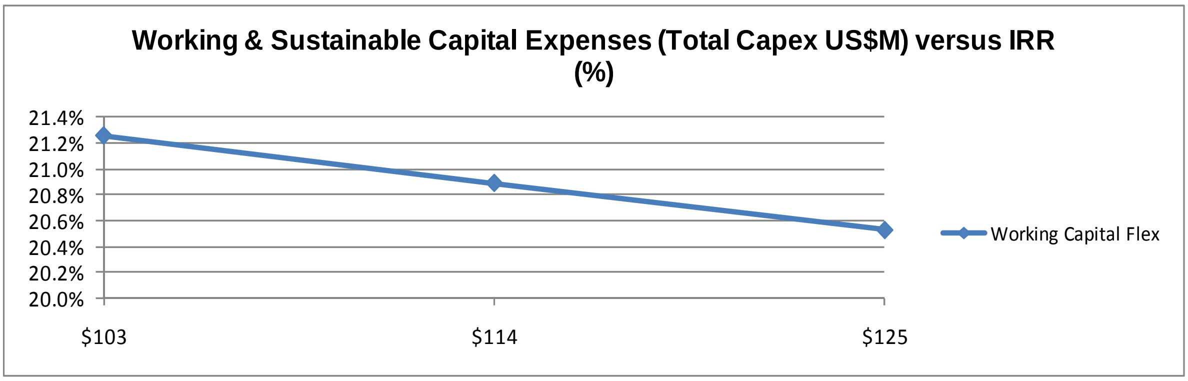
Alternatively, a 10% decrease in capital expenditure increases the net revenue to US$887.2M and positive cumulative payback shifts to 2017.

Figure 19.9 Change in IRR with Increasing Fixed Capital Expenditure



Working and sustaining capital expenditure sensitivity has been evaluated for a range of ±10%. The results indicate only a marginal impact on IRR and net revenue. The IRR remains in the range of 21%, Figure 19.10, and net revenue shifts from US$858.0M to US$835.2M with increasing working and sustaining capital costs (Table 19.3). Positive cumulative payback remains at 2018.

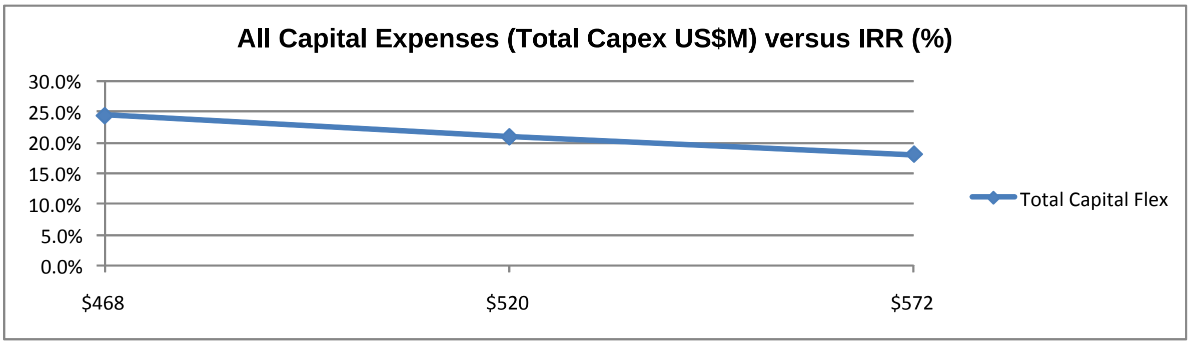
Figure 19.10 Change in IRR with Increasing Working and Sustaining Capital Expenditure



Overall Capital Expenditure sensitivity has been evaluated for a range of ±10%. The results indicate that the total capital expenditure has a more significant influence on the IRR with a 24% to 18% spread shown in Figure 19.11.

The net revenue decreases from US$898.6M to US$794.6M upon increasing overall capital expenses. Upon decreasing capital expenses, positive cumulative payback shifts to 2017 (Table 19.3).

Figure 19.11 Change in IRR with Increasing Overall Capital Expenditure



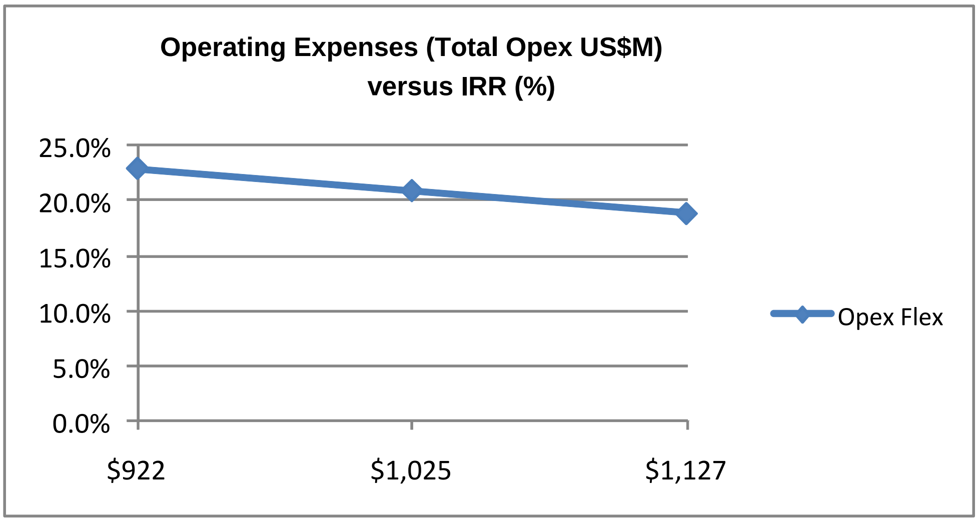
19.4.6 Operating Costs

Operating cost sensitivity has been evaluated for a range of ±10%. The results indicate a decreasing IRR with increasing operating expenses and a range of 23% to 19% as shown in Figure 19.12.

A 10% increase in operating expenditure reduces the net revenue of the GCP to US$744.1M and positive cumulative payback is 2018 (Table 19.3).

Alternatively, a 10% decrease in operating expenditure increases the net revenue to US$949.0M with payback shifting to 2017.

Figure 19.12 Change in IRR with Increasing Operating Costs

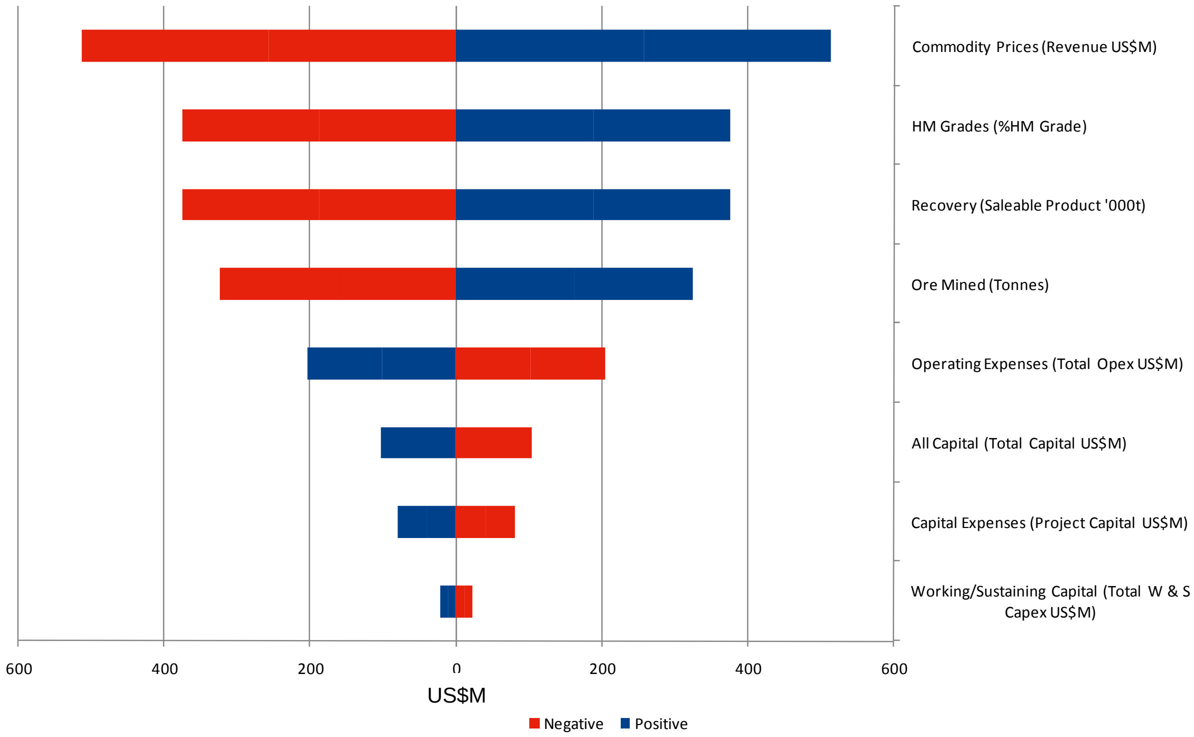


19.4.7 Conclusion

A range of sensitivities have been evaluated across a range of ±10%. In terms of net revenue, and shown in Figure 19.13, the GCP is most sensitive to:

- Commodity price.
- Heavy mineral grade.
- Recovery.
- Ore mined.
- Operating expenses.
- All capital expenditure.
- Fixed capital expenditure.
- Working and sustaining capital expenditure.

Figure 19.13 GCP Sensitivity Analysis Impact on Net Revenue



The impact of sensitivity analysis across a range of ±10% on IRR are summarised in Table 19.4.

Table 19.4 Sensitivity Impact on IRR

Sensitivity	IRR @ 90%	IRR @ 100%	IRR @ 110%	IRR Change +/-10%
Ore Mined (Tonnes)	18%	21%	24%	6%
HM Grades (%HM Grade)	17%	21%	24%	7%
Recovery (Saleable Product '000t)	17%	21%	24%	7%
Commodity Prices (Revenue US$M)	16%	21%	26%	10%
Operating Expenses (Total Opex US$M)	23%	21%	19%	-4%
Capital Expenses (Project Capital US$M)	24%	21%	18%	-6%
All Capital (Total Capital US$M)	24%	21%	18%	-6%
Working/Sustaining Capital (Total W & S Capex US$M)	21%	21%	21%	>-1%

The greatest negative IRR impacts are from:

- All capital expenditure.
- Fixed capital expenditure.
- Operating expenses.
- Working and sustaining expenditure.

The greatest positive IRR impacts are from:

- Commodity price.
- Heavy mineral grade.
- Recovery.
- Ore mined.

Given that commodity price, heavy mineral grade, recovery and ore mined all result in both increased net revenue and project IRR, the greatest potential upside for the GCP can be achieved by optimising internal mining and processing practices in a climate of reasonable macro-economic parameters.

MDL Mineral Sands Group

GRANDE CÔTE OPERATIONS SA | GRANDE CÔTE PROJECT | **DEFINITIVE FEASIBILITY STUDY**

SECTION 20

Ownership, Legal and Contractual

Copy 16

AMC CONSULTANTS

CONTENTS

TABLES

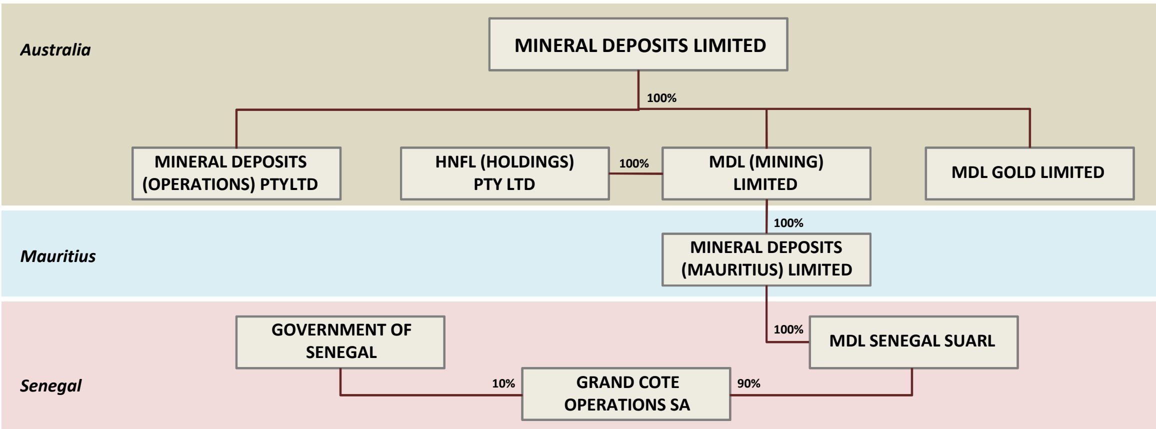
FIGURES

20 OWNERSHIP, LEGAL AND CONTRACTUAL

20.1 Company Structure

MDL's interest in the Grande Côte Project is held by the Senegal-based company Grande Côte Operations SA (GCO). GCO is 90% owned by a Mauritius-based company Mineral Deposits Mauritius Limited (MDM) which in turn is 100% owned by MDL (see Figure 20.1). The remaining 10% of GCO is held by the GRS.

Figure 20.1 Mineral Deposits Limited Corporate Structure 2009



As announced by MDL in April 2010, "On account of the size of the Grande Côte Project and ongoing development potential at the company's Sabodala gold mine, the Board of MDL has concluded that the interests of shareholders will best be met by spinning out the Grande Côte Project and financing it external to MDL through a separate IPO." This strategy will result in a restructuring of the ownership of the Grande Côte Project. At the time of publication of this DFS the new structure has not been finalised.

20.2 Mineral and Land Tenure

Prior to the incorporation of GCO, MDM established MDL Senegal Suarl (MDLSS) under a Mining Convention with the Senegal Government September 2004. The Mining Convention was established in accordance with Law No. 2003-36 of 24 November 2003, constituting the Mining Code and in accordance with Decree No. 2004-647 of 17 May 2004, setting out the procedures for the application of the law constituting the Mining Code.

The purpose of the Mining Convention was to provide a contractual basis for the relationship between the Senegal Government and MDLSS over the entire period of the mining operation. The Mining Convention defines the general, legal, financial, fiscal, economic, administrative and specific corporate conditions under which MDLSS can undertake exploration and mining activities in the Grande Côte Permit Area.

Furthermore, the Mining Convention indicates that:

- An exploration permit is attributed for a period of three years from the date of ministerial signature and is renewable for three-year periods on the condition that MDLSS complies with the works and expenditure commitments as specified in the Mining Convention and regulations as detailed in the Mining Code.
- On each renewal of the exploration permit, a fraction of at least one-quarter of the exploration area must be relinquished.
- Exploration and mining activities should be limited to zircon, ilmenite, rutile, leucoxene and related minerals.
- In the event of the discovery of a mineral deposit, the economic viability must be assessed, and if the deposit is found to be viable an application for an exploitation permit or mining concession shall be made to the Senegal Government.

A mining concession was applied for by MDLSS in 2004 and elaborated on in a series of letters from July through October 2007 in conjunction with the submission of a feasibility study.

As required under the Environmental Code (2001) and Mining Convention, an Environmental and Social Impact Assessment Study (Etude d' Impact Environmental et Social, EIES) was completed in December 2005, by Tropica Environmental Consultants, an environmental company registered by the Senegalese Ministry of Environment and Nature Protection. In December 2005, MDL submitted the EIES in support of its application for a mining concession. The EIES was approved by the Environmental Department of the Ministry of Environment and Nature Protection of the GRS on 20 January 2006.

The mining concession was granted to MDL by Supplementary Deed No. 1 to the Mining Convention on 24 September 2007 for a period of 25 years. The mining concession allows for the development, extraction, processing, transport and marketing of zircon, ilmenite, rutile, leucoxene and related minerals. The mining concession is renewable and the Senegal Government has 10% free participation in the exploitation of the project.

In accordance with the Mining Convention and Supplementary Deed No. 2 (9 July 2008), MDM and the Senegal Government created a separate Senegal-based company, Grande Côte Operations SA (GCO), and MDL transferred the mining concession to GCO. GCO is jointly owned, under a shareholders agreement, by MDM (90%) and the Senegal Government (10%) and is required to subscribe to the terms and conditions of the Mining Convention. GCO is the developer and will be the operator of the Grande Côte Project.

Importantly no further deeds are required for GCO to develop and operate the GCP and mineral tenure is secured by GCO by the Mining Convention and Supplementary Deeds No. 1 and No. 2. This also includes the discretionary authorization for the extension of the period of investment in alignment with the project development timetable.

On 12 February 2008, the Minister of Mines issued interminesterial arrêté 1059 granting MDL the land (354 ha) for the MSP site. This interminesterial arrêté was revised in January 2010 to include an additional (31.7 ha) for the starter pit and the dredge construction site.

At present the land parcels required for site access roads and the road haulage corridor to the ICS rail head have not been officially secured. GCO has the full support of the local community, regional authorities and the mining ministry in this matter, coupled with an excellent understanding of the processes, relevant authorities and stakeholders that need to be consulted to secure the necessary approvals for land transfers.

GCO followed a similar process to securing the land allocated for the MSP and dredge construction sites and no obstacles are anticipated in securing the additional land portions. A nominal sum has been included in the capital estimate in the event that compensation of land owners and users is required.

20.3 Other Licences and Permits

The Mining Convention and Supplementary Deed No. 1 specifies the requirements for the extraction, processing and transport of product, power generation and environmental activities.

MDL has rights to the import of equipment, goods and services required for its activities without restriction and the export of mineral substances extracted their concentrates, primary and other derivatives after having affected all legal and regulatory formalities for their export.

MDL and its subcontractors have a total tax exemption which includes value-added tax on goods and services, exit taxes and duties, minimum revenue tax, trading licences and land or property taxes with the exception of residential buildings, default tax for employers, taxes on deeds registering the incorporation of companies and capital increases.

Supplementary Deed No. 1 also requires MDL to establish:

- A Senagalese foreign currency bank account for the transactions necessary to carry out its mining operations.
- A foreign currency bank account abroad to receive all the proceeds from the sale of mined products, enabling the payment of goods, services and creditors overseas.

MDL is authorised to produce or appoint a subcontractor to produce electrical energy to meet the needs of its various on-site operations and facilities and to make surplus available commercially on terms and conditions determined by mutual agreement and in compliance with the laws and regulations of the Republic of Senegal governing the electricity sector.

Finally, GCO requires a licence for the pumping of water from the deep aquifer. GCO foresee no obstacle to the granting of the licence for the deep water borefield.

20.4 Royalty and Taxation Agreements

The royalty and taxation arrangements for the GCP are detailed in Mining Convention and Supplementary Deed No.1. Specific articles that relate to project cash flows and expenditures are detailed in Table 20.1.

Table 20.1 Royalty and Taxation Arrangements

Topic	Article	Description
Tax Exemptions during Investment Period	Article 24: Clause 24.1 of the Mining Convention	During the investment and production launch period of new exploitation or the extension of the production capacity of pre-existing exploitation, the holder of the mining exploitation permit or mining concession, in addition to enterprises working on its behalf, benefits from an exemption from all excise and import duties including value added tax (VAT), COSEC charges and other taxes of all kinds, with the exception of the Statistical Royalties of the West African Economic and Monetary Union (WAEMU), unless this exemption has been specifically set out in the context of an external financial agreement, for: - Equipment, materials, supplies, machines, heavy machinery, plant and work vehicles included in the authorized programme and to be used directly and definitively for mining operations. - Fuel and lubricants supplied to fixed facilities, drilling equipment, machines and equipment for use in mining operations. - Petroleum products used to produce energy for the undertaking of the authorized exploitation programme. - Spare parts for machines and equipment specifically intended for the undertaking of mining.
Tax Exemptions during Operation	Article 10 of Supplementary Deed No. 1 being new Article 25.2 of the Mining Convention	Over a period of fifteen (15) years calculated from the date of issue of the mining concession, not counting the two-year investment period, and subject to the provisions of Article 26 of this Convention, the holder of the mining concession shall benefit from a total taxation exemption, including: - Exemption from value-added taxes on goods and services acquired from local suppliers or service providers based outside of Senegal. - Exemption from exit taxes and duties. - Exemption from the default minimum revenue taxation charges. - Exemption from trading licences and land and property taxes for property on which structures have been, are being, will be or may be built, with the exception of residential buildings. - Exemption from default tax payments for employers. - Exemption from taxes and duties imposed on deeds registering the incorporation of companies and capital increases. The provisions of this Article shall also be applicable to subcontractors.

Topic	Article	Description
Exemption Period for Company Tax	Article 12 of Supplementary Deed No. 1 being new Article 16.2 of the Mining Convention	"The holder of the mining concession benefits over a period of fifteen (15) years from an exemption from company tax, calculated from the date of issue of the mining concession."
Requirement for Social Development Funds	Article 16 of Supplementary Deed No. 1 supplementing Article 31 of the Mining Convention	"Over the entire period of validity of the mining concession in both its pre-production and production phases, the exploitation company shall agree to contribute to the social development of local communities in the Grande Côte region, which are located in areas surrounding the exploitation site. Thus, it shall agree to invest an amount of $US150,000 per year for this purpose."
Contribution to basis and further training of Senegalese Ministry of Mines Personnel	Article 17 of Supplementary Deed No. 1 replacing Article 31.3 of the Mining Convention	"- contribute, on the basis of a protocol to be concluded with the Ministry for Mines, to the basic and further training of Senegalese officers responsible for the management and promotion of the mining sector and logistical support to the technical services of the Ministry for Mines; to this end, the exploitation company[1] shall agree to allocate the sum of $US50,000 per year for each year of production."
Mining Royalty	Article 23 of Supplementary Deed No. 1	MDL shall accept that the mining royalty to be paid pursuant to Article 57 of the Mining Code be 5% of the pithead value. The 2% surplus has been set aside to support the New Town development project.[2]

These royalty and taxation requirements have been included in the capital and operating cost estimates developed in the DFS, see Sections 16, 17 and 19.

20.5 Basis of Financing

MDL is considering a range of possible financing options of the GCP.

20.6 Intellectual Property

The GCP is based on well-established industry technology and there are no patent or licensing issues related to the mining, extraction or transport of saleable product.

20.7 Insurances

A comprehensive suite of insurances will be required for the GCP. These will include marine cargo, public liability, motor vehicle, contract plant and mobile plant, personal accident, medical health fund and industrial special risk insurance. Static risk insurance is already in place to cover the dredge pump in United Kingdom and spares in Belgium. The industrial special risk insurance covers material damage, business interruption and

[1] GCO

[2] The 2% for the New Town development is included in the 5% total.

machinery breakdown, but does not cover loss of profit. A total allowance of US$2.0M pa is included in the operating costs for these insurances. The amount is based on similar insurance cost at Sabodala with adjustments for lower manning, less heavy equipment and light vehicles.

Political risk insurance will also be required as part of the debt financing arrangements. MDL has previously obtained political risk insurance for Sabodala Gold Project in eastern Senegal. This insurance was obtained through 1st City at a rate of 0.75% of the loan amount. It is anticipated that political risk insurance will be at a similar rate for the GCP.

20.8 Contracts and Caveats

GCO has a number of existing contracts in place. These include:

- Employment contracts with Senegal nationals directly through GCO.
- Employment contracts with expatriates through MDM.
- Contracts with service providers for consulting services related to the development of the GCP.
- Service contract with Connecteo for provision of internet bandwidth, and Vigassistance for security guards.

MDL has confirmed there are no caveats outstanding on the project or any legal disputes relating to the development and operation of the project.

20.9 Corporate, Legal and Insurance Costs

Details of the corporate, legal and insurance capital and operating costs are in Section 16 and 17 of the DFS.

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SECTION 21
Risk Analysis

Copy 16

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CONTENTS

TABLES

FIGURES

21 RISK ANALYSIS

21.1 Introduction

Project risks were identified and assessed by GCO in two risk workshops. The initial risk assessment workshop, facilitated by Ausenco Minerals and attended by GCO and AMC personnel, was undertaken in February 2010 to identify risks and opportunities with potential to impact or enhance project value. A risk register was developed that identified each risk, assigned a risk rating based on the likelihood and consequences of the risk event occurring and identified appropriate control measures to mitigate and manage the risks.

The second risk assessment workshop, facilitated by AMC and attended by GCO, Earth Systems and Umwelt personnel, was undertaken near the completion of the feasibility study in late May 2010. This workshop reviewed the previous risk workshop output and also considered in greater depth geological, mining, environmental and social risks.

The risk register covered all technical disciplines and interfaces associated with the delivery of the GCP. Marketing, financing and political risk factors were not within the scope of the risk assessment workshops.

21.2 Risk Assessment Process

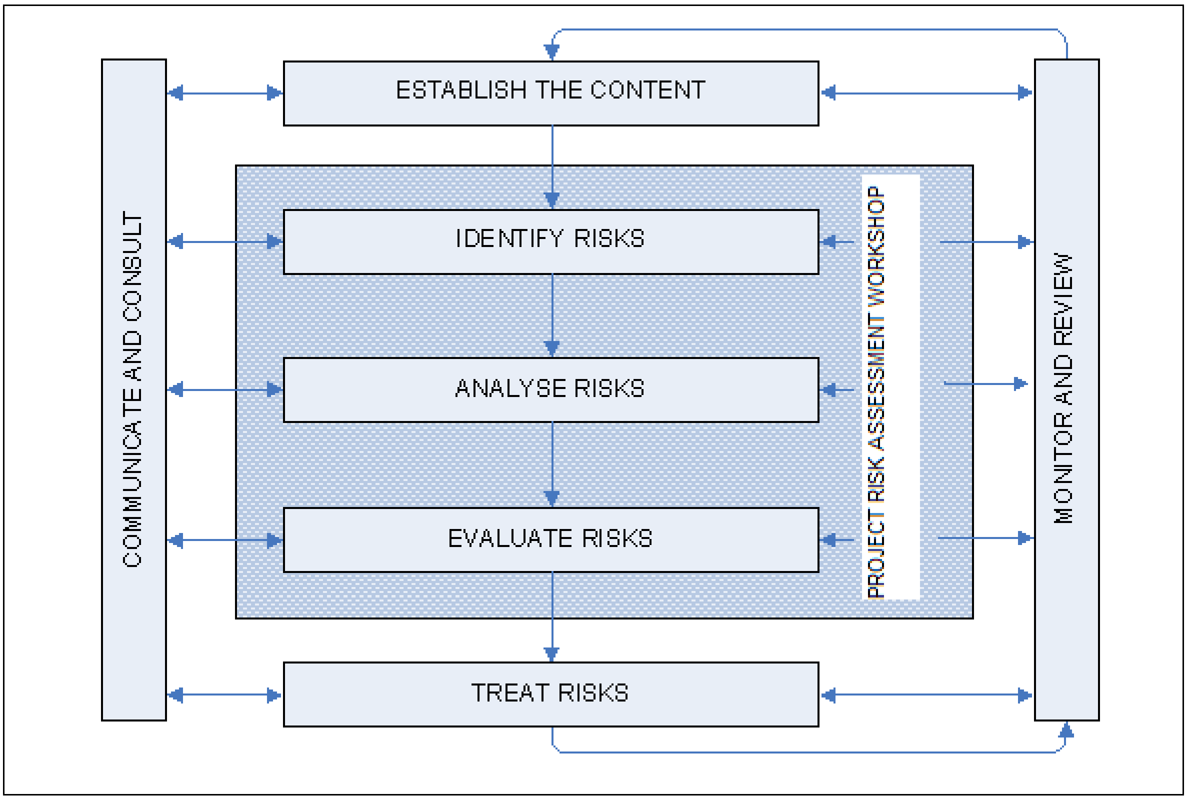
The objectives of the risk assessment workshops were to:

- Identify the major risks to the successful delivery of the Grande Côte Project.
- Allocate ownership of risks to the relevant party.
- Develop a project risk register for ongoing management of risks and opportunities.
- Provide a risk assessment for the DFS document.

A broad spread of discipline and industry experts participated in the risk assessment workshops to identify potential risks, assess the severity of these risks and propose controls for further consideration by the GCP team.

The project risk assessment workshop addressed three key elements of the risk management model shown in Figure 21.1: identify risks, analyse risks and evaluate risks.

Figure 21.1 Risk Management Model



- **IDENTIFY –** the what, where, when, why and how events could prevent, degrade, delay or enhance the achievement of objectives.
- **ANALYSE –** the consequences, likelihood and existing controls to manage the risk events. These factors were analysed and a score was assigned to each risk resulting in a ranking for that risk. This ranking is an indicator of the severity of the risks.
- **EVALUATE –** the effectiveness of mitigation actions in reduction of consequences or likelihood by nominating post-mitigation consequence and likelihood ratings. This provided a post-treatment severity ranking allowing the prioritisation of risk mitigations based on severity.

21.3 Assigning Risk Ratings

Table 21.1 and Table 21.2 list the categories utilised to measure and assess risks and opportunities based on projected consequences and likelihood of the risk or opportunity occurring. Existing controls are included in the assessment to ensure accurate measurement.

Table 21.1 Risk Consequence Matrix

Consequences	1: Minor	2: Moderate	3: Serious	4: Major	5: Critical
Health & safety	Low-level symptoms requiring first aid treatment only	Medical treatment injury	Serious injury/ permanent disability or impairment to one or more persons	Single fatality or severe permanent impacts to >10 persons	Multiple fatalities as a result of short or long-term health effects or irreversible impacts to >50 people
Environment	Limited damage to a localised area. No lasting effects	Localised short to medium-term damage to an area of minor local significance	Localised medium-term damage to an area of local value	Widespread long to medium-term damage to valued area	Significant, extensive detrimental long-term impact
Reputation	Local public concern/ complaints Minor technical non-compliance	Negative publicity and attention from local media Moderate breach of regulations	Attention from media, negative regional publicity Serious breach of regulations with fine.	Significant negative attention, national publicity Major breach of regulation. Reputation tarnished	Negative international publicity. Very serious litigation Reputation severely tarnished Share price may be affected
Financial	<US$0.8M	US$0.8M–$5M	US$5M–20M	US$20M–40M	> US$40M
Project Construction schedule	<1 week	1–4 weeks	1–2 months	2–4 months	>4months
Existing operations & services interruption	Minors repairs, restricted area shutdown <1 day	Restricted area shutdown 2–4 days	Restricted area shutdown 1 week – 1 month	Critical path area shutdown 1 – 2 months	Complete shutdown of site operations >2 months
Legal	Minor non-compliances and breaches of regulations	Minor legal issues, moderate non-compliances and breaches of regulations	Serious breach of regulation with prosecution or moderate fine possible	Major breach of regulation. Major litigation	Significant prosecution and fines. Very serious litigation including class action
Social	Community grievances easily resolved	Community grievances which require high level local input	Community dispute which is difficult to resolve	Community disruption of project	Community stop project
Opportunities	Small benefit, low financial gain	Minor improvement to image, some financial gain	Some enhancement of reputation, high financial gain	Enhanced reputation, major financial gain	Significant enhanced reputation, huge financial gain

Table 21.2 Risk Likelihood Matrix

Likelihood Descriptors				
1: Rare	**2: Unlikely**	**3: Possible**	**4: Likely**	**5: Almost certain**
Have never heard of this happening	The event might occur once in your career	The event or similar has occurred elsewhere	The event has occurred several times or more in your career	Occurs more than once per year

21.4 Risk Severity Rating

The risk severity rating is determined by the assessment of consequence and likelihood using the matrix in Table 21.3 and Table 21.4.

Note, the risk severity is an assessment of the likelihood of the nominated risk consequence occurring.

Table 21.3 Risk Severity Ranking Matrix

		Consequence Rating				
		1: Minor	**2: Moderate**	**3: Serious**	**4: Major**	**5: Critical**
Likelihood Rating	**5: Almost certain**	Moderate	High	High	Extreme	Extreme
	4: Likely	Moderate	Moderate	High	High	Extreme
	3: Possible	Low	Moderate	Moderate	High	High
	2: Unlikely	Low	Low	Moderate	Moderate	High
	1: Rare	Low	Low	Low	Moderate	Moderate

Table 21.4 details the relevance of the colour coding per the risk severity ranking matrix.

Table 21.4 Risk and Opportunity Colour Code Ranking

Risk and Opportunity Colour Code	
Extreme Risks that significantly exceed the risk acceptance threshold and need urgent and immediate attention. Opportunities that show outstanding potential to positively affect outcomes of the project.	(red)
High Risks that exceed the risk acceptance threshold and require proactive management. Opportunities that show high potential to positively affect outcomes of the project.	(purple)
Medium Risks that lie on the risk acceptance threshold and require active monitoring. Opportunities that may have moderate positive benefit to the project.	(yellow)
Low Risks that are below the risk acceptance threshold and do not require active management. Opportunities that may have minor positive effect on outcomes of the project.	(green)

21.5 Risk Register

The risk register developed for the GCP is shown in Table 21.5. Table 21.6 shows a summary of the risk rankings by class.

Table 21.5 Risk Register of Grande Côte Project by Class

Risk Register of Grande Côte Project											
				Before Controls					Revised Controls		
Class	Risk Event	Risk Summary	Possible Causes	Initial Consequences	Initial Likelihood	Initial Risk Ranking	Proposed Controls	Owner	Revised Consequences	Revised Likelihood	Revised Risk Ranking
Geology, Mineralisation and Resources											
Geology, Mineralisation & Resources	Mineral Resource	Lower recovery through the spirals	Higher proportion of HM fines within the resource	2	3	Medium	Regular plant monitoring and adjustment	GCO	1	3	Low
Geology, Mineralisation & Resources	Mineral Resource	Reduction of sales product vs budget	Variable assemblage within the VHM	3	2	Medium	Controls built into resource block model	GCO	3	2	Medium
Geology, Mineralisation & Resources	Mineral Resource	Plant performance inability to cope with resource quality variation	Variable HM grade within the resource	1	3	Low	Controls built into mine and plant design	GCO	1	3	Low
Mining											
Mining	Operational	Inability to contain water due to topography	Pond daylighting	3	4	High	Build lateral berm with tailings – preferentially coat with slime tailings; tails management planning	GCO	2	2	Low
Mining	Operational	Poor operational performance at start up	Inadequate skill levels and/or training	3	4	High	High level of expatriates with knowledge; budget allowance for ramp-up; design mine path for first 12 months to suit less experienced operators; cross training; recruitment policy for expatriates and nationals	GCO	2	2	Low
Mining	Operational	Increased OPEX costs	Increased fuel costs	3	3	Medium	Fuel hedging	GCO	2	3	Medium
Mining	Operational	Unplanned beaching the dredge and the floating plant	Power loss	4	2	Medium	Permanent mobile gensets for pumping	GCO	4	1	Medium
Mining	Operational	Interruption of operations due to rate of face advance	Inability to advance services	2	3	Medium	Mine planning	GCO	2	2	Low
Mining	Operational	Beaching the floating plant	Power outage requiring plant to discharge hoppers	2	3	Medium	Distribution of discharge by moving floating plants	GCO	2	2	Low
Mining	Operational	Bog front of dredge	Face collapse; wave action	1	1	Low	Negligible risk due to low face height	GCO	1	1	Low
Mining	Operational	Operational delays	Lightning and other natural hazards	1	3	Low	Operating controls	GCO	1	1	Low
Mine & Site Geotechnical											
Mine & Site Geotechnical	Technical	Additional foundation design costs	Incomplete geotechnical investigation	2	2	Low	Additional geotechnical site investigations	GCO	1	1	Low
Mine & Site Geotechnical	Technical	Additional road design costs	Incomplete geotechnical investigation	2	2	Low	Additional geotechnical site investigations	GCO	1	1	Low
Mineral Processing											
Mineral Processing	Operational	Poor operational performance at start up	Inadequate skill levels and/or training	3	4	High	High level of expatriates with knowledge; budget allowance for ramp-up; cross training; recruitment policy for expatriates and nationals	GCO	2	2	Low
Mineral Processing	Operational	Unscheduled shutdowns of the pumping systems	Concentrate pumping issues	3	4	High	HMC pumping system bypass; ability to truck concentrate	GCO	1	1	Low
Mineral Processing	Operational	Reduced recovery	Trash on spirals	2	3	Medium	Daily housekeeping	GCO	1	1	Low
Mineral Processing	Operational	Reduced recovery	Slurry density control	2	3	Medium	Supervision and monitoring; process control; automatic dilution	GCO	1	1	Low
Mineral Processing	Operational	Reduced recovery and/or off-spec product	Insufficient temperature control in the dry mill	2	3	Medium	Supervisory and process controls	GCO	1	1	Low
Mineral Processing	Operational	Reduced recovery and/or off-spec product	Excess humidity affecting recovery in the dry mill	2	3	Medium	Supervisory and process controls	GCO	1	1	Low
Mineral Processing	Operational	Reduced recovery and/or off-spec product	HTR cleanliness	2	3	Medium	Supervisory and process controls	GCO	1	1	Low
Mineral Processing	Operational	Reduced recovery and/or off-spec product	Incorrect batch feed; incorrect plant settings to match feed stock specifications	2	3	Medium	Supervisory and process controls	GCO	1	1	Low
Mineral Processing	Operational	Reduced recovery and/or off-spec product	Power fluctuations	2	3	Medium	If required install capacitor banks	GCO	1	1	Low
Mineral Processing	Operational	High operating costs	Inadequate transfer of skills	2	3	Medium	Adequate management	GCO	1	1	Low
Tailings Disposal											
Tailings Disposal	Technical	Beach the surge bin	Tails overtaking the plant	2	3	Medium	Supervision and monitoring	GCO	2	2	Low
Tailings Disposal	Technical	Beaching the floating plant	Stack does not release water at anticipated rate	2	2	Low	Supervision and monitoring; increase water supply from bore fields	GCO	2	1	Low

Risk Register of Grande Côte Project											
				Before Controls					Revised Controls		
Class	Risk Event	Risk Summary	Possible Causes	Initial Consequences	Initial Likelihood	Initial Risk Ranking	Proposed Controls	Owner	Revised Consequences	Revised Likelihood	Revised Risk Ranking
Water Management & Hydrology											
Water Management & Hydrology	Operational	Unplanned beaching the dredge and the floating plant	Water supply loss	4	1	Medium	Bores and piping include contingency	GCO	4	1	Medium
Water Management & Hydrology	Hydrology	Reduced HMC production	Inability to supply sufficient water to operate at elevated pond levels	3	2	Medium	Optimise hydrology model, lateral and deep water bore control	GCO	1	1	Low
Water Management & Hydrology	Hydrology	Insufficient capital allowance for deep water bores	Poor yield per bore	2	2	Low	Finalise in situ pump testing	GCO	2	1	Low
Water Management & Hydrology	Hydrology	Aquifer depletion	Overuse of aquifer	1	1	Low	Recovery testing	GCO	1	1	Low
Water Management & Hydrology	Hydrology	Pumping impact on other stakeholders	Pumping impact water availability to neighbours	2	2	Low	Control water table level balance by fluctuating between upper and lower aquifer	GCO	2	2	Low
Water Management & Hydrology	Hydrology	Insufficient capital allowance for water bores	Inaccurate hydrology model	2	2	Low	Providing a combination of deep and lateral bores; refining the ground water model	GCO	2	1	Low
Infrastructure & Services											
Infrastructure & Services	Accommodation	A larger than budgeted construction camp may be required (currently budgeted temporary camp capacity is 800)	Increased manning to meet schedule	2	3	Medium	Schedule management and increase temporary camp/local accommodation capacity	GCO	2	1	Low
Infrastructure & Services	Road	Increased road maintenance costs	Higher than anticipated road damage during construction and/or operations	2	3	Medium	Scheduled inspection and maintenance	GCO	2	2	Low
Infrastructure & Services	Railway	Management of the concession changes disrupting rail operations	Commercial relationship failure	3	3	Medium	Stock management at the port to limit interruptions; agreement in place with government regarding concession planning	GCO	2	1	Low
Infrastructure & Services	Port	Off-spec product	Contamination in ship	3	3	Medium	Management control ship inspection prior to loading	GCO	1	1	Low
Infrastructure & Services	Port	Inaccurate-spec product	Inadequate QA/QC	2	3	Medium	Representative sampling prior to loading; undercover storage; product quality control from MSP	GCO	1	1	Low
Infrastructure & Services	Power	Interruption to natural gas supply	Broken line, gas plant breakdown	3	3	Medium	Dual fuel power station capable of burning HFO; diesel and natural gas	GCO	1	1	Low
Infrastructure & Services	Power	Interruption to natural gas supply. Higher operating costs	Lack of sufficient gas reserves	4	2	Medium	Heads of agreement of supply; dual fuel power station capable of burning HFO, diesel and natural gas.	GCO	3	1	Low
Infrastructure & Services	Communications	Inadequate site communications capacity and functionality	Inadequate IT infrastructure, connectivity and capacity	2	1	Low	Install current Sabodala systems from start		1	1	Low
Infrastructure & Services	Railway	Derailment	Rail condition, rolling stock condition	1	3	Low	New rolling stock, speed limits, rail maintenance and upgrades	GCO & Con-cession owner	1	2	Low
Infrastructure & Services	Port	Lack of access to a quay	Alternate users	2	2	Low	Alternative site is available	GCO & GRS	2	1	Low
Infrastructure & Services	Power	Power outage	Equipment breakdown	1	1	Low	Copy and improve on Sabodala power plant	GCO	1	1	Low
Health and Safety											
Health and Safety	Community Safety	Traffic incidents on roads or rail	Increased traffic; low public awareness; conditions of the roads	4	5	Extreme	GCO road to ICS and village bypasses; traffic management plan; community education; Contractor compliance with traffic management plan; logistics contractor selection and management	GCO	4	2	Medium
Health and Safety	Community Safety	Public accidents in mine	Unrestricted access	4	5	Extreme	Fence during construction and security staff control of boundary post construction	GCO	4	2	Medium
Health and Safety	Safety	Safety incidents	Lack of procedural safety culture among national workforce; lack of understanding of mechanical and electrical equipment	4	3	High	Safety Management Plan; policing of safety issues; training and monitoring; adequate safety resourcing of the project	GCO & EPCM	3	2	Medium
Health and Safety	Health	Malaria, dengue	Environmental conditions; hygiene; standing water; community rubbish control; lack of nets	4	4	High	Identification and treatment; utilise Sabodala malaria control programs; spraying; nets; removal of standing water; education programs	GCO	3	2	Medium

Risk Register of Grande Côte Project											
				Before Controls					Revised Controls		
Class	Risk Event	Risk Summary	Possible Causes	Initial Consequences	Initial Likelihood	Initial Risk Ranking	Proposed Controls	Owner	Revised Consequences	Revised Likelihood	Revised Risk Ranking
Health and Safety	Health	Other health issues	Environmental conditions; hygiene; food standards; differing standards of health in community; water quality; community rubbish control	3	3	Medium	Safety management plan; education; community health plan; on-site paramedic	GCO & EPCM	2	2	Low
Health and Safety	Security	Travel security expats in-country	Kidnap; theft; flights arrive in early hours of the morning	3	2	Medium	Meet and greet and escort by GCO personnel; pre-travel education; project security plan within safety management plan	GCO	3	1	Low
Health and Safety	Safety	Expat breach of law leading to fines or imprisonment	Breach of law after hours – misdemeanour; drug consumption; fraternisation	3	1	Low	Expatriate cultural and social awareness training	GCO & EPCM	1	1	Low
Health and Safety	Safety	Personnel exposure to radiation	Radiation level in some reject streams may exceed allowable limits; Monazite presence; dust from process stream	3	1	Low	Good dust control; shielding; monitoring; education	GCO	1	1	Low
Socio-Economic Impact											
Socio-Economic Impact	Community relations	Lack of community support	Untimely or unclear communications; local expectations	5	4	Extreme	Lessons learned from Sabodala; proactive CA plan run by GCO	GCO	2	2	Low
Socio-Economic Impact	Community relations	Impact of workforce on local community during construction period	Integration of workforce into community; cultural misalignment; in-migration	3	4	High	Closed construction camp; 'dry' camp	GCO	2	3	Medium
Socio-Economic Impact	Community relations	Tension/dispute between different community groups	Resource allocation among communities	3	4	High	Lessons learned from Sabodala; proactive CA plan run by GCO	GCO	2	3	Medium
Socio-Economic Impact	Community relations	Expectation of local workforce to gain employment which cannot be achieved	Local perceptions; rumour	4	3	High	Community liaison; manage expectations; project transparency	GCO	3	2	Medium
Socio-Economic Impact	Community relations	Over-integration of construction workforce in community; breakdown of local social fabric; loss of control of behaviour	Construction force integrated with community; cultural misalignment	4	3	High	Codes of conduct; cultural training and awareness; closed camp	GCO	2	2	Low
Socio-Economic Impact	Community relations	Abrupt drop in level of water table attributed to GCO but caused by other factors	Coincidental environmental factors (e.g. low-rainfall season); water drawn by other parties	4	3	High	Base line level; addressed in ESMP and adequate regional and national communication strategy	GCO	2	2	Low
Socio-Economic Impact	Community relations	Disruption to livelihood assets	Mining activities	4	4	High	Change in the mining plan; strong community relationships; establishing a base line and a transparent process for compensation from the beginning of the project	GCO	2	2	Low
Socio-Economic Impact	Community relations	Opportunistic migration associated with temporary elevated water tables	Raised water table plus infrastructure as a consequence of mining	3	3	Medium	Community and government relations	GCO	2	2	Low
Socio-Economic Impact	Community relations	Project being blamed for totally unrelated issues	Poor communication; lack of transparency	3	3	Medium	Community liaison and engagement	GCO	2	2	Low
Socio-Economic Impact	Community relations	Localised reduction of the reserve	Inability to access land in a timely fashion for mining	4	2	Medium	Change in the mining plan; strong community relationships	GCO	2	2	Low
Socio-Economic Impact	Community relations	In-migration on the dredge path and opportunistic development	Favourable water level rise and infrastructure, perceived potential compensation	4	2	Medium	Establishing a base line and a transparent process for compensation from the beginning of the project	GCO	2	2	Low
Socio-Economic Impact	Community relations	Disruption to tourism	Access conflicts	1	1	Low	Communication	GCO	1	1	Low
Environmental											
Environmental	Environmental	Excessive particulates from windblown dust	Operational activities	3	4	High	Dust suppression; dust monitoring	GCO	2	3	Medium
Environmental	Environmental	Impacting on localised biodiversity values	Removal of habitat	2	5	High	Base line study and rehabilitate mine area	GCO	2	2	Low
Environmental	Environmental	Localised flooding due to topography	Pond daylighting	3	4	High	Build lateral berm with tailings - preferentially coat with slime tailings; tails management planning; compensation to land owners	GCO	2	2	Low

Risk Register of Grande Côte Project											
				Before Controls					Revised Controls		
Class	**Risk Event**	**Risk Summary**	**Possible Causes**	**Initial Consequences**	**Initial Likelihood**	**Initial Risk Ranking**	**Proposed Controls**	**Owner**	**Revised Consequences**	**Revised Likelihood**	**Revised Risk Ranking**
Environmental	Environmental	Destabilised dunes	Failure of stabilisation measures	4	3	High	Undertake stabilisation trials	GCO	2	2	Low
Environmental	Environmental	Fuel truck spill	Road accident	2	3	Medium	Speed limits; transport protocols; appropriate supplier	Fuel supplier	2	2	Low
Environmental	Environmental	Acid generation	Sulphide presence	2	3	Medium	Dose pond if required, mixing lime into sand; tailings management; exclusion; elevated mine pond; further test work	GCO	1	3	Low
Environmental	Environmental	Excessive noise	Operational activities	1	3	Low	Noise insulation; bunding; location; buffer zone	GCO	1	2	Low
Environmental	Environmental	Excessive light	Operational activities	1	1	Low	Directional lighting and location	GCO	1	1	Low
Environmental	Environmental	Excessive particulate emissions from combustion	Operational activities	2	2	Low	Preferential natural gas/low-sulphur HFO	GCO	1	1	Low
Environmental	Environmental	Rehabilitation plan fails	Seasonal impacts	1	1	Low	Operational trials	GCO	1	1	Low
Environmental	Environmental	Water pollution by hydrocarbons	Leakage from gear boxes etc on floating plant	1	3	Low	Maintenance supervision; catch trays	GCO	1	1	Low
Project Execution											
Project Execution	Financial	Forex increasing cost to complete	Currency variations	4	4	High	Hedging; conservative exchange rate assumptions	GCO	2	2	Low
Project Execution	Financial	Capital escalation	Cost increases, inflation	4	4	High	Firm price contracts; equipment pricing	GCO	3	3	Medium
Project Execution	Financial	Lack of controls causing cost overruns or schedule delays	Poor procedures and planning	4	3	High	Good procedures and planning adequate controls	GCO	3	3	Medium
Project Execution	Financial	Under-resourcing of owner's team	Poor resource planning	4	3	High	Adequate and timely resource planning	GCO	2	2	Low
Project Execution	Financial	Under-resourcing of EPCM/contractors	Poor resource planning	4	4	High	Adequate and timely resource planning	EPCM/ GCO	2	3	Medium
Project Execution	Financial	Late scope changes negatively impacting on cost and schedule	Inadequate scope definition	3	3	Medium	Freeze scope; scope change procedure	GCO	3	2	Medium
Project Execution	Financial	Procurement delays	Poor planning or late engineering, inadequate scope, insufficient expediting procedures	3	3	Medium	Logistics planning and survey; singular country purchasing procedure; identification of long lead items; comprehensive project scheduling	GCO	2	2	Low
Project Execution	Financial	Delays due to poor logistics planning	Poor procedures and planning	3	3	Medium	Logistics planning and survey; singular country purchasing procedure; identification of long lead items; comprehensive project scheduling	GCO	2	2	Low
Project Execution	Financial	Customs clearance issues	Inadequate documentation	2	3	Medium	Procedures and relationship management	GCO	1	1	Low
Project Execution	Financial	Poor-quality work	Skills shortage; poor contractor selection; lack of adequate QA/QC procedures	2	3	Medium	Vendor selection and QA/QC prior to shipping	GCO/ EPCM	2	2	Low
Project Execution	Financial	Contractor mobilisation delays	Contractor inexperience; contractor award delays	3	3	Medium	Planning and selection of contractors	GCO	3	2	Medium
Project Execution	Financial	Force Majeure events	Events outside owner's control	4	2	Medium	Insurance; contingency plan	GCO	2	2	Low
Project Execution	Financial	Commission issues delaying schedule	Poor engineering and inadequate training	3	3	Medium	Engineering reviews; timely mobilisation of commissioning team	GCO	3	2	Medium
Project Execution	Financial	Poor contracting strategy	Poor planning; poor contractor selection	3	3	Medium	Owner's contracting strategy; timely decision-making	GCO	2	2	Low
Project Execution	Financial	Delays due to visa issues	Government procedures and resource planning	2	2	Low	Adequate and timely resource planning	GCO	2	1	Low
Ownership, Legal and Contractual											
Ownership, Legal & Contractual	Licences and permits	Loss of permits and/or licences	Approval process; non-compliance; changes in law	3	2	Medium	Identify permit requirements and establish a permit matrix	GCO	1	1	Low
Ownership, Legal & Contractual	Licences and permits	Delayed permit for deep water bores	Approval process	4	2	Medium	Expedite permitting process	GCO	4	1	Medium
Ownership, Legal & Contractual	Financial	Non-acceptance of ongoing closure	Misaligned expectations	2	3	Medium	Develop agreed sign-off criteria	GCO	1	2	Low
Ownership, Legal & Contractual	Land access	Inability to secure land for access routes	Approval process	2	2	Low	Change route	GCO	1	1	Low

Table 21.6 Summary of Risk Register by Rank and Class

Class	Ranking	Initial Number of Risks	Revised Number of Risks
Geology, Mineralisation and Resources		**3**	**3**
	Medium	2	2
	Low	1	1
Mining		**8**	**8**
	High	2	2
	Medium	4	4
	Low	2	2
Mine & Site Geotechnical		**2**	**2**
	Low	2	2
Mineral Processing		**10**	**10**
	High	2	2
	Medium	8	8
Tailings Disposal		**2**	**2**
	Medium	1	1
	Low	1	1
Water Management & Hydrology		**6**	**6**
	Medium	2	2
	Low	4	4
Infrastructure & Services		**11**	**11**
	Medium	7	7
	Low	4	4
Health and Safety		**8**	**8**
	Extreme	2	2
	High	2	2
	Medium	2	2
	Low	2	2
Socio-Economic Impact		**12**	**12**
	Extreme	1	1
	High	6	6
	Medium	4	4
	Low	1	1
Environmental		**11**	**11**
	High	4	4
	Medium	2	2
	Low	5	5
Project Execution		**15**	**15**
	High	5	5
	Medium	9	9
	Low	1	1
Ownership, Legal and Contractual		**4**	**4**
	Medium	3	3
	Low	1	1
Grand Total		**92**	**92**

In summary, a total of 92 risks were identified and assessed, the majority of which are associated with project execution. Of these, nine risks summarised in Table 21.7 are considered key issues for GCO management based on the risk rating.

Table 21.7 Summary of Key Issues for Management of GCO Identified in Risk Register

Class	Risk Summary	Initial Risk Ranking	Proposed Controls	Owner	Revised Risk Ranking
Mining and mineral processing	Poor operational performance at start up	High	High level of expatriates with knowledge; budget allowance for ramp-up; design mine path for first 12 months to suit less experienced operators; cross training; recruitment policy for expatriates and nationals	GCO	Low
Health and Safety	Traffic incidents on roads or rail	Extreme	GCO road to ICS and village bypasses; traffic management plan; community education; contractor compliance with traffic management plan; logistics contractor selection and management	GCO	Medium
Health and Safety	Public accidents in mine	Extreme	Fence during construction and security staff control of boundary post construction	GCO	Medium
Health and Safety	Malaria, dengue	High	Identification and treatment; utilise Sabodala malaria control programs; spraying; nets; removal of standing water; education programs	GCO	Medium
Socio-Economic Impact	Lack of community support	Extreme	Lessons learned from Sabodala; proactive CA plan run by GCO	GCO	Low
Socio-Economic Impact	Disruption to livelihood assets	High	Change in the mining plan; strong community relationships; establishing a base line and a transparent process for compensation from the beginning of the project	GCO	Low
Project Execution	Forex increasing cost to complete	High	Hedging; conservative exchange rate assumptions	GCO	Low
Project Execution	Capital escalation	High	Firm price contracts; equipment pricing	GCO	Medium
Project Execution	Under-resourcing of owner's team and/or EPCM/contractors	High	Adequate and timely resource planning	EPCM/GCO	Medium

21.6 Opportunity Register

The opportunity register developed for the project is shown in Table 21.8. In summary, a total of nine feasible, qualitative opportunities were identified that could potentially add value to the project. The key opportunities are centred on mineral processing, socio-economic and project execution as summarised in Table 21.9.

Table 21.8 Opportunity Register of Grande Côte Project

Opportunity Register of Grande Côte Project						
Class	**Risk Event**	**Opportunity Summary**	**Basis for Opportunity**	**Potential Upside**	**Likelihood of realisation**	**Opportunity Ranking**
Geology, Mineralisation & Resources	Mineral Resource	Increase of sales product vs budget	Variable assemblage within the VHM	3	3	Medium
Geology, Mineralisation & Resources	Mineral Resource	Increased mine life	Mining additional portions of the Mining Concession	4	4	High
Mineral Processing	Operational	Increase the rutile and leucoxene recovery	Focused flow sheet refinement	3	4	High
Water Management & Hydrology	Hydrology	Pumping impact on other stakeholders	Pumping impact water availability to neighbours	2	2	Low
Socio-Economic Impact	Community relations	Good community relations	Job creation	3	4	High
Socio-Economic Impact	Community relations	Good community relations	Industry creation	3	4	High
Socio-Economic Impact	Community relations	Good community relations	Training and development	3	4	High
Socio-Economic Impact	Community relations	Good community relations	Improvement to community infrastructure	3	4	High
Socio-Economic Impact	Community relations	Good community relations	Improving health and education	3	4	High
Project Execution	Financial	Value engineering to reduce CAPEX	Identification of achievable capital savings	4	4	High

Table 21.9 Summary of Key Opportunities for Management of GCO

Class	Opportunity Summary	Initial Risk Ranking
Mineral Processing	Increase the rutile and leucoxene recovery	High
Socio-Economic Impact	Good community relations	High
Project Execution	Value engineering to reduce CAPEX	High
Geology, Mineralisation & Resources	Increased mine life	High

Key project opportunities are centred on maximising socio-economic benefits, value engineering to reduce capital costs, improved mineral processing recoveries and longer mine life. In summary:

- Despite repeatable and consistent results the rutile and leucoxene recoveries measured as part of the testwork program were significantly lower than industry standard recoveries at comparable operations. Therefore there is significant project upside for increased recoveries and revenue from these minerals.
- The construction and operation of the GCP is expected to result in very substantial financial and social benefits to surrounding communities. These include direct and indirect job creation, creation of local industry to support the project, and training and skills transfer to local people. Added social benefits include improved health and education levels plus improved local infrastructure such as roads.
- During the DFS, Ausenco identified considerable capital cost savings that could be obtained through a fresh look at the MSP design and layout. Rationalisation of the structures and facilities including integration of the ilmenite and zircon building at the MSP could result in saving of the order of US$5M to $10M. In addition, further optimisation of the major structural sections of the plant such as pontoons allowing easier transportation and assembly were identified. Funds and schedule allowances are included as part of the project execution phase to realise these opportunities.
- The DFS scope was based on defining Reserves for the first 14 years of mine life. There is a significant portion of the ore body within the Mining Concession that has not been fully explored. Based on existing geological and exploration data a further 10+ years of project life can be reasonably expected.

Abbreviations

2004 JORC Code	Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves
3Al2O3.2SiO2	Mullite
Al2O3	Aluminium oxide (Alumina)
AMC	AMC Consultants Pty Ltd
AS/NZS	Australian & New Zealand Standards
Ausenco	Ausenco Limited
AZS	Alumina-Zirconia-Silica
BEC	BEC Engineering
BRGM	Bureau de Recherches Géologiques et Minières
CAGR	Compounded Annual Growth Rate
CaO	Calcium
CAT	Caterpillar (Industrial Equipment)
CCP	Conceptual Closure Plan
CIF	Cost Insurance and Freight
Citrix	A suite of software products developed by Citrix Systems that enables bandwidth efficient access to corporate applications via the internet and other networks
Classic	Classic Information Systems
Cr2O3	Chromium trioxide (Chromium)
CRT	Cathode Ray Tubes
CY	Calendar Year
DEDI	Downer EDI Mining – Mineral Technologies
DFS	Definitive Feasibility Study
DMCP	Detailed Mine Closure Plan
DuPont	EI du Pont de Nemours and Company Inc
EHS	Environmental Health and Safety
EIES	Environmental and Social Impact Assessment (Etude d'impact environnemental et social)
EMP	Electron microprobe
EMRC	Environmental Management and Research Consultants
EPCM	Engineering, Procurement, Construction and Management
ES	Electrostatic

ESMMP	Environmental and Social Management and Monitoring Plan
ESMS	Environmental and Social Management Systems
ESSM	Environmental and Social Monitoring Manual. Prepared by Umwelt (Australia) Pty Limited on behalf of Grande Cote Operations.
FCFA	Franc Communauté Financière Africaine
Fe	Iron
Fe2O3	Iron oxide (Ferric Iron)
FeO	Ferrous Iron oxide
FeTiO3	Ilmenite
FOB	Freight on Board
FoS	Factor of Safety
GCO	Grande Côte Operations Pty Ltd
GCP	Grande Côte Project
GCPA	Grande Côte Project Area
GCPDA	Grande Côte Project Development Area
GCZP	Grande Côte Zircon Project
GDP	Gross Domestic Product
GEC	Global Economic Crisis
GIS	Geographic Information System
GRS	Government of the Republic of Senegal
GSHAP	Global Seismic Hazard Assessment Project
GSM	Global System for Mobile Communications (Groupe Spécial Mobile)
GWQMP	Groundwater Quality Monitoring Plan. Prepared by Umwelt (Australia) Pty Limited on behalf of Grande Cote Operations.
H2SO4	Sulfuric Acid
HAL	Hot Acid Leaching
Hf	Hafnium
HFO	Heavy Fuel Oil
HM	Heavy Mineral
HMC	Heavy Mineral Concentrate
HS	Highly susceptible (magnetics)
HT	High Tension
HTR	High Tension Electrostatic Roll
ICS	Industrie Chemique Senegal

ICT	Information and Computer Technology
IFC	International Finance Corporation
IMF	International Monetary Fund
IMS	Integrated Management System
IPBX	Internet Protocol Private Branch Exchange
IRM	Induced Roll Magnet
IRMS	Induced Roll Magnetic Separator
IRR	Internal Rate of Return
ISDN	Integrated Services Digital Network
ISO	International Organisation for Standardisation
ISP	Internet Service Provider
IT	Information Technology
JICA	Japan International Cooperation Agency
JSEA	Job Safety Environment Analysis
Kbps	Kilobits per second – one thousand bits per second data transmission rate
KNA	Kriging Neighbourhood Analysis
KZN	KwaZulu-Natal Sands
LAN	Local Area Network
LCD	Liquid Crystal Displays
LHM	Light heavy mineral (>2.85 SG & >4.05 SG)
LIMS	Low intensity magnetic separator
LPG	Liquid Petroleum Gas
LST	lithium sodium tri-polytungstate
M	Molar (mass of chemical element or chemical compound)
Mbps	Megabits per second – one million bits per second data transmission rate
MDL	Mineral Deposits Limited
MDLSS	Mineral Deposits Limited Senegal Suarl
MDM	Mineral Deposits Mauritius Limited
MgO	Magnesium
MLA	Mineral Liberation Analyser
MnO	Manganese
MOS	Management Operating Strategy

MS	Microsoft
MSC	Dredge Erection Site
MSP	Mineral Separation Plant
MSP	Mineral Separation Plant.
NaOH	Sodium Hydroxide
NFP	French Standards
NPV	Net Present Value
ODBC	Open Database Connectivity
OHS	Occupational Health and Safety
OHSMP	Occupational Health and Safety Management Plan
OK	Ordinary Kriging
OS	Oversize
P2O5	Phosphate
PAEP	Plan of Action of Farmers Entrepreneurship
PAP	Project Affected Persons
PC	Personal Computer – used here as desktops, laptops, notebooks etc.
PCDP	Public Consultation and Disclosure Plan
PDP	Plasma Display Panels
PGES	Environment & Social Management Plan (Plan de gestion environnnementale et sociale)
PGRM	Natural Resource Management Plan
PGS	Social Management Plan
PHSS	Hygiene – Health – Safety Plan
POP	Post Office Protocol
PSD	Particle Size Distribution
PSZ	Partially Stabilised Zirconia
PVC	Polyvinylchloride
QA/QC	Quality Assurance / Quality Control
QAQC	Quality assurance / Quality Control
QIT	Quebec Fer et Titane
RAP	Resettlement Action Plan
RBM	Richards Bay Minerals
RC	Reverse Circulation

RGWT	Regional Groundwater Table.
RL	Reduced Level
RPD	Repeatability Plot
S.A.R.L.	Need to work out what this stands for
SDP	Social Development Plan
Senegal	The Republic of Senegal
SG	Specific gravity
SiO2	Silica di-oxide (Sand/ Silica)
SLA	Service Legal Agreement
SMS	Short Message Service
SOE	Standard Operating Environment
SPT	Standard Penetration Test
SQL	Sequential Query Language
SR	Synthetic Rutile
SSL	Secure Sockets Layer
STIs	Sexually transmitted infections
STP	Sewage Treatment Plant
TBE	Tetrabromoethane
Th	Thorium
Ti	Titanium
TiCl4	Titanium tetrachloride
TIMET	Titanium Metals Corporation
TiO2	Titanium dioxide (Titania/ Rutile)
TiO2 Pigment	Titanium Pigment
TZMI	TZMI Minerals International Pty Ltd
TZP	Tetragonal Zirconia Polycrystal
U	Uranium
UGI	Upgraded Ilmenite
UGS	Upgraded Slag
UK	United Kingdom
UPS	Uninterrupted Power Supply
URIC	Unroasted ilmenite circuit
US	United States

USD	United States Dollars
UTM	Universal Transverse Mercator
UV	Ultra Violet
V2O5	“Vanadium”
VHM	Valuable heavy mineral (>4.05 SG)
VoIP	Voice over Internet Protocol – method for carrying voice traffic over the internet and other networks
VPN	Virtual Private Network
VSAT	Very Small Aperture Terminal – a small fixed satellite antenna that provide data communications
WAN	Wide Area Network
WCP	Wet Concentrator Plant
WHIMS	Wet high intensity magnetic separation
W/W	Weight divided by weight
XRF	X-Ray Fluorescence
Y	Yttrium
ZBS	Zirconium Basic Sulphate
ZiSO4	Zircon Sand
ZOC	Zirconium oxychloride octohydrate ZrOCl2.8H2O
ZrCl4	Zirconium tetrachloride
ZrO2	Zirconia
ZrOCl2	Hydrolysed Zirconium oxychloride octohydrate
ZrSiO4	Zircon
ZUP	Zircon Upgrading Process

Glossary

Aeolian	Wind related erosional, transportation and depositational processes.
Artesian well	A water well drilled into a confined aquifer where enough hydraulic pressure exists for the water to flow to the surface without pumping.
Auger	A tool having a helical shaft that is used for boring holes into the ground and removing the loosened soil or soft or weathered rock.
Baseline Study	The ground study to be undertaken by the Company at a specific point in time prior to the commencement of the Construction Works, which will identify and catalogue all man made improvements on or to the GCP Lands.
Batch	A group of samples to be processed as a single unit.
Becher process	Synthetic rutile process.
Buffer Zone	A 50 m buffer zone around the current proposed mining area has been defined as an area that may experience project related impacts and is likely to be required for community safety. Note that a 250 m buffer zone was used in the 2007 Baseline Study which has subsequently been refined to 50 m in the 2009 update.
Cut-off grade	A grade value used to make a decision about how the material is to be managed or processed (such as whether it is mined it or not, or send for processing or to backfilling).
Domain	A zone defined by the statistical similarity / distribution of a particular variable.
Drill cuttings	Particles of soil or rock resulting from the cutting action of drilling or augering a hole.
Equator Principals	Guidelines for financial institutions to determine, assess and manage environmental and social risk in project financing.
Humic horizon	Layer of dark brown organic matter in the soil horizon.
Internal Laboratory Standands	A standard submitted into a batch of samples by the assaying laboratory to ensure that the analytical processes are accurate between calibrations of the machines. This is a measure of accuracy.
IRR	Internal rate of return.
Kriging Neighbourhood Analysis (KNA)	Geostatistical technique used to define the kriging search neighbourhood parameters.
Lacustrine	Means “of a lake” or “relating to a lake.”
Lithium sodium tri-polytungstate (LST)	A non toxic, water soluble heavy liquid that is now in common use in the mineral sands industry.

Littoral	A coastal zone that extends from the high water mark, which is rarely inundated, to the shoreline areas that are permanently submerged.
Magstream Process	A technique that uses ferro-fluids and magnetic and centrifugal forces to produce precise split points over a range of specific gravities – have met check.
Mineral Liberation Analyser (MLA)	A quantitative mineralogy system that integrates Scanning Electron Microscopy (SEM) and Energy Dispersive X-Ray Spectrometry (EDS) analysis technologies. The technology gathers data on grain size distribution and mineral abundance and associations in each of the deposits.
Monazite	Yellow or brown mineral, rare earth phosphate that may contain the element Thorium.
Niayes	Inter dune depression.
Ordinary Kriging (OK)	Geostatistical technique used to interpolate the value of a random field (ie. grade or density).
Oversize (OS)	A proportion of a heavy mineral deposit that is above a certain grain size and may not be extracted by dredging methods or able to pass through processing plant. – mining engineer to check.
Peat	An accumulation of partially decayed vegetation matter, formed in wetland bogs, moors, muskegs, mires and peat swap forests.
Piezometer	A small-diameter observation well used to measure the hydraulic head of groundwater in aquifers.
Project Affected Persons	Project Affected Persons are those persons and families affected or impacted by the Project, who have land, assets or derive some livelihood in those areas to be handed over to the GCO, temporarily or indefinitely. It is these PAPs who may be entitled to any applicable compensation.
Reverse Circulation	A counterflow method of circulating drilling fluid and spoil in a drill hole. In the direct circulation method, drilling fluid is pumped down a hollow drill pipe, through the drill bit, and back to the surface in the annular space around the drill pipe; and the cuttings are carried to the surface by the flow. In the reverse-circulation or counterflow system, drilling fluid is pumped out of the drill stem at the top circulated through a pit where cuttings are removed, and returned to the annular space around the drill stem. Circulation is upward inside the drill stem and downward outside it.
Shewart Chart	A graphical technique for determining whether a process is or is not in a state of statistical control. Being in statistical control means that the extent of variation of the output of the process does not exceed that which is expected on the basis of the natural statistical variability of the process. A type of control chart.

Sighter	Small size timed samples of spiral products in a closed circuit test rig.
Slimes	A proportion of a heavy mineral deposit that is too fine to be economically extracted.
Strand Lines	Thinly bedded HM concentrations reworked as lag deposits in mobile dunes.
Swale	A low tract of land that is wet or marshy, can be natural or man-made.
Tetrabromoethane (TBE)	Chemical used for heavy mineral separation.
Top cut	The reduction in the grade of a high grade outlier sample prior to grade estimation. Outliers are usually identified using one of several statistical methods such as mean plus two standard deviations or using a percentile such as the grade value at the 95th percentile. Top cutting is done to reduce the effect a high grade sample may have on an estimation.
Umpire Sample Duplicates	A duplicate sample assayed by a third party laboratory to resolve an assay precision dispute.
Universal Transverse Mercator (UTM)	A grid based method of specifying locations on the surface of the Earth that is a practical application of a 2-D Catesian coordinate system.
Variogram	A graph representing the spatial continuity of data and how the continuity of the data changes as a function of distance and direction.

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